The Effect of Increasing Levels of Postruminal Casein Infusion on Low-Quality Forage Intake

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Story in Brief

Twelve steers (average initial BW = 629 kg) fitted with rumen and abomasal cannulas were used to determine the effect of increasing levels of postruminal casein infusion on low-quality forage intake. Treatments were 1) CON, basal diet; ad libitum access to low-quality forage (6% CP, DMB), 2) 300 g casein ruminally + basal diet R, 3) 150 g casein postruminal + basal diet (P1), 4) 300 g casein postruminal + basal diet (P2), 5) 450 g casein postruminal + basal diet (P3), and 6) 600 g casein postruminal + basal diet (P4). The amount of forage dry matter intake (FDMI) was measured. The highest infusion of postruminal casein (600 g) and ruminal infusions (300 g) allowed for similar forage intake demonstrating the fact that intake of low-quality forage seen with postruminal casein was 62% as efficient at increasing FDMI as R. In addition, postruminal infusions of casein did not significantly increase FDMI over the CON until P3 (1.17, 1.21, 1.29, 1.41 for CON, P1, P2, P3, respectively). This data concludes the potential use of an undegradable intake protein (UIP) source as a degradable protein source (DIP) when rumen nitrogen is limiting.

Key words: Beef Cattle, Recycling, Urea, Abomasal Infusion

Introduction

Ruminal nitrogen availability has a significant impact on low-quality forage intake in ruminants. Supplementation of protein directly to the source (rumen) of deficiency has produced favorable results (Basurto et al., 2003; Bandyk et al., 2001; Mathis et al., 1999; Köster et al., 1996;) and is usually the most efficient way to correct a ruminal deficiency. Since ruminants have the ability to utilize endogenous urea via saliva or diffusion into the rumen this could be a potential site of manipulation of diets to increase the efficiency of nitrogen use. Following the hydrolysis of urea in the rumen, a greater amount of ammonia would be available to ruminal microbes leading to a subsequent increase in digestibility and passage rates from the rumen. The efficiency of nitrogen use will theoretically decline with recycling due to the energetic cost, but the amount of nitrogen retained as a fraction of nitrogen intake should increase on ruminal nitrogen deficient diets. Therefore, an experiment was conducted to: 1) increase postruminal casein infusion levels to realize a level of protein that would optimize low-quality forage intake, and 2) determine the efficiency of nitrogen recycling and evaluate the effects on low-quality forage intake.

Materials and Methods

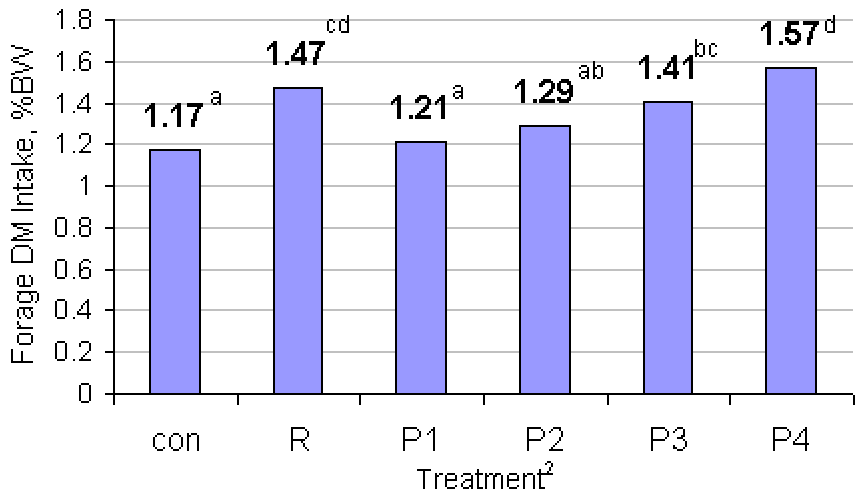
Experimental Procedure. Twelve ruminally cannulated steers (average initial BW = 614 kg ± 83) were fitted with a non-surgical abomasal infusion apparatus, which was anchored in the abomasum. All steers were allowed ad libitum access to low-quality forage (LQF). Treatments were: 1) infusion of water only (CON), 2) 300 g of casein (Calcium Caseinate, New Zealand Milk Products, Santa Rosa, CA) infused into the rumen (R), 3) 150 g of casein infused postruminally (P1), 4) 300 g of casein infused postruminally (P2), 5) 450 g of casein infused postruminally (P3), or 6) 600 g of casein infused postruminally (P4). Levels of ruminal and postruminal casein infusions were determined by evaluating previous research (Basurto et al., 2003; Bandyk et al., 2001; Cochran et al., 1998; Köster et al., 1996; NRC, 1996). Cochran et al (1998) and Köster et al (1996) used breakpoint analysis to determine the amount of rumen degradable protein that optimized forage intake. Based on their conclusions along with Basurto et al. (2003) and Bandyk et al. (2001), we used a value of 4.5 g DIP/kg $BW^{.75}$ to establish the rumen infusion level. Postruminal casein infusions were bracketed below and above this level to determine a level of casein postruminally that would optimize forage intake. Experimental periods lasted 21 d with infusions lasting 14 d, followed by 7 d of no infusions with the expectation of calculating the rate of increasing FDMI and a subsequent rate of decreasing FDMI. Casein solutions were mixed every morning in 6 L of warm water. The infusion treatments were dosed twice daily at 0700 and 1600 in equal volumes of 2.5 L using a hand pump. The CON steers were infused with equal volumes of water postruminal, while R steers did not receive any postruminally infusion of water. Intakes were recorded each morning at 0800 and orts were sampled and oven-dried (60°C) to determine dry matter intakes.

Statistical Analysis. Steers were arranged in a 6 x 6 Latin square design with three periods instead of six. This allowed for the same number of observations in only three periods. The MIXED procedure of SAS (SAS Inst. Inc., Cary, NC) was used to evaluate treatment means of the intake data. Classes were period, steer, diet, and square. Square and steer (square) were included as random variables. Least squares means of the diet were separated using least significant differences. PROC REG was used to determine the slope of the postruminal infusion treatments by regressing forage dry matter intake (FDMI) as a percent of body weight (BW) on level of infused casein. Slopes and intercepts of all treatments were analyzed with the GLM procedure of SAS. The model included intake, diet, and day (diet). Non-orthogonal contrast statements were used to make all significant comparisons among the slopes.

Results and Discussion

As level of postruminally infused casein increased, FDMI increased (P<.05; Figure 1). This is probably due to the ability of ruminants to recycle nitrogen during times of ruminal nitrogen deficiencies that are often found in cattle consuming low-quality forages. The lowest level of postruminal infusion (P1) was not different (P<.05) from control, which suggests that nitrogen was possibly used initially by the gastrointestinal tract with small amounts available for recycling. These results agree with those of Bandyk et al. (2001) who suggested this as a reason for the lag time associated with nitrogen transport back to the rumen. Consequently, increasing nitrogen above the point at which it is no longer needed for gut tissue maintenance allows for higher levels of plasma urea that is ultimately recycled back to the rumen or excreted in urine.

Figure 1. Effect of postruminal infusion on low-quality forage intake[1]



[1]n = 12
[2]CON, infusion of water only; R, 300 g of casein infused into the rumen; P1, 150 g of casein infused postruminally; P2, 300 g of casein infused postruminally; P3, 450 g of casein infused postruminally; P4, 600 g of casein infused postruminally.
[a-d]Means with uncommon letters are significantly different (P<.05, except for P3 vs P4 comparison = P<.10).

The rate at which FDMI increased from d 0-7 of infusions is shown in Table 1 and Figure 2. The R infusion had a greater (*P*<.10) rate of FDMI between d 0-7 compared with P1, P2, and P3. The slopes were not different, however, for R and P4, suggesting that a postruminal supply of protein can increase the rate (Figure 2) and amount (Figure 1) of FDMI. Table 1 also illustrates that P4 significantly (*P*<.10) increases FDMI at a faster rate compared with lower levels of postruminal casein infusion. Statistical analysis concluded that intercepts were different (data not shown). The authors cannot explain why this happened. Due to the adaptation period and by expressing intake as a percent of body weight, these cattle should have had equal intercepts.

Table 1. Slopes of the relationship between forage intake and day 0-7 of casein infusion[3]

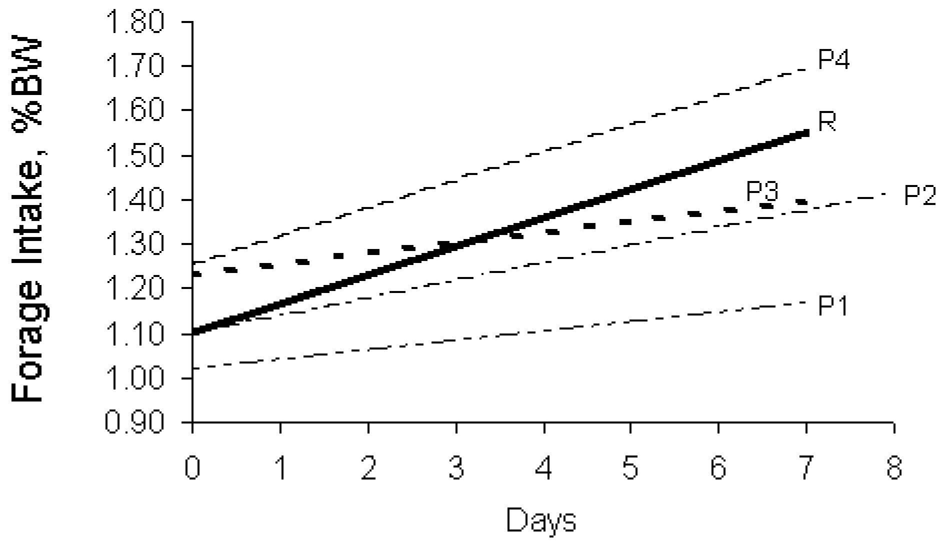
	Treatments[1]					Contrast						
Item	R	P1	P2	P3	P4	SEM[2]	R vs P1	R vs P2	R vs P3	P1 vs P4	P2 vs P4	P3 vs P4
Slope	.0648	.0210	.0386	.0233	.0633	.0101	.0040	.0739	.0061	.0052	.0903	.0079

[1]R, 300 g of casein infused into the rumen; P1, 150 g of casein infused postruminally; P2, 300 g of casein infused postruminally; P3, 450 g of casein infused postruminally; P4, 600 g of casein infused postruminally.

[2]Standard error of the mean (n = 6).

[3]Non-significant contrasts are not shown.

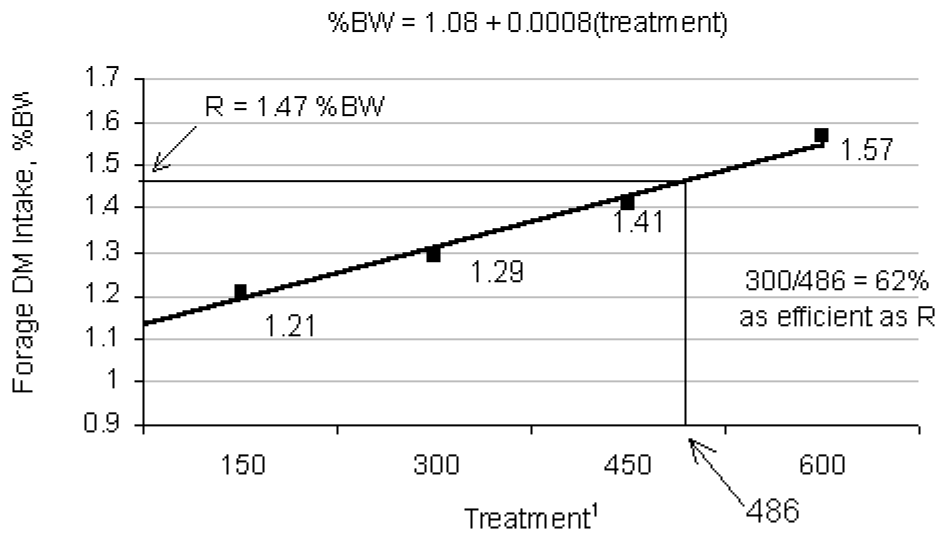
Figure 2. Relationship between forage intake and days 1-7 of casein infusion[1]



[1]R, 300 g of casein infused into the rumen; P1, 150 g of casein infused postruminally; P2, 300 g of casein infused postruminally; P3, 450 g of casein infused postruminally; P4, 600 g of casein infused postruminally.

The means of postruminal infusion FDMI from Figure 1 were regressed on level of postruminal casein infusion to determine a prediction equation (Figure 3). As level of casein increased during the experiment, FDMI increased linearly ($y = 1.08 + 0.0008x$, $r^2 = .95$; Figure 3). This equation allows us to calculate an efficiency of use of postruminal protein if the rumen is severely nitrogen deficient. For example, if R = 1.47% BW, it will take 486 g of postruminal casein to equal the FDMI of 300 g of R, if the rumen is severely nitrogen deficient. Therefore, in the present study, postruminal casein was 62% as efficient at increasing FDMI as R (300 g / 486 g = 62%).

Figure 3. Relationship between forage intake (%BW) and casein infusion from day 7-14



[1]150 g of casein infused postruminally (P1); 300 g of casein infused postruminally (P2); 450 g of casein infused postruminally (P3); 600 g of casein infused postruminally (P4).

Implications

When the rumen is deficient in nitrogen, however, protein supplied postruminally relative to amounts in this study can increase forage intake. Postruminal supply of protein will increase FDMI possibly through recycling. However, this mechanism is 38% less efficient than if the deficiency was corrected with ruminally degraded protein.

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