Nitrogen Retention of Steers Consuming Hays of different Nutritive Value and the Effect of Supplemental Nitrogen on Nitrogen Retention of Animals fed Prairie Hay

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Story in Brief

Trial 1, Six mature multi-cannulated Angus steers were fed *ad libitum* one of three hays, prairie hay, bermuda or alfalfa, in a replicated 3 x 3 Latin square design to evaluate the effect of nutritive value on nitrogen retention (NR). Trial 2, to determine the effect of DIP or UIP on NR cattle consuming low quality forage, eight mature crossed steers in a replicated 4 x 4 d Latin square design were infused continuous with: 1) Control (CON): water (3.6 L) into abomasum; 2) UIP: casein (400 g) dissolved in water into the rumen; 3) UIP: casein (400 g) dissolved in water into abomasum and 4) UDIP: urea dissolved in water (123 g) into rumen. In the trial 1, absorbed N and retained N increased consistently with nitrogen intake, being ALF > BER > PRA. However, PRA had negative N retention (-7.9 N g d^{-1}). Fecal N was similar between BER and ALF, but higher compared to PRA. In contrast, urinary N and urea N were similar between BER and PRA, but lower than ALF. In trial 2, N infusions increased absorbed N (AN), fecal N (FN), urinary N (UN), total N excretion (TNE) and retained N (NR) compared to CON, except urinary urea N (UUN). However, AN, TNE and NR were similar among N infusions. Differences in excretion routes among N infusions were detected. UUE was greater for UIP and UDIP compared to CON, but CON and DIP were equal. Considering retention and excretion of N, Bermuda seems be better forage compared to alfalfa and prairie hay. Independent of infusion site or N source, N supplementation improves N retention of cattle consuming prairie hay.

Key Words: Forage, Nutritive value, Nitrogen, Supplementation, Ruminant

Introduction

Although, animal performance, voluntary intake and digestion are typically improved with protein supplementation, fecal nitrogen and urinary nitrogen excretions become greater, increasing N excretion into environment. The increment in urinary N excretion is positively related to blood urea nitrogen concentration. Lapierre and Lobley (2001) suggested that a first strategy to increase the efficiency of N utilization would be to reduce the amount of feed N converted to urea. A strategy to do this could be by the use of protein sources of low ruminal degradability (Bohrent et al. 1999). It has been suggested that when nitrogen is released slowly, the nitrogen utilization could be improved (Owens et al, 1980). The objectives of this study were to compare NR and nitrogen excretion of steers consuming forage of different nutritive value and to determine the effect of continuous infusion of DIP or UIP on NR of steers consuming low quality forage.

Materials and Methods

Trial 1. To compare three forages of different nutritive value on retention and excretion of nitrogen, six mature steers (491 kg) with cannulae in rumen and duodenum were fed prairie hay

(4.8 % CP), Bermuda hay (BER, 11.4% CP) and Alfalfa hay (ALF, 19% CP) in a replicated 3 x 3 Latin square design (Steel et al., 1997). Animals were individually housed in 3 x 4 m pens in an environment-controlled room. Each experimental period consisted of an adaptation phase (11 d) and a sample collection phase (4 d).

Data for nutritional composition and digestibility of forages used in this study have been published previously (Basurto et al, 2001). Forages were coarsely chopped through a 3-cm screen. Forage was weighed and offered *ad libitum* daily at 0800. Criterion for *ad libitum* was that refusal weight was not less than 5 lb. In sampling phase, orts were weighed y sampled; the remaining was withdrawn of feeders. From day 12 to 15, forage intake (FI) was recorded. Daily samples of feed offered and previous day's refusals were dried at 55 C for 96 h in an air-forced oven. At the end of each period, a composite sample was made per animal. Total fecal output of day 12 to 15 was weighed, sampled (approx. 500 g), and dried daily. At the end of each period, samples were individually ground and, then, composited by weight within steer-period. From day 12 to 15, jugs with capacity of 20 L containing enough 6 N HCl (200 to 600 ml per jug) to keep urinary pH below 3 were used to collect the total urinary output. Total urine volume was weighed and sampled. Urinary density was measured by weighing 1000 ml of urine. Data were analyzed using a model that included square, pen nested in square, period nested in square, and treatment effects with the GLM procedure of SAS. When the F-test was significant, means comparison were carried out with a Bonferroni test, considering significant level at $P<.05$.

Trial 2. Trial 2 is described in greater detail in the accompanying report (Basurto et al, 2003). Briefly, eight cannulated mature crossed steers consuming prairie hay in replicated 4 x 4 Latin square design (Steel et al., 1997) were continuously infused with: 1) Control (CON) water into abomasum; 2) UIP: Casein (400 g d^{-1}) into abomasum; 3) DIP Casein (400 g d^{-1}) into rumen; 4) UDIP: urea (123 g d^{-1}) into rumen. Nitrogen infusions were iso-nitrogenous and equaled, 55 g N d^{-1}. Fecal and urine collections were similar to those described for trial 1. The statistical model included square, period and animal.

Results and Discussion

Trial 1. As expected, the highest ($P<.05$) intake of nitrogen was of steers fed ALF and the lowest of steers fed PRA. Nitrogen intake of BER fed steers was intermediate (Table 1). Absorbed nitrogen followed the same tendency. It is known that nitrogen digestibility increases as nitrogen intake increases. However, it is expected that the greater nitrogen digestibility, the greater ruminal absorption.

It is known that alfalfa protein is extensively degraded in the rumen. Basurto, et al (2001) previously reported that in vivo DIP contents of ALF, BER and PRA were 86.7, 74, and, 67.4 % of the total CP. Fecal nitrogen consists of endogenous nitrogen secretions, microbial debris and indigestible dietary nitrogen. Although fecal nitrogen increased with the increase in nitrogen intake, it is possible that fecal nitrogen composition could be different among forages in the study. For instance, the proportion of endogenuous nitrogen could be higher in PRA than the others forages. Animals fed ALF excreted more urinary N and urea N than animals fed BER or PRA. Taking the difference in nitrogen intake, the increase in urinary N output from PRA to BER was smaller than from BER to ALF. Van Soest (1994) reported that there is a threshold (plasma urea 5 meq / L), from which urinary excretion rate is increased linearly. As nitrogen intake increased, more urea N was excreted. Animals consuming ALF and BER had positive NR, contrasting to the negative NR of PRA.

Table 1. Nitrogen retention (g / day) of steers fed hays of different nutritive value - Trial 1				
	Treatments [1]			
Item	ALF	BER	PRA	EEM
N intake	438.9[a]	203.0[b]	57.8[c]	10.7
Fecal N	125.9[a]	95.5[a]	45.5[b]	10.9
Absorbed N	313.0[a]	107.5[b]	13.3[c]	6.7
Urinary N	117.9[a]	34.8[b]	20.2[b]	8.2
Urinary urea N	63.1[a]	10.5[b]	1.9[b]	9.0
Retained N	195.0[a]	72.7[b]	-7.88[c]	12.7

[1] ALF: Alfalfa hay; BER: Bermuda hay; PRA: Prairie hay

[2] Standard Error of the Mean

[a, b, c] Means within row with uncommon superscripts differ ($P<.05$)

Trial 2. Nitrogen infused was included in nitrogen intake, so animals receiving casein or urea had higher nitrogen intake compared to CON (Table 2). However, N infusions increased intake of prairie hay (Basurto et al, 2003). It was detected that UDIP ingested more nitrogen ($P<.05$) from forage than animals in UIP, but similar than DIP. Except urinary urea nitrogen (UUE), Fecal N (FN), absorbed N (AN), urinary N (UN) and retained nitrogen (NR) were greater for N-supplemented treatments, compared to CON. However, no differences were detected in AN, UN and RN among UIP, DIP and UDIP. Although TNE was similar for N-supplemented animals, excretion routes varied depending on infusion site and nitrogen sources. Ruminal infusions increased FN compared to UIP. In contrast, DIP treatment excreted less nitrogen than UDIP tratement, but FN did not differ due to DIP and UIP treatments. These differences can be due to forage intake and/or nitrogen of microbial origin. It is interesting that DIP and CON did not differ ($P<.05$) in UUE; however animals supplemented DIP excreted similar ($P>.05$) amounts of FN than animals fed UIP or UDIP. It was expected that animales receiving UIP excrete less N, because a lower or slower urea production could take place. However, the lower forage intake could limite energy intake, decreasing nitrogen retention. In an accompanying report (Basurto et al., 2003), digestible organic matter intake was higher for DIP and UDIP treatments. In spite of differences in excretion routes, animals with supplemental nitrogen had similar NR. However, this study shows that it is possible to manipulate routes of nitrogen excretion without affecting NR of mature animals. In the current experimental conditions, urea was an adequate DIP source to improve NR of animals consuming low quality forages.

Table 2. The effect of continuous infusion of DIP or UIP on digestion, excretion and retention of nitrogen (g day) of steers fed prairie hay - Trial 2					
	TREATMENTS [1]				
Item	CON	UIP	DIP	UDIP	$\sqrt{MSE}$ [2]
N intake [3]	60[a]	126[b]	136[b,c]	140[c]	7.3
Fecal N	42[a]	56[b]	67[c]	64[c]	5.9
Absorbed N	15[a]	70[b]	70[b]	76[b]	4.1

Urinary N	19[a]	44[b,c]	36[b]	52[c]	7.7
Urinary urea N	1.6[a]	10.9[b]	7.9[a,b]	13.5[b]	4.3
Total N excretion	62[a]	100[b]	102[b]	116[b]	10.4
Retained N	-5[a]	25 [b]	33[b]	24[b]	8.8

[1] CON: *ad libitum* prairie hay; UIP: CON + continuous infusion of casein (400 g) into abomasum; DIP: CON + continuous infusion of casein (400 g) into rumen and UDIP: CON + continuous infusion of urea (123 g) into rumen

[2] √Mean Square Error

[3] Nitrogen infused (55 g N d^{-1}) from casein or urea is included in nitrogen intake

[a, b, c] Means within row with uncommon superscripts differ ($P<.05$)

Implications

Although three forages in first trial differed in their nutritional quality, nitrogen retention and excretion routes changed as forage nitrogen intake increased. Nitrogen supplementation is important to improve nitrogen balance of animals fed low quality forage. In addition, nitrogen excretion can be manipulated by the use of UIP or DIP sources without affecting nitrogen balance. The utilization of urea can be improved by slow infusion or release into rumen.

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