Urea Recycling in Beef Cattle Fed Prairie Hay-Based Diets[1]

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Introduction

Maximizing utilization of native rangeland is an important aspect of the cow/calf phase of beef production. Native rangeland is often of poor quality (less than 7% crude protein). Protein content of the rangeland is important because nitrogen is a key growth factor used by ruminal microbes. Without adequate nitrogen, the ruminal ecosystem will not operate at peak efficiency, which subsequently reduces the supply of nutrients to the animal.

Historically, producers have provided supplemental nutrients to their cattle to achieve maximum performance. Both supplemental protein and energy have been provided to cattle consuming low-quality forage with varying levels of success. Typically, supplemental energy without adequate protein reduces fiber digestion by cattle. On the other hand, supplemental protein consistently improves overall performance.

Previous research has established that cattle conserve nitrogen in the body through urea recycling. This process allows cattle to preserve nitrogen when forage quality is not adequate. Research quantifying urea recycling and how it is affected by supplemental protein and energy in cattle fed low-quality forage is sparse.

Objectives of this experiment were to determine the impacts of supplemental protein and energy on forage intake, digestion, and urea kinetics in growing beef cattle.

Experimental Procedures

Six Angus-cross steers (initial body weight 470 lb) were used in a metabolism trial to measure the effects of supplemental energy and protein on intake, digestion, and urea kinetics. The steers were ruminally and duodenally cannulated. The trial was conducted as a 6 × 6 Latin square with treatments in a 3 × 2 factorial arrangement. The energy treatments were: (1) no supplemental energy, (2) 600 g of glucose dosed ruminally once daily, and (3) 480 g of volatile fatty acids (40% acetate, 30% propionate, and 30% butyrate) infused over 8 hours daily. Casein (120 or 240 g) was dosed once daily as the degradable intake protein supplement. The steers were given ad libitum access to low-quality prairie hay (5.8% crude protein).

Each period was 14 days long. The first 9 days were used for adaptation to treatments. During the next 4 days, total fecal and urine collections were used to assess digestion and urea kinetics. Ruminal and duodenal collections occurred over the final day of each period. Labeled urea was infused intravenously from day 10 through 14 of each period to provide a means of measuring urea kinetics.

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Results and Discussion

Forage intake, digestion, and urea kinetics are shown in Table 1. The volatile fatty acid infusion decreased (P<0.01) forage intake by 27%. Decreases in forage intake due to glucose (7%) and increases due to increasing casein (4.5%) were not significant.

Glucose decreased total tract neutral detergent fiber digestibility (P<0.01), and the depression in response to supplemental glucose tended to be greater at the low level of casein. Providing supplemental energy to cattle without sufficient protein can have detrimental effects on forage digestion. Ruminal microbes that ferment glucose compete for nutrients with microbes that digest fiber. When a large amount of a readily useable substrate (glucose) is provided, glucose-digesting microbes grow quickly and consume large amounts of ruminally available nitrogen. Thus, energy supplementation can exacerbate protein deficiencies, limit productivity of fiber-digesting microbes, and depress fiber digestion. Producers should be conscious of the protein content of the diet before providing supplemental energy to avoid depressing forage digestion.

Neither supplemental energy nor increased casein significantly affected the amount of urea produced in the body or recycled to the gut. However, gut entry (recycling) of urea as a percentage of total urea production was decreased by casein (P=0.01) and increased by provision of glucose (P=0.05). Supplemental volatile fatty acids had no effect on the proportion of total urea production that was recycled to the gut. We observed differences between glucose and volatile fatty acid treatments because there were fundamental differences between the treatments. Glucose was provided as an energy source for ruminal microbes, whereas volatile fatty acids were provided as an energy source for the animal only. Ruminal microbes produce volatile fatty acids as end products of their metabolism; thus, they have no use for the supplemented volatile fatty acids. Increased urea recycling with supplemental energy is a function of increased microbial activity in the rumen and the subsequent increased demand for nitrogen. Nitrogen is a critical growth factor for ruminal microbes. Providing additional casein ameliorates the deficiency, explaining the lower proportion of urea production that was recycled to the rumen at the 240 g/day casein level.

Duodenal flows of nitrogen represent the amount of protein (amino acids) that is available to the animal and represent the sum of microbial protein synthesis in the rumen and dietary protein that is not degraded (bypass protein). Increasing casein tended to increase duodenal nitrogen flow (P=0.15), but there was not an energy effect. Microbial nitrogen was increased by increasing casein (P=0.04), demonstrating that the low level of supplementation (120 g/day of casein) did not meet the microbial requirement. As part of our urea kinetics measurements, we quantified the amount of recycled urea that was incorporated into microbial nitrogen. Providing additional casein tended to decrease microbial capture (P=0.08), particularly when glucose was supplemented. Glucose significantly increased the amount of microbial capture of recycled urea (P=0.01), mostly at the lower level of casein supplementation, because of an increased need for nitrogen in the rumen facilitated by increased activity of glucose-digesting bacteria.

Implications

Cattle have the ability to recycle nitrogen to the rumen and to use this mechanism as a means of meeting ruminal nitrogen requirements. Providing supplemental energy to cattle consuming low-quality forage can be detrimental to forage digestion when protein is deficient. Increasing protein ameliorated the negative impact of supplemental glucose on forage digestion. Thus, producers may be able to provide supplemental energy to their cattle if they are mindful of the protein content in the total diet.

Table 1. Effects of degradable intake protein (DIP) and energy [glucose (GLC) or volatile fatty acid (VFA)] supplementation on intake, digestion, urea kinetics, and microbial flow in growing steers fed low-quality forage

	120 g/d DIP			240 g/d DIP				P-value		
Item	Control	GLC	VFA	Control	GLC	VFA	SEM	DIP	Energy	DIP × Energy
Organic matter intake, lb/day										
Forage	8.2	8.2	6.6	9.3	8.1	6.4	0.9	0.42	0.01	0.27
Total	8.4	9.7	7.7	9.9	9.7	7.9	0.9	0.19	0.01	0.27
Total tract digestibility, %										
Organic matter	56.0	55.1	62.6	55.7	60.2	59.4	2.1	0.75	0.04	0.09
Neutral detergent fiber	54.0	44.1	53.2	52.9	49.5	50.2	2.5	0.81	0.01	0.12
Urea kinetics, g/day of nitrogen										
Production	39	68	61	55	45	63	12	0.89	0.39	0.15
Gut entry (Recycled)	32	65	54	43	37	48	12	0.38	0.32	0.16
% of total production	83	93	86	77	82	76	4	0.01	0.05	0.65
Duodenal flow, g/day of nitrogen										
Total nitrogen	56	59	51	72	67	59	10	0.15	0.55	0.85
Microbial nitrogen	37	38	33	54	45	41	7	0.04	0.39	0.68
Microbial nitrogen from recycled urea	7.7	15.4	7.7	8.7	8.2	6.6	1.9	0.08	0.02	0.03
% of total microbial nitrogen	20.7	40.5	24.1	16.2	18.1	16.1	3.8	0.01	0.01	0.01