SUPPLEMENTATION WITH UNDEGRADABLE INTAKE PROTEIN INCREASES UTILIZATION OF LOW-QUALITY FORAGE AND MICROBIAL USE OF RECYCLED UREA

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Introduction

Low-quality forage utilization (intake and digestion) is improved by protein supplementation. Typically, the recommendation is to select supplements that are high in degradable intake protein because this fraction of the protein directly addresses the ruminal nitrogen deficiency that exists when low-quality forages are fed. However, the low cost of by-products (e.g., distiller's grains) that are high in undegradable intake protein makes them an attractive source of supplemental protein even though the response per unit of supplemental protein is less for undegradable protein than for degradable protein. One of the primary barriers to utilizing highly undegradable protein sources as supplements is the lack of information regarding their ability to provide nitrogen to ruminal microbes and, ultimately, their effectiveness as protein supplements to cattle fed low-quality forage. Because the protein is not ruminally degraded, the use of undegradable protein supplements to meet ruminal nitrogen requirements depends on the ability to recycle nitrogen to the rumen in the form of urea. Subsequently, the urea is utilized as a nitrogen source by ruminal microbes.

Our objective was to measure how much nitrogen is recycled as urea and how much recycled nitrogen is used to meet microbial growth requirements when increasing amounts of undegradable intake protein were provided to steers consuming prairie hay. This data will be useful in developing supplementation strategies for cattle consuming low-quality forage.

Experimental Procedures

Four duodenally and ruminally fistulated Angus × Hereford steers (average initial body weight 694 pounds) were used to evaluate the effect of increasing amounts of supplemental undegradable intake protein on forage utilization and recycled urea use by ruminal microbes in cattle consuming low-quality forage. All steers were given *ad libitum* access to prairie hay (4.7% crude protein and 73% NDF). Four levels of supplement were provided (0, 0.27, 0.54, and 0.81 pounds per day) as casein, a source of pure protein that is highly digestible. The casein was continuously infused into the abomasum, so the protein physically bypassed the rumen and was made directly available for absorption by the animal. By using casein, researchers were able to determine the effects of only supplemental undegradable intake protein on forage utilization and urea recycling. On a protein equivalent basis, treatments provided the same amount of protein as 0, 0.51, 1.02, and 1.53 pounds of soybean meal per day.

Calculations of intake, digestion, and nitrogen balance were made using observations of hay intake and total collections of feces and urine. Duodenal samples were used to determine microbial flow from the rumen and ruminal digestion. Additionally, labeled urea was infused intravenously, allowing meas-

urement of urea metabolism by the animal and the contribution of urea recycling to meeting microbial nitrogen requirements in the rumen.

Results and Discussion

Provision of supplemental undegradable intake protein increased forage intake and intake of total digestible organic matter (Table 1). This is in accordance with previous observations in which supplemental undegradable intake protein increased forage utilization. The magnitude of the increase in response to undegradable intake protein was less than if the same amount of protein had been provided as degradable intake protein. This supports the observations that the primary barrier to low-quality forage utilization is a ruminal nitrogen deficiency and that degradable intake protein is more effective than undegradable protein at increasing utilization of low-quality forages. There were no increases in digestibility of either organic matter or neutral detergent fiber with supplemental undegradable intake protein.

Urea production increased with increasing undegradable intake protein, as did the amount of urea entering the gut (recycled). Urea production increased because the cattle did not require all of the absorbed protein for growth, so excess protein was catabolized by the animal and converted to urea. More than 89% of the urea that was produced was recycled to the gut, so increases in urea production were linked to increases in recycling.

Urea produced by cattle can be excreted in the urine (and lost) or it can be recycled to the gut. The urea that enters the rumen can be utilized by ruminal microbes to meet some of their nitrogen requirement for growth. Because of urea recycling, a portion of the nitrogen contained in undegradable protein is ultimately available to ruminal microbes. In other words, the urea recycling mechanism allows the animal to conserve and utilize nitrogen from protein that is not directly available in the rumen. Microbial protein production, measured as microbial nitrogen flow, increased with supplementation of undegradable intake protein. Correspondingly, the amount of microbial nitrogen coming from recycled urea increased with increasing amounts of undegradable intake protein, indicating a dependence on urea recycling when a supplement high in undegradable intake protein was fed. The contribution of recycled urea nitrogen to microbial protein as a percent of total microbial flow increased from 31% for 0 to 58% for 0.54 pounds of undegradable intake protein, underscoring the fact that a portion of the response to supplemental undegradable intake protein can be attributed to nitrogen recycling.

Implications

Undegradable intake protein can make substantial contributions to meeting ruminal nitrogen demands in cattle consuming low-quality forage. Supplements high in undegradable intake protein are viable alternatives to highly degradable protein supplements.

Table 1. Effects of Undegradable Intake Protein Supplementation on Intake, Digestion, Urea Metabolism and Microbial Flow in Steers Fed Low-quality Forage

	Undegradable Intake Protein, pounds/day			
Item	0	0.27	0.54	0.81
Organic matter intake, pounds/day				
Forage[b]	13.4	15.2	17.4	16.1
Total[b]	13.4	15.4	17.9	17.0
Digestible[a]	8.1	9.0	10.6	10.1
Total tract digestibility, %				
Organic matter	60.4	58.7	58.1	59.5
Neutral detergent fiber	59.0	55.9	54.3	56.7
Urea kinetics, g nitrogen/d				
Production[a]	27.1	49.9	82.2	85.8
Gut entry (recycled)[a]	26.3	48.7	77.2	76.6
Duodenal flows, g nitrogen/d				
Total [a]	80.8	113.8	161.2	161.1
Microbial nitrogen [a]	45.7	65.3	81.2	75.7
Undegradable intake protein[a]	35.1	48.5	79.1	85.5
Recycled urea nitrogen in microbes				
Nitrogen, g/d[b]	13.9	28.3	47.7	33.9
% of total microbial nitrogen[b]	31.4	42.5	58.0	44.2
% of urea production	52.6	57.0	57.5	41.0

[a]Linear effect of degradable intake protein ($P \leq 0.05$).
[b]Quadratic effect of degradable intake protein ($P \leq 0.05$).