

Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 1 *Cattleman's Day (1993-2014)*

Article 158

2007

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T.A. Wickersham

R.C. Cochran

E.E. Wickersham

See next page for additional authors

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Recommended Citation

Wickersham, T.A.; Cochran, R.C.; Wickersham, E.E.; Gnad, D.P.; and Titgemeyer, Evan C. (2007) "Supplementation with degradable intake protein increases low-quality forage utilization and microbial use of recycled urea," *Kansas Agricultural Experiment Station Research Reports*: Vol. 0: Iss. 1. <https://doi.org/10.4148/2378-5977.1561>

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Supplementation with degradable intake protein increases low-quality forage utilization and microbial use of recycled urea

Authors

T.A. Wickersham, R.C. Cochran, E.E. Wickersham, D.P. Gnad, and Evan C. Titgemeyer

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

T. A. Wickersham, E. C. Titgemeyer, R. C. Cochran, E. E. Wickersham, and D. P. Gnad

Introduction

A common production practice throughout the United States is to supplement protein to cattle consuming low-quality forage (forage with a crude protein content of less than 7%) in order to improve animal performance (i.e., maintain body condition score and body weight) during the winter. Protein supplementation increases forage utilization (intake and digestion) and cow performance by supplying ruminal microbes with protein that is essential for microbial growth. Increased microbial activity in turn provides sources of both protein and energy to the cow. In addition to the protein that is fed and degraded in the rumen, ruminants have the ability to recycle urea—the same compound found in fertilizer and cattle feed—to the rumen, where microbes can use the urea to fulfill a portion of their nitrogen requirement. Although nutritionists know that recycling occurs, we have inadequate data to describe this process and, subsequently, the contribution from recycled urea is not adequately included in our present cattle feeding systems. Previous research at Kansas State University has clearly demonstrated that the greatest response to supplemental protein occurs when the supplemental protein is highly degraded within the rumen, as the degradable fraction of protein is directly available to ruminal microbes. The current project's objective was to measure how much recycled urea is used to meet the microbial nitrogen requirement when increasing amounts of degradable intake protein were provided to steers consuming low-quality forage. Researchers hoped to generate data useful in re-

fining supplementation recommendations for cattle consuming low-quality forage.

Experimental Procedures

Five duodenally and ruminally fistulated Angus × Hereford steers (average initial body weight 613 pounds) were used to evaluate the effect of increasing amounts of supplemental degradable 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 (4.9% crude protein and 72.3% NDF). Four levels of supplement were provided (0, 0.22, 0.44, 0.66 pounds per day) as casein, a source of pure protein that is highly degradable in the rumen. By using casein, researchers were able to study just the effects of supplemental degradable intake protein. The casein was placed directly into the rumen at the beginning of each day. On a protein equivalent basis, treatments provided the same amount of protein as 0, 0.42, 0.84, and 1.26 pounds of soybean meal per day. Previous research at Kansas State University had demonstrated that the highest level of supplementation was close to the degradable intake protein requirement for maximum forage utilization.

Calculations of intake, digestion, and nitrogen balance were made using observations of hay intake and total collection of feces and urine. Duodenal samples were used to determine microbial growth in the rumen. Additionally, we infused labeled urea intravenously, allowing measurement 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, degradable intake protein increased forage intake and intake of total digestible organic matter (Table 1). This is in accordance with previous observations in which supplemental degradable intake protein increased forage utilization. It has been clearly demonstrated that the most efficient supplements for increasing intake and digestion of low-quality forage are supplements that are high in degradable intake protein, because this fraction of the protein directly addresses the ruminal nitrogen deficiency that occurs when low-quality forages are fed. In this study there were modest increases in digestibilities of organic matter and neutral detergent fiber with increasing degradable intake protein supplementation.

Urea production increased with increasing degradable intake protein, as did the amount of urea entering the gut. Urea production increased as degradable intake protein was supplemented because the metabolism of the nitrogen contained in the supplemental protein resulted in the formation of urea by the animal. Gut entry (recycling) of urea also increased with protein supplementation, because

almost all of the urea was recycled by the nitrogen-deficient steers (i.e., recycling was greater than 95% of production). Urea can either be excreted in the urine and lost, or it can be recycled to the gut.

The amount of recycled urea incorporated into microbial nitrogen increased with increasing degradable intake protein; however, the proportion of microbial nitrogen from recycled urea was relatively constant (28%) across the treatments.

These data are valuable because they provide information about how ruminal nitrogen requirements are being met. This is important because recycled urea can be an important contributor of nitrogen to the rumen, and this should be accounted when estimating ruminal nitrogen requirements and, subsequently, the amount of protein to supplement. Recycling of nitrogen provides the cow with a greater supply of protein and energy due to increased microbial activity.

Implications

Degradable intake protein supplementation increased forage intake and digestion. Urea recycling played a significant role in meeting ruminal nitrogen requirements, and it should be considered as a source of nitrogen available to meet the needs of rumen microbes.

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

Item	Degradable Intake Protein, pounds/day			
	0	0.37	0.74	1.11
Organic matter intake, pounds/day				
Forage ^a	9.9	12.0	13.6	15.2
Total ^a	9.9	12.2	14.0	15.9
Digestible ^a	4.9	6.3	7.8	9.1
Total tract digestibility, %				
Organic matter ^a	49.8	52.0	55.0	56.9
Neutral detergent fiber ^a	47.0	49.6	52.8	54.3
Urea kinetics, g nitrogen/d				
Production ^a	19.9	24.8	42.9	50.9
Gut entry (recycled) ^a	19.8	24.5	42.4	48.6
Duodenal flows, g nitrogen/d				
Total ^a	67.5	90.9	113.3	153.3
Microbial nitrogen ^a	40.3	61.3	81.4	108.8
Undegradable intake protein ^a	27.2	29.6	31.9	44.5
Recycled urea nitrogen in microbes				
Nitrogen, g/d ^a	12.3	15.6	23.9	28.9
% of total microbial nitrogen	32.3	25.0	30.0	24.8
% of urea production	60.6	63.2	55.2	59.1

^aLinear effect of degradable intake protein (P<0.05).