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Mariela Lamothe
University of Nebraska - Lincoln

Terry J. Klopfenstein
University of Nebraska - Lincoln, tklopfenstein1@unl.edu

Don C. Adams
University of Nebraska - Lincoln, dadams1@unl.edu

Jacqueline A. Musgrave
University of Nebraska - Lincoln, jmusgrave1@unl.edu

Galen E. Erickson
University of Nebraska - Lincoln, gerickson4@unl.edu

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Microbial Protein Production in Gestating Cows Supplemented with Different Sources of Rumen Degradable Protein Grazing Dormant Range

Mariela Lamothe
Terry Klopfenstein
Don Adams
Jacki Musgrave
Galen Erickson[1]

Synthesis of microbial protein increased as amount of digestible organic matter consumed increased, but efficiency of microbial protein synthesis did not change and averaged 8.5% of digestible organic matter intake.

Summary

Twenty-four gestating spring calving cows grazing dormant native range were used to determine the effect of two different sources of DIP supplementation in the winter. Supplementation treatments were: 1) supplement containing urea as a source of non-protein nitrogen, 2) corn gluten feed (CGF) as a source of true protein, and 3) no supplement . Forage intake was greater for cows supplemented with urea compared to no supplement, and forage intake tended be greater for cows supplemented with urea than CGF. Microbial protein (MCP) synthesis estimated from urinary excretion of allantoin was greater for cows receiving urea than CGF or no supplement. However, efficiency of MCP synthesis did not differ among treatments and was approximately 8.5% of digestible organic matter intake.

Introduction

University of Nebraska research showed the first limiting nutrient for beef cows grazing dormant native range during the winter was rumen degradable protein (DIP; *1996 Nebraska Beef Cattle Report,* pp. 14-16). Furthermore, cows can meet their metabolizable protein (MP) requirements through synthesis of microbial protein, if DIP is supplemented. There are different sources of DIP available for supplementation. Urea is the least expensive source of DIP, but it does not provide true protein. In vitro studies indicate microbes respond positively to dietary addition of amino acids suggesting supplementing true protein instead of non-protein N (NPN) would increase microbial protein production. Enhanced animal performance was observed when sources of natural protein instead of urea were supplemented to cows grazing winter range (*1998 Nebraska Beef Cattle Report,* pp. 11-14). In addition, the slower rate of degradation of natural protein compared to urea more closely matches the rate of fiber degradation. Corn gluten feed provides high DIP in the form of amino acids and small peptides. Therefore, we compared effects of supplementing NPN as well as true protein on MCP synthesis and efficiency in cows grazing dormant native range in December.

Procedure

The experiment was conducted at the University of Nebraska's Gudmundsen Sandhills Laboratory near Whitman, Neb., in December, 2000. Twenty-four pregnant cows were randomly assigned to three DIP supplemental treatments. Treatments were: 1) supplement containing urea as a source of non-protein N (UREA), 2) corn gluten feed as a source of true protein (CGF), and 3) no supplement (CONTROL).

Cows grazed in a pasture located on a sands range site which was dominated by little bluestem, prairie sandreed, sand bluestem, and switchgrass. Cows were individually supplemented during three weeks from Nov. 27 to Dec. 14. Cows were offered approximately 3.5 lb DM three times weekly for the first week. Following the first week, cows received approximately 2 lb/day for the rest of the trial. Supplements were formulated to provide the same amount of DIP (180 g/day). Table 1 shows the composition of the supplements.

Table 1. Composition of supplements (% of DM) offered to cows grazing dormant range in December

Item	CGF[a]	Urea[b]
Steep liquor	41.3	—
Corn bran	58.7	55.8
Molases	—	22.8
Starch	—	10.1
Urea	—	6
Dicalcium phosphate	—	5.3

[a]Corn gluten feed.
[b]Supplement containing urea.

Intake was determined from fecal output and feed indigestibility over a five-day collection period (December 11 to 15). Forage intake was estimated as: forage organic matter intake (FOMI) = (total fecal OM output – estimated fecal OM from supplement) / (1 – forage IVOMD). Fecal output was measured using intra-ruminal slow releasing chromium devices. Four steers were used to calibrate Chromium payout from the time-release capsules to total fecal collection. Forage diets were collected with four esophageally fistulated cows, and samples were freeze dried, ground and analyzed for DM, OM, IVOMD, CP and UIP.

Approximately 50 ml of urine were taken daily the last five days of the experiment as a spot sample from each cow. Samples were frozen for further analysis of allantoin and creatinine. Creatinine was used as a marker for estimation of urine output. Urine volumes used to calculate daily excretion of allantoin from spot urine samples were estimated as: BW(lb)* 12.1/creatinine concentration (mg/L), where 12.1 represents the mean daily creatinine excretion rate in mg/lb BW/day. Allantoin concentration was measured colorimetrically by using a spectrophotometer. The ratio of allantoin to creatinine in spot urine samples was used to determine MCP supply. Cows were individually weighed in the second week of the trial. Data were analyzed as a complete randomized design using the MIXED procedure of SAS with supplement as treatment factor.

Results

Chemical composition of native range and the two supplements are shown in Table 2. Supplements did not differ in digestibility or CP content.

Despite numerical differences, there were no overall significant differences in forage organic matter intake expressed either as lb/day or percentage of BW among the three treatments ($P > 0.05$; Table 3). Still, cows receiving the urea supplement tended to consume more, and this tendency was more marked between the urea and control group (24.4 and 17.8 lb/day; 2.3 and 1.6% BW respectively). When comparing total intake (forage + concentrate), it was higher for cows in the urea treatment than the control (26.5 versus 17.8 lb/day; $P < 0.05$), but there was no significant difference between the two supplemented groups. Based on the creatinine analysis, urine output was significantly higher for the urea sup-

(Continued on next page)

Table 2. Chemical composition of forage and supplements offered to cows grazing dormant native range in December.

Item	Range	CGF[a]	Urea[b]
DM, %	—	86.3	86.5
OM, %	85.9	91.2	91.9
IVDMD, %	52.0	88.7	88.8
IVOMD, %	56.3	90.9	90.1
CP, % DM	7.5	25.8	26.7
UIP, % DM	1.6	—	—
DIP, % CP	78.6	—	—

[a]Corn gluten feed.
[b]Supplement containing urea.

Table 3. Intake, urinary parameters and MCP synthesis and efficiency of cows grazing dormant range and receiving different DIP supplemental treatments in December.

Item	Control	CGF	Urea	SE
BW, lb	1,096	1,056	1,076	31
FOMI, lb/day	17.8 [b]	19.4 [bc]	24.4[c]	2.53
FOMI, %BW	1.6 [b]	1.8 [bc]	2.3[c]	0.24
Suppl. OMI, lb/day	0	2.0	2.1	—
Total OM, lb/day	17.8[a]	21.4[ab]	26.5[b]	2.55
Allantoin, mmol/L	28.8[a]	17.7[b]	16.2[b]	2.9
Urine Volume, L	3.9[a]	9.5[ac]	18.7[b]	3.5
Allantoin:Creatinine	0.99[a]	1.12[ac]	1.55[b]	0.11
DOMI, lb/day	10.1[a]	12.8[a]	15.6[b]	2.0
MCP, g/day[d]	405[a]	465[a]	607[b]	66.7
MCP Eff, %	8.9	8.1	8.5	1.5

[a,b]Means with unlike superscripts differ within a row ($P < 0.05$)
[b,c]Means with unlike superscripts differ within a row ($P < 0.1$)
[d]Estimated from allantoin excretion.

plemented cows compared to the control unsupplemented cows (Table 3). Allantoin concentration decreased with supplementation indicating a dilution of the allantoin (and creatinine) by the greater urine volume. The allantoin to creatinine ratio increased with supplementation resulting in more allantoin being excreted, further resulting in prediction of more microbial protein being produced with supplementation.

The greater total intake of the urea treatment compared to the other two treatments was also seen for MCP production ($P = 0.11$; Table 3), with cows fed the urea supplement producing more MCP than those without supplementation ($P < 0.05$) and those supplemented with CGF ($P = 0.14$). However, the higher MCP supply when urea supplement was fed did not reflect better MCP efficiency, given total digestible organic matter intake was also increased by feeding the urea supplement ($P < 0.05$). As a result, MCP efficiency did not differ among treatments and averaged 8.5% of DOMI ($P = 0.96$).

We hypothesized that supplementing DIP would produce a positive response in MCP, and providing amino acids with CGF instead of non-protein nitrogen (urea) would cause a greater response. However, the response to CGF was not greater than supplementation with urea, as a source of DIP. Both supplements provided similar amounts of DIP and phosphorous. Corn gluten feed contains corn bran and steep liquor. The urea supplement contained corn bran, starch and molasses as energy sources. Research conducted (K. Karges, M.S. Thesis, 1990) at the University of Nebraska indicated MCP production in vitro from corn starch and molasses was greater than from steep liquor. The response occurred because more energy was available to the microbes from the corn starch mixture than the steep liquor. In the current experiment, both supplements were formulated to contain similar amounts of corn bran; therefore, the higher energy availability from the corn starch-molasses (urea supplement) than from the steep liquor (CGF supplement) may have enhanced microbial growth and flow of microbial protein to the small intestine.

Forage in this trial supplied approximately 26.4 g of DIP/lb of DM which is higher than expected for dormant range. Forage intake was 20.7 lb of DM for the control group resulting in a DIP supply of 545 g/day. Using the forage intake (20.7 lb DM) and MCP efficiency (8.9%) as inputs in the NRC model, control cows required 471 g DIP/day; therefore DIP was not deficient. If DIP was not deficient, even for the control diet, adding DIP as NPN or protein would give no response because energy was first limiting. If more energy is available to rumen bacteria from corn starch and molasses, the response observed with urea supplement could have been mainly due to the supplemental energy and not to the DIP source in itself. Given our experiment was designed to compare DIP sources, we cannot prove this hypothesis as carbohydrate source and nitrogen source are confounded.

Microbial crude protein synthesis was related to total digestible organic matter intake and MCP efficiencies were similar indicating the amount of energy available for microbes was the important factor. This supports the NRC model that if DIP requirements are met, it is energy supply (TDN) that drives MCP yield. In conclusion, a CP content of 7.5% in the forage was sufficient to meet microbes' requirements for N or amino acids. When DIP is not deficient, supplying energy enhances MCP synthesis; however, the efficiency of use of that energy to synthesize MCP seems to be constant at approximately 8.5% of DOMI.

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[1]Mariela Lamothe, graduate student; Terry Klopfenstein, Professor, Galen Erickson, assistant professor, Animal Science, Lincoln; Don Adams, Professor, J. Musgrave, research technician, West Central Research and Extension Center, North Platte.