NITROGEN SOURCE AND DIGESTION IN RUMEN CULTURES

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Story in Brief

Semi-continuous rumen cultures were fed 55 percent concentrate diets with no supplemental nitrogen (B; 9.2 percent crude protein) or diets supplemented with urea (U; 13.2 percent crude protein), casein (C; 12.1 percent crude protein) or soybean meal (S; 12.4 percent crude protein). Digestion of organic matter, starch and nitrogen did not differ with nitrogen source but acid detergent fiber digestion was increased by addition of all sources of N (29.7 vs 39.9, 41.7 and 44.4 percent for B vs U, C and S treatments, respectively). Microbial efficiency and composition of bacterial cells were not altered by nitrogen source or level.

Key Words: Protein Source, Soybean Meal, Urea, Fiber Digestion.

Introduction

Ruminants can be maintained entirely on nonprotein nitrogen (NPN), but level of production generally is lower with NPN than with protein in the diet. This may be due to ruminal or post-ruminal differences. Supply of microbial protein may be inadequate to satisfy the amino acid requirements of high producing ruminants. In the rumen, ammonia nitrogen permits most species of ruminal microbes to survive though some bacteria require preformed N compounds such as amino acids or peptides for survival or growth. This trial was conducted to investigate the effect of level and source of dietary nitrogen on digestion and microbial efficiency in semi-continuous rumen cultures. It was conducted in tandem with a trial in which similar diets were fed to dairy cows (Goetsch and Owens, 1985).

Materials and Methods

Twelve culture flasks were used in a completely randomized design trial for 14 days. Ruminal fluid, buffer, finely ground substrate (Table 1) and a magnetic stir bar were introduced into 250 ml Erlenmeyer flasks and incubated at 39 C. Twice daily, flasks with a fluid volume of 200 ml were stirred to a homogeneous mix and 37 percent of the volume (75 ml) was removed. Fresh substrate, buffer and water were injected into the cultures to obtain a discontinuous removal rate equal to 3.1 percent/hour. Cultures were gassed with CO_2 at transfer times. Days 1 through 6 were for culture stabilization and samples were taken on days 7 through 14. Effluent material was analyzed for dry matter, ash, N, acid detergent fiber (ADF), starch, total nucleic acid-N (NAN), ammonia-N, NAN and ammonia-N. Bacterial cells were isolated by centrifugation (IBC) and bacteria and protozoa were counted.

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Table 1. Diet compositions.

Ingredient, % of dry matter	Diet B	U	C	S
Corn starch	7.2	6.0	3.4	----
Urea	----	1.2	----	----
Casein	----	----	3.8	----
Soybean meal	----	----	----	7.2
Ground milo	45.3	45.3	45.3	45.3
Ground alfalfa hay	20.0	20.0	20.0	20.0
Dried sorghum silage	25.0	25.0	25.0	25.0
Dicalcium phosphate	1.5	1.5	1.5	1.5
Limestone	.5	.5	.5	.5
Trace mineralized salt	.5	.5	.5	.5

Results and Discussion

Protozoa numbers were not maintained but decreased over time so that levels from day 7 to 14 were lower than found in vivo (Table 2).

Table 2. Numbers of bacteria and protozoa, pH, ammonia-nitrogen concentration and composition of isolated bacterial cells.

Item	Diet B	U	C	S
Bacteria numbers, $X10^{10}_{3}$/ml	6.2	5.5	7.2	6.3
Protozoa numbers, $X10^{3}$/ml	.4	6.9	7.7	1.7
Culture pH	6.7	6.8	6.7	6.7
Isolated bacteria cells				
Nitrogen, % of dry matter	7.1	6.7	6.5	7.0
Nucleic acid-nitrogen, % of nitrogen	20.2	29.7	22.7	20.2
Ash, % of dry matter	13.1	18.4	19.2	16.4

Dilution rates were the same for liquid and solid which may have washed out protozoa. In the rumen, protozoa associate with particles and pass more slowly than liquid. Numbers of protozoa tended to be higher with U and C diets. With the low protein treatment, protozoa were absent and ADF digestion was reduced (Table 3). This may reflect protozoal involvement in physical disruption of fiber though ADF digestion was not reduced with low protozoal numbers with soybean meal as a source of protein. N content of IBC was similar for all treatments (Table 2) but, the NAN:N ratio of IBC for U cultures tended to be slightly greater than for other diets.

Extent of OM digestion tended to be greater for C and S than for B and U diets (Table 3) and was slightly greater than ruminal OM disappearance of similar diets in vivo (Goetsch and Owens, 1985). Starch digestion was similar for all diets and higher than in vivo ruminal

Table 3. Digestion measures for the 8-day collection period.

	Diet			
	B	U	C	S
Organic matter digestion (true), % of input	50.8	50.6	54.2	54.0
Starch digestion, % of input	90.6	90.0	90.2	89.2
Acid detergent fiber digestion, % of input	29.7[a]	39.9[b]	41.7[b]	44.4[b]
Nitrogen disappearance, % of input	49.2	45.7	50.9	51.0
Nitrogen passage, mg				
Input	168.0	239.2	219.9	223.6
Outflow				
Total	215.9	238.5	256.5	249.0
Microbial	55.4	52.1	56.9	60.2
Feed	90.1	137.6	114.2	116.3
Ammonia	70.4	48.8	85.4	72.5
Microbial efficiency, g microbial nitrogen/kg organic matter fermented	10.6	9.9	10.0	10.7

[a,b]Means in a row with different superscripts differ (P<.05).

starch disappearance (Goetsch and Owens, 1985). This difference may be due to finer grinding of the diet for use in vitro or to culture conditions. In vitro, grain settled due to lack of culture agitation. Settled particles are more subject to washout in vivo than in vitro due to their particle size, specific gravity and proximity to the exit point. Extent of ADF digestion and treatment differences observed in vitro were similar to those observed in vivo (Goetsch and Owens, 1985).

Conversion of feed N in vitro to ammonia and to microbial matter was similar for all treatments and was slightly lower than measured in the rumen of cows (Goetsch and Owens, 1985). Extent of digestion of N for the U diet tended to be lower than for C and S diets. Since many bacteria in the rumen which hydrolyze urea are facultative anaerobes, urease activity in this anaerobic culture media may have been low. Microbial efficiency was lower in vitro than in vivo (Goetsch and Owens, 1985), but differences due to source or level of N were negligible in both trials. Similarities between in vitro and in vivo responses to these protein sources and levels indicate that in vitro procedures may be useful to predict animal responses to diet changes providing specific ruminal factors such as passage rate and gut volume are not altered by treatments.

Literature Cited

Goetsch, A.L. and F.N. Owens. 1985. Nitrogen source and digestion in dairy cows. Anim. Sci. Res. Rep. MP-117: .