Rumen Microbial Protein Synthesis from Urea When Fed With a Low Quality Roughage Diet in Automatic Feeders Designed to Simulate Sustained Release of Ammonia

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Story in Brief

Four 275 kg (600 lb.) Angus steers, fitted with permanent rumen and abomasal cannulae, were fed four low quality roughage rations with varying levels of non-protein nitrogen to study the microbial protein production. Dry, tall, winter range grass (crude protein <3.0 percent) constituted 75 percent of the daily ration and was supplemented to 9.0 percent crude protein with soybean meal and urea. Urea supplied 0, 25, 50 or 75 percent of the supplemental nitrogen and ground milo was substituted for soybean meal to keep the energy content as equal as possible. Steers were fed hourly by an automatic feeder system to a daily intake of 5000 gms (11 lbs.)

The microbial protein produced per day was relatively constant regardless of the level of nitrogen supplied by urea. Daily passage of protein nitrogen which escaped rumen degradation was significantly higher ($P<.05$) on the 100 percent soybean meal supplemental diet when compared to the 75 percent urea supplemental diet; therefore, the amount of protein presented to the small intestine to be used by the host animal as a protein source was also significantly higher ($P<.01$) for the 100 percent soybean meal supplemented diet since microbial protein production was constant. However, no significant difference was noted in the amount of protein presented to the small intestine when the 100 percent soybean meal supplemented diet was compared to the 25 or 50 percent urea supplemented diets.

Equal microbial protein production on diets ranging from 0 to 75 percent of the supplemental nitrogen as urea nitrogen illustrates that non-protein nitrogen can be utilized on low quality roughage if prolonged ammonia release can be facilitated by a sustained release product.

Introduction

The economic advantage of utilizing urea in range protein supplements and the narrow margin under which cow-calf programs are now

operating makes it necessary that procedures be developed to maximize the utilization of non-protein nitrogen (NPN) in range supplements. Many experiments on the utilization of NPN in rations containing high levels of low quality roughage have been conducted in the past.

For a large part, most of the experiments have been rather inconclusive for several reasons. First, the exact protein requirement at maintenance nutritional level have not been well established. Secondly, the traditional measurements of weight change, nitrogen balance and nitrogen digestibility are probably invalid under these conditions. Therefore, it becomes obvious that improved measurements of nitrogen utilization must measure the ability of the nitrogen source to support the rumen microbial population since non-protein nitrogen must be utilized via this pathway anyway.

New techniques have recently been developed which enable the measurement of protein passage through the digestive tract and the partition of the ingesta protein into microbial or nonmicrobial, thus giving an opportunity to determine the ratio of incorporation of dietary nitrogen into microbial nitrogen. The study reported here was designed to measure the microbial protein synthesis from urea when fed in conjunction with a low quality roughage diet.

To aid in the investigation, automatic feeders were employed to eliminate the diurnal variation in the nitrogen fractions passing the abomasum. In addition, the hourly feeding system imposed a slow release of ammonia from the urea supplied in the diet. Since urea is rapidly hydrolyzed in the rumen to ammonia, and cellulose in range forage is hydrolyzed too slowly to supply carbon chains for protein synthesis when the urea is fed once daily, the frequent ingestion of small portions of the urea supplements, as facilitated by the automatic feeding system, enabled us to study a sustained release urea supplement — low quality roughage diet.

Materials and Methods

Four 275 kg (600 lb.) steers were fitted with permanent rumen and abomasal cannulae and were housed in individual pens with slotted floors. They were fed at hourly intervals with the use of automatic feeders. This feeding system enabled the maintenance of a constant flow of digesta through the digestive tract as well as produced a sustained release of ammonia from the urea in the urea rations. The total daily intake was 5000 gm/day and consisted of 3750 gm ground weathered range grass and 1250 gm protein supplement pelleted together into a complete diet. Ration 1 supplied 100 percent of the supplemental nitrogen as soybean meal, while rations 2, 3 and 4 supplied 25, 50 and 75 percent of the

supplemental nitrogen as urea, respectively (Table 1). All rations were formulated to be as equal in nitrogen and energy content as possible; however, protein and nitrogen intake differed somewhat (Table 2).

Rumen and abomasal samples were taken on days 10, 11 and 12 after the steers were started on a new ration. All samples were immediately frozen until chemical analyses were carried out. Samples were analyzed for total nitrogen, ammonia nitrogen and urea nitrogen. In addition, the abomasal samples were analyzed for ribonucleic acid (RNA) content. RNA is almost entirely of microbial origin since plant nucleic acids are rapidly degraded in the rumen; therefore, using a RNA nitrogen/total microbial nitrogen ratio of 10 percent, it is possible to calculate the amount of microbial protein synthesized in the rumen.

Table 1. Ration Composition

Ingredient	Ration 1	2	3	4
	%			
Mature Weathered Bluestem	75	75	75	75
Dehydrated Alfalfa Meal	1.25	1.25	1.25	1.25
Dehydrated Molasses	1.25	1.25	1.25	1.25
Ground Milo	9.15	12.36	15.57	18.78
Soybean Meal (44%)	11.75	7.86	3.97	.07
Urea (281%)	–	.53	1.07	1.60
Monosodium Phosphate	.74	.74	.74	.74
Sodium Sulfate	.10	.10	.10	.10
Salt, Trace Mineral	.25	.25	.25	.25
Chromic Oxide	.50	.50	.50	.50

Table 2. Daily Intake of Protein, Nitrogen and Digestible Energy

Ingredient	Ration 1	2	3	4
Protein Intake (g/day)	483	480	421	442
Nitrogeen Intake (g/day)	77.3	76.8	67.4	70.8
Digestible Energy Intake (kcal/day)	9786	9654	9521	9389

Results

The nitrogen fractions in the rumen contents expressed on a percent of total nitrogen basis are presented in Table 3. As expected no urea nitrogen was found in the rumen contents of the steers fed the 100 percent soybean meal supplement; however, these steers did have as large a percent of ammonia nitrogen present as did the steers on the urea diets. Soybean meal protein is fairly soluble and is rapidly degraded in the rumen. As a result, large amounts of ammonia nitrogen do go through the ammonia pool before being utilized or absorbed. As the percent of urea in the supplement increased, the percent of ammonia nitrogen present in the rumen also increased, leaving the urea nitrogen levels in the rumen approximately equal. The percentage of protein nitrogen remaining in the rumen was relatively constant regardless of the level of urea in the ration.

Basically the same pattern is seen when the nitrogen fractions in the abomasal contents are expressed as a percent of total nitrogen (Table 4). No urea nitrogen was found in the abomasal contents of the steers fed the 100 percent soybean meal supplement and very little difference was noted in the ammonia nitrogen percentages among the diets. The 100 percent soybean meal supplement had a higher percentage protein

Table 3. Nitrogen Fractions in Rumen Contents

Ration	Urea-N/ Supplemental-N	Urea-N	NH_3-N	NON NH_3-N
	%	% of Total — N		
1	0	0	8.1	91.9
2	25	1.0	6.1	93.0
3	50	1.1	6.6	92.3
4	75	1.1	7.9	91.0

Table 4. Nitrogen Fractions in Abomasal Contents

Ration	Urea-N/ Supplemental-N	Urea-N	NH_3-N	NON NH_3-N
	%	% of Total — N		
1	0	0	6.1	93.9
2	25	0.3	6.5	93.2
3	50	0.9	6.1	93.0
4	75	0.8	7.2	92.0

nitrogen in the abomasal contents and this level tended to decrease as the percent urea in the diet increased.

There was a slightly higher percent total nitrogen and protein nitrogen when expressed as a percent of dry matter in the abomasal contents of the 100 percent soybean meal supplemented steers than in steers fed the urea diets and these levels tended to decrease as the percentage of urea in the supplements increased (Table 5). The percent microbial nitrogen was fairly constant among diets; therefore, the percent undegraded protein nitrogen bypassing the abomasum also decreased as the urea level in the ration increased.

The nitrogen production per day for all rations is presented in Table 6. The amount of nitrogen lost in the rumen when expressed as gms/day or as a percent of nitrogen intake was somewhat lower for the 50 percent urea supplemented diet. It should be noted that the microbial nitrogen produced per day was relatively constant among rations regardless of the level of nitrogen supplied as urea. Daily passage of protein nitrogen which escaped rumen degradation was significantly higher ($P < .05$) on the 100 percent soybean meal supplemented ration when compared to the ration containing the 75 percent urea supplement. No significant differences were noted among the 100 percent soybean meal, 25 or 50 percent urea supplemented rations nor among all the urea rations for

Table 5. Nitrogen Fractions in Abomasal Dry Matter

Ration	Urea-N/ Supplemental-N	Total-N	Urea-N & NH_3-N	Non NH_3-N	Microbial N	NH_3-N Bypassed
	%		mg/g D. M.			
1	0	20.1	1.2	18.9	10.1	8.8
2	25	19.2	1.3	17.9	10.8	7.1
3	50	17.5	1.2	16.3	9.7	6.6
4	75	17.1	1.4	15.7	10.6	5.1

Table 6. Total Abomasal Passage in Nitrogen Fractions

Ration	Urea N/ Supplemental N	N lost in Rumen	Microbial N	Protein-N Bypass	Protein reaching small intestine
1		17.7	30.0[1]	25.4[1]	351.3[1]
2	25	19.9	31.8[1]	21.7[1,2]	333.8[1]
3	50	12.7	30.6[1]	22.0[1,2]	320.6[1]
4	75	18.4	31.5[1]	16.2[2]	295.6[2]

[1,2] Means under each heading bearing a different superscript letter differ significantly ($P < .05$).

protein bypass. The amount of protein presented to the small intestine to be used by the host animal as a protein source was significantly higher ($P<.01$) for the 100 percent soybean meal, 25 and 50 percent urea supplemented diets when compared to the 75 percent urea supplement, certainly a reflection of the reduced protein nitrogen bypass on the 75 percent urea supplemented diet. Maximum microbial protein was produced in all rations for the energy level supplied regardless of the form in which nitrogen was supplemented.

Conclusions

Equal microbial protein produced on diets ranging from 0 to 75 percent of the supplemental nitrogen as urea nitrogen illustrates that non-protein nitrogen can be utilized on low quality roughage rations if frequent ingestion can be facilitated or initiated by a sustained release product.

Performance of Four-Year-Old Hereford, Hereford X Holstein and Holstein Females As Influenced by Level of Winter Supplementation Under Range Conditions

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Story in Brief

The productivity of winter-calving, 4-year-old Hereford, Hereford x Holstein and Holstein females under tallgrass range conditions was compared. Two levels of winter supplementation (Moderate and High) were imposed on groups within each breed at calving and extended through the rest of the winter. An additional group of Holsteins was fed a Very High level of supplement.

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