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Utilization of Urea by Sheep and Goats Fed High Roughage Diets[1]

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Abstract

Two experiments were conducted to test the utilization of urea-containing high fiber diets by small ruminants. In Experiment I wheat straw/alfalfa hay diets were supplemented with 0, 1 or 2% urea to achieve 7, 10 or 13% crude protein equivalent. When fed to growing Toggenburg wether goats, voluntary intake was slightly lower ($P>.05$) for the diet without urea. Digestibilities of dry matter and fiber ($P<.05$) and crude protein ($P<.01$) were lower for the diet without urea but not different for the diets with 1 or 2% urea. Less nitrogen was retained ($P<.01$) on the zero-urea diet, with no difference between the 1 or 2% urea diets. In Experiment II urea was compared with soybean oil meal as a nitrogen source in low or medium fiber diets for growing, wethered Toggenburg goats or Suffolk sheep. All diets were adjusted to 11-12% crude protein equivalent. The goats showed lower digestibility of dry matter and fiber but higher intakes of total and digestible dry matter than the sheep; the two animal species showed no difference in nitrogen retention even though blood urea nitrogen levels were higher ($P<.01$) in the goats. No important differences were noted in diet utilization due to nitrogen source (urea or soybean oil meal) in either sheep or goats.

(Key words: Ruminant nutrition; Non-protein nitrogen; Sheep; Goats; Crop Residues.)

Introduction

Goats and sheep in the Philippines and other tropical regions are fed a wide variety of crop residues and byproducts. Not always are diets for small ruminants adequate in protein, especially during the dryer periods in regions having a wet-dry climatic pattern. The efficacy of feeding urea to cattle and sheep in such situations is well known (Briggs, 1967). Among the few reported studies of urea for goats, Lindahl (1972) reported the successful use of a urea-ground corn mixture to replace linseed oil meal for dairy goats.

There has been conflicting information in the literature about the comparative utilization of nitrogen by goats and other ruminants, with some suggestions of a higher requirement by goats in certain situations (Huston, 1978; Sands and McDowell, 1978) and other suggestions that goats are more efficient than other ruminants in recycling urea on low quality diets ingested at near-maintenance level (MacFarlane, 1982).

The present studies were conducted to investigate the comparative utilization of urea by growing goats and sheep on a high-roughage diet, and to compare the effects of different levels of nitrogen intake by goats when urea was added to a basal diet designed to be nitrogen-deficient.

Experimental Procedures

Experiment I was conducted with 9 Toggenburg wether goats, mean weight 25 kg. All diets contained chopped wheat straw (about 50% of total dry matter), chopped alfalfa hay (21.5%), ground corn grain (18.5%) and a standard mineral and vitamin mix (1.1%). Diets 1, 2 and 3 also contained 0, 1.1 and 2.3% urea and 8.7, 7.9 and 7.1% molasses, respectively. Each diet was fed to 6 of the 9 goats, 3 in each of 2 experimental periods which included 10 days for diet adaptation, 6 days on ad-libitum intake, and 7 days at 90% of ad libitum intake during which total fecal and urine collections were made. Experimental diets were prepared daily and fed individually in one feeding. Daily feed, orts,

feces and urine samples were preserved for later compositing and preparation for analysis. Kjeldahl nitrogen was determined by standard procedures (AOAC, 1970); acid-detergent fiber was determined by the procedure of Goering and Van Soest (1971). Statistical analyses followed methods of Snedecor and Cochrane (1976).

Procedures were similar in Experiment II except that 16 animals were fed 4 different diets during 4 experimental periods of 21 days each, including 7 days for adaptation, 7 days to measure ad libitum intake and 7 days for fecal and urine collection. Blood samples were drawn from the jugular vein on the last day of each collection period and were immediately centrifuged, the plasma being preserved for later blood urea nitrogen determination (as part of a standard 13-point profile). Rumen fluid samples were also taken, via a tube passed through the esophagus, and preserved for later determination of volatile fatty acids on a Varian 3700 gas chromatograph.

The ingredients used in Experiment II diets, and their respective proportions, are shown in table 1. The animals used included 8 wethered Toggenburg goats (mean weight 31 kg) and 8 wethered Suffolk sheep (43 kg mean weight).

Results and Discussion

The results of Experiment I are summarized in table 2. The diets as fed were about 7, 10 and 13% crude protein, respectively; the 7% level was expected to be inadequate for growing kids and the 10% level to be marginally adequate (NRC, 1981). These levels were chosen in hopes of showing a definite response to urea addition.

There was a slight response in dry matter intake for diets 2 and 3 over diet 1, although not significant. Dry matter digestibility, on the other hand, was significantly higher for diets 2 and 3 than for diet 1. Digestibility of the lignocellulose fraction (acid-detergent fiber) and crude protein followed the same response. Apparently the rumen microbial population was not function-

ing optimally at the very low proportion of nitrogen available from diet 1. Fecal excretion of microbial cell wall material accounted for nearly two-thirds of the nitrogen intake from diet 1, as evidenced by the very low (37%) apparent absorption of nitrogenous substances. The nitrogen balance data showed that fecal N was nearly constant across all diets; however, urinary N increased linearly from diet 1 to diet 2 and from diet 2 to diet 3. Retained N was extremely low from diet 1, and not significantly different between diets 2 and 3.

All of these results point to diet 1 as being indeed deficient in nitrogen, and diet 2 with 10% crude protein (including 1.1% urea) as being apparently adequate in nitrogen for these animals and this type of ration.

The statistical analysis showed significant animal effects ($P<.05$) for dry matter intake and nitrogen retention and a significant period effect ($P<.05$) also for dry matter intake as well as for urinary excretion of N.

The diets chosen for Experiment II were intended to be isonitrogenous at a crude protein level slightly higher than diet 2. The actual composition of Experiment II diets is shown in table 1. The experiment was designed to allow detection of interactions among fiber level, nitrogen source, and animal species in terms of intake, digestibility, and nitrogen retention.

The lignocellulose (acid-detergent fiber) values shown in table 1 do not accurately reflect the total fiber differences between diets 4 and 6 on the one hand and 5 and 7 on the other, due to the large difference in hemicellulose content in alfalfa (very low) versus wheat straw (very high). The diets labeled "medium" fiber would show a much larger margin of difference in total cell wall (neutral-detergent fiber) compared to the "low" fiber diets 4 and 6.

Results of Experiment II are summarized in table 3. There were no statistically significant two-way or three-way interactions among the main effects of fiber level, N source, and animal species.

The effects of fiber level were as expected, with reduced intake ($P<.01$)

and slightly lower dry matter digestibility for the higher fiber level. Fecal N excretion was also lower (P<.01) at the higher fiber level, possibly a reflection of a slightly reduced rumen microbial activity with a higher proportion of fiber and lower total dry matter intake. It is known that virtually all fecal N is from endogenous sources (Van Soest, 1982); rumen microbial fecal N could be expected to be more variable than N from lower tract tissues or microbes.

There were no important differences attributable to dietary nitrogen source. The levels of urea used in these diets were apparently satisfactory for both the sheep and the goats, for diets of this type.

Some notable differences occurred between the two animal species. Dry matter intake was higher by the goats (P<.01) whereas dry matter and fiber digestibility tended to be lower; the net effect was for a higher daily intake of digestible dry matter and, therefore, digestible energy. These tendencies corroborate previous reports by Brown and Johnson (1981) and Luginbuhl and Johnson (1982), who theorize differential rates of fiber particle breakdown and passage between goats and sheep, especially with high fiber feeds.

Total concentration of volatile fatty acids in the rumen were higher in the goats than the sheep (P<.01), although proportions of individual VFA's were not different. Blood urea nitrogen concentration was also higher for the goats (P<.01).

Conclusion

It appears that 10% crude protein in a medium fiber diet will maintain normal rumen function in the growing Toggenburg goat, and that the addition of 1.1% urea (3.2% crude protein equivalent) to the total dry matter of a diet containing 7% natural protein is satisfactory. Further, it was shown that Suffolk wether lambs and Toggenburg wether kids perform similarly on diets of the type fed in Experiment II. Caution must be used, however, in extrapolating

these results to tropical conditions without further testing. Breed differences, dietary fiber quality, and differences in climatic adaptation could alter the results.

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Table 1. Diets used in Experiment II, showing proportions of ingredients on a dry matter basis.

Ingredients	Diet No. 4	5	6	[illegible]
	%			
Chopped wheat straw	35	0	35	50
Chopped alfalfa hay	35	0	35	20
Molasses	12	1	12	12
Ground corn grain	15	5	7	2
Urea	1.[illegible]	2.1	-	-
Soybean oil meal	-	-	9	14
Mineral and vitamin mix	2	2	2	2
Chemical composition				
Crude protein	11.[illegible]	1.7	11.[illegible]	12.2
Acid-detergent fiber	32	5	34	36

Table 2. Diet composition, intake, digestibility, and nitrogen balance for Experiment I.

Parameter measured	Diet number and description 1 no urea	2 1.1% urea	3 2.3% urea
Chemical composition, %			
Crude protein	7.3	10.1	12.9
Acid-detergent fiber	29.3	29.3	29.3
Dry matter intake per day			
g	706	3	716
g/kg body weight	26	7	27
g/kg body weight$^{.75}$	59	2	61
Digestibility, %			
Dry matter	50^{a}	6^{b}	54^{b}
Acid-detergent fiber	19^{a}	9^{b}	28^{ab}
Crude protein	37^{A}	4^{B}	70^{B}
Nitrogen balance, g/day			
Total intake	1.2^{A}	3.9^{AB}	18.3^{B}
Urea-N intake	0	3.8	7.4
N in feces	[illegible].9	5.3	5.2
N in urine	$.4^{A}$	6.2^{B}	10.1^{C}
N retained	$.6^{A}$	2.8^{B}	2.6^{B}

^{a,b} $P<.05$
^{A,B,C} $P<.01$

Table 3. Intake, digestibility and nitrogen balance, Experiment II, showing main effects of diets and animal species.

Parameter measured	Diet number and description				Animal species	
	4 Urea Low fiber	5 Urea Medium fiber	6 Soybean meal Low fiber	7 Soybean meal Medium fiber	Goats	Sheep
Dry matter intake						
g/day	933^{A}	809^{Bc}	898^{ABd}	798^{Bc}	931^{A}	788^{B}
g/kg body weight/day	26^{Ac}	24^{ABd}	25^{Acd}	21^{B}	30^{A}	18^{B}
g/kg $W^{.75}$	63^{Ac}	58^{ABd}	62^{Acd}	52^{B}	70^{A}	47^{B}
Digestibility, %						
Dry matter	63	59	61	54	57	61
Acid-detergent fiber	42	43	44	42	41	44
Crude protein	85	86	85	86	85	86
Dig. dry matter intake, g	587	487	542	459	551^{a}	489^{b}
Nitrogen balance, g/day						
Total intake	19.8	18.6	19.8	18.6	20.8^{a}	17.6^{b}
Urea-N intake	5.5	7.6	–	–	–	–
N in feces	2.9^{A}	2.5^{B}	2.9^{A}	2.4^{B}	2.9^{A}	2.4^{B}
N in urine	10.8	10.3	10.5	9.9	11.0^{A}	9.7^{B}
N retained	6.2	6.2	6.3	6.5	6.7	5.9
Blood urea N, mg/100 ml					22.1^{A}	16.2^{B}

a,b,c,d $P<.05$

A,B $P<.01$