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UREA AND NITRATE INTERRELATIONSHIPS IN SHEEP UNDER FEEDLOT CONDITIONS

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Several sources of nonprotein nitrogen, including urea and nitrate, are known to be utilized by rumen microbes for protein synthesis after conversion to a common intermediate, ammonia. This has led to the speculation that the presence of urea may result in a decrease in the utilization of nitrate or its reduction products, thereby increasing the apparent toxicity of nitrate.

The experiments reported herein were conducted to determine if measurable urea-nitrate interrelationships exist in sheep under feedlot conditions, and the extent of nitrogen utilization from urea and nitrate by sheep fed rations containing otherwise suboptimum quantities of crude protein.

Experimental Procedure

These studies consisted of three experiments. Dietary conditions provided for the simultaneous adaptation of lambs to urea and sodium nitrate (experiment 1); an exposure to sodium nitrate without prior adaptation after lambs had been brought to full feed on a ration containing urea (experiment 2); and the use of soybean meal, urea and nitrate independently as nitrogenous supplements to rations providing suboptimum levels of crude protein (experiment 3). Lambs used in all experiments were vaccinated against enterotoxemia (overeating disease), and those used in experiments 1 and 2 were drenched with thiabendazol to rid them of internal parasites.

Experiment 1. Eighty ewe and wether lambs were allotted on the basis of sex, weight and source into 8 lots of 10 lambs each (4 ewes and 6 wethers) for 4 replicated treatments. All lambs were full-fed rations consisting of 3 parts corn silage (67.7% moisture) to 1 part concentrate (rolled shelled corn and supplements).

Treatments consisting of additions to the concentrate portion of the ration were as follows: (1) urea, (2) urea plus sodium nitrate, (3) soybean meal and (4) soybean meal plus sodium nitrate. The addition of 2% urea (42% nitrogen content) to the concentrate mixtures resulted in about 1% urea in the total air-dry (12% moisture) ration. Soybean meal (7% of air-dry ration) was used at the expense of corn to furnish an equivalent amount of nitrogen in the rations not containing urea. Before addition of nitrate, all rations had a crude protein content of 10.8% (N × 6.25, 12% moisture basis). Sodium nitrate, when used, was added at a level of 5% in the concentrate portion resulting in 2.5% in the total air-dry ration. Sodium chloride was used in non-nitrate rations to provide sodium in an amount equivalent

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to that in the sodium nitrate rations. All concentrate mixtures contained 20 mg. chlortetracycline and 2000 I.U. vitamin A per lb. Trace mineral salt and dicalcium phosphate were available free choice.

Blood samples were obtained on days 21 and 81 of the 82-day experimental period and analyzed for total hemoglobin and methemoglobin. Some death losses occurred due to enterotoxemia and the weight gain data were calculated only for lambs completing the trial. Feed consumption data were adjusted by subtracting an average value for each lamb removed.

Experiment 2. Eight lots of 11 ewe lambs were used in four replicated treatments as described in experiment 1. However, sodium nitrate was not added to the rations until after a 2-week pretreatment period during which the lambs were fed the experimental rations with sodium nitrate omitted. The sodium nitrate was then added to the appropriate rations. The level of feed intake at that time was 2.2 lb. (air-dry basis) per head daily. Methemoglobin and total hemoglobin were determined periodically, and carcass data were obtained at slaughter after 109 days on experiment.

Experiment 3. Ninety-six ewe la bs were brought to full feed during a 2-week preliminary period on a ration consisting of 3 parts corn silage (65.4% moisture) to 1 part of ground corn grain. They were allotted on basis of weight into 8 lots of 12 lambs each for 4 replicated treatments. The control group continued to receive the pretreatment ration containing 8.04% crude protein (12% moisture basis). Other treatments consisted of the addition of 2.90% sodium nitrate, 1.06% urea (45% nitrogen) or 6.86% soybean meal to the concentrate portion of the respective rations resulting in 1.45% sodium nitrate, 0.53% urea or 3.43% soybean meal in the total air-dry rations. Each of the three nitrogenous supplements provided additional nitrogen equivalent to 1.5% (N × 6.25) crude protein in the total air-dry ration. All concentrate mixtures contained 2 mg. diethylstilbestrol and 2000 I.U. of vitamin A per lb.

Sodium sulfate was added to the control, nitrate and urea rations to furnish the calculated amount of sulfur in the soybean meal ration. Sodium chloride was added to the control, soybean meal and urea rations in amounts equivalent to the sodium contributed by sodium nitrate in the nitrate ration. Trace mineral salt and dicalcium phosphate were available free choice. Blood analysis and the calculation of feed consumption when losses occurred were as described for experiment 1. Carcass data were obtained at slaughter after 90 days on experiment.

Results and Discussion

Experiment 1. Data pertaining to this experiment are presented in table 1. Lambs fed these rations of corn and corn silage with 1% urea (air-dry basis) gained 19.5% (urea-control) and 16.5% (urea-nitrate) less than those fed corresponding rations with soybean meal. This level of urea also appeared to reduce feed intake and to increase feed require ents per unit of gain.

When sodium nitrate (2.5% of air-dry ration) was included in the rations, rate of gain was decreased (not statistically significant) for lambs fed soybean meal but was essentially unchanged for those fed urea where the gains were already lower. Rations containing sodium nitrate were consumed in slightly larger amounts than those without nitrate, and the accompanying lower weight gains resulted in higher feed requirements per unit of gain. However, methemoglobin values obtained at 21 and 81 days were low and were about the same for sheep fed rations with and without nitrate. There were no visible signs of nitrate toxicity during the experiment.

During the initial 2 weeks while bringing the lambs to full feed, higher weight gains were recorded for the nitrate-fed lambs than for those not fed the source of nitrate. These data are as follows (lb./day): Soybean meal, 0.23; soybean meal-nitrate, 0.46; urea, -.01: urea-nitrate, 0.24. Average daily feed consumption was low during this period and the total crude protein intake was less than that recommended for lambs. The additional 21 gm. average of crude protein (N × 6.25) per lamb daily supplied by sodium nitrate during this time may have been beneficial under these conditions. This trend was reversed during the remainder of the experiment resulting in the over-all reduction in weight gain as shown in table 1.

Experiment 2. Results from experiment 2 are presented in table 2. In the absence of nitrate, lambs fed urea gained 16.9% less than those fed the corresponding soybean meal ration. Sodium nitrate reduced average daily gain 15.5% when fed in conjunction with soybean meal, but again had almost no effect when fed with urea where gains were already lower. Carcass characteristics showed only minor variations.

These results differ from those obtained experiment 1 primarily in the greater reduction of weight gain attributed to nitrate when fed in the soybean meal ration. This difference between experiments is accounted for mainly on the basis of results obtained during the first 2 weeks of the experiments. In experiment 1, the lambs were brought to full feed during the first 2 weeks on the experimental rations. During this time lambs (experiment 1) receiving the nitrate rations made gains that exceeded those of lambs receiving the corresponding control rations. In experiment 2, nitrate was not added until after the lambs had been brought to full feed on the control rations. Under these conditions which allowed no gradual adaptation to nitrate and no initial difference in crude protein content of rations, average daily gain for lambs fed the soybean meal-nitrate ration was only 0.029 lb. during the first 2-week period while lambs fed soybean meal without nitrate gained 0.189 lb. daily. Nitrate added to the urea ration resulted in no reduction in average daily gains (urea, 0.148 lb.; urea-nitrate, 0.176 lb.) during this period. These data indicate that the prior adaptation to urea in this experiment may have been an important factor in the greater initial tolerance of urea-fed lambs to the nitrate. The methemoglobin data tend to support this conclusion. Averages of 3.03 and 1.33 gm. methemoglobin per 100 ml. blood were observed on the second day of nitrate feeding in lambs fed the soybean meal-nitrate and the urea-nitrate rations, respectively. However, much lower methemoglobin levels were observed at all other sampling periods and there were no visible signs or deaths attributable to nitrate toxicity.

While differences pertaining to weight gains were not statistically significant, they very closely follow the over-all trends established in the first experiment. However, unlike the results obtained in experiment 1, the weight-gain reduction attributed to the feeding of sodium nitrate with soybean meal was accompanied by a lower feed consumption.

Experiment 3. Data obtained with lambs fed the low-protein ration supplemented with soybean meal, urea or sodium nitrate to obtain equal levels of crude protein are presented in table 3. The crude protein content (9.54%, air-dry basis) of rations obtained from supplementation of the control ration (8.04% protein, air-dry basis) is below the requirement listed by the National Research Council for fattening lambs. However, it was considered that rations borderline or mildly deficient in protein content would provide a more critical comparison between the sources of supplemental nitrogen.

Lambs fed the low-protein control ration gained 0.28 lb. daily. The addition of soybean meal, urea or sodium nitrate to increase the total crude protein content by 1.5 percentage units improved weight gains by 21-24% with only slight differences being observed between sources of nitrogen. These increases were not statistically significant in this experiment. However, the improvement was consistent and uniform for all sources of supplemental nitrogen and represent sizeable increases in relation to the amount of increase in protein content of the rations.

Average feed consumption values were highest for groups of lambs receiving the nitrogenous supplements, but the increases in feed consumption were not proportionate to the increases in weight gain. When compared with the control group, the feed required per lb. of gain was significantly ($P < .05$) lower for the groups fed urea and nitrate, and approached significance for those fed soybean meal.

Methemoglobin values were low for all groups, including the nitrate-fed lambs, when measured after 2 and 21 days on treatment. Also, there were no differences in the carcass data obtained for the various groups at the termination of the experiment.

The similarity in the utilization of soybean meal, urea and sodium nitrate as sources of crude protein in this experiment differs from the trend established in the previous two experiments. The experiments differed in that rations used in experiment 3 had lower levels of urea (0.53 vs. 0.93%) and sodium nitrate (1.45 vs. 2.5%), and sulfur was added to the urea and sodium nitrate rations. How these variations may have influenced the results has not been determined.

The existence of a nutritional interrelationship between nitrate and urea is neither supported by the data reported herein nor by previously documented experimental data. However, this does not preclude the possibility of an interrelationship between nonprotein nitrogenous compounds when fed with high-roughage rations, a condition providing the greatest potential for toxicity of both nitrate and urea. The data indicate that nitrate below toxic levels in ruminant rations may serve as a source of crude protein comparable to an equivalent amount of nitrogen from soybean meal and urea in fattening rations.

Summary

Two experiments were conducted to study nitrate-urea interrelationships, and a third was conducted to compare the utilization of soybean meal, urea and nitrate when added to a low-protein ration. All experiments utilized lambs fed corn and corn silage rations under feedlot conditions.

In two experiments, sodium nitrate (2.5% of ration, air-dry basis) tended to reduce weight gains when fed in rations with soybean meal (7%, air-dry basis) but it had only a slight effect in rations with an equivalent amount of crude protein from urea (1%, air-dry basis) where gains were already below those of the lambs fed soybean meal. In these instances, lambs fed urea made average weight gains that were 16.5 - 19.5% less than those made by lambs fed soybean meal. No evidence was obtained to support a nitrate-urea interrelationship.

In a third experiment, the crude protein content of an 8.04% protein ration was increased to 9.54% using soybean meal, urea or sodium nitrate to furnish equivalent amounts of nitrogen. Under these conditions the three nitrogen sources were utilized equally well as sources of crude protein.

TABLE 1. EFFECTS OF UREA AND NITRATE ON LAMB PERFORMANCE (EXPERIMENT 1 - 82 DAYS)

Item	Soybean meal		Urea	
	Control	$NaNO_3$	Control	$NaNO_3$
No. of lambs	19	18	20	19
Av. initial wt., lb.	70.7	69.3	69.9	71.3
Av. daily gain, lb.	0.305	0.285	0.246	0.238
Av. daily feed, lb.[a]	2.73	2.89	2.54	2.64
Feed/lb. gain, lb.[a]	8.96	10.09	10.31	11.20
Av. hemoglobin, gm./100 ml.				
21 days	14.12	13.54	13.99	13.66
81 days	13.33	13.93	13.56	13.85
Av. methemoglobin, gm./100 ml.				
21 days	0.11	0.16	0.15	0.21
81 days	0.50	0.40	0.43	0.48

[a]On a 12% moisture basis.

TABLE 2. EFFECTS OF UREA AND NITRATE ON LAMB PERFORMANCE (EXPERIMENT 2 - 109 DAYS)

Item	Soybean meal		Urea	
	Control	$NaNO_3$	Control	$NaNO_3$
No. of lambs	20	21	21	21
Av. initial wt., lb.	61.5	58.6	60.7	60.7
Av. daily gain, lb.	0.303	0.256	0.252	0.246
Av. daily feed, lb.[a]	2.85	2.54	2.58	2.58
Feed/lb. gain, lb.[a]	9.42	9.91	10.27	10.56
Marbling[b]	5.4	5.2	5.3	5.1
Carcass grade[c]	11.7	11.4	11.6	10.9
Dressing percent	50.7	50.5	50.3	48.9
Av. hemoglobin, gm./100 ml				
1 day	11.4	11.6	11.7	10.5
2 days	--	11.2	--	10.5
3 days	--	11.3	--	10.1
4 days	--	11.3	--	10.0
7 days	11.0	11.1	11.1	10.4
23 days	12.1	13.1	12.0	12.3
53 days	13.5	13.6	13.6	13.1
Av. methemoglobin, gm./100 ml.				
1 day	0.02	0.25	0.16	0.50
2 days	--	3.03	--	1.33
3 days	--	0.52	--	0.73
4 days	--	0.34	--	0.21
7 days	0.10	0.27	0.12	0.15
23 days	0.15	0.34	0.07	0.35
53 days	0.10	0.50	0.12	0.38

[a] On a 12% moisture basis.

[b] Code: Small, 5; moderate, 6.

[c] Code: Good, 8; choice, 11· prime. 14.

TABLE 3. EFFECTS OF EQUAL NITROGEN LEVELS FROM UREA, SOYBEAN MEAL AND SODIUM NITRATE ON LAMB PERFORMANCE (EXPERIMENT 3 - 90 DAYS)

Item	Control	Urea	Soybean meal	Sodium nitrate
No. of lambs	24	20	22	24
Av. initial wt., lb.	67.4	67.6	67.6	67.9
Av. daily gain, lb.	0.256	0.312	0.318	0.312
Av. daily feed, lb.[a]	2.38	2.54	2.67	2.46
Feed/lb. gain, lb.[a]	9.34	8.20[d]	8.42	7.92[d]
Marbling[b]	5.1	5.2	5.4	5.0
Carcass grade[c]	11.0	10.8	11.1	10.7
Dressing percent	49.0	46.8	48.2	48.4
Av. hemoglobin, gm./100 ml				
2 days	11.99	12.84	11.49	12.43
21 days	12.79	13.13	12.99	12.79
Av. methemoglobin, gm./100 ml.				
2 days	0.06	0.06	0.04	0.07
21 days	0.12	0.07	0.06	0.10

[a]On a 12% moisture basis.

[b]Code: Small, 5; moderate, 6.

[c]Code: Good, 8; choice, 11; prime, 14.

[d]Significantly ($P < .05$) lower than the value for the control.