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Urea-Nitrate Interrelations In Sheep Under Feedlot Conditions[1]

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Sublethal levels of nitrate in ruminant rations have been shown to have the potential for reducing weight gains. 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. Whether the toxicity of nitrate for ruminants may be increased by feeding rations containing urea has not been shown previously.

Three experiments 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 suboptimum quantities of protein. Dietary conditions imposed 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 a full feed on a ration containing urea (experiment2); and the use of soybean meal, urea and sodium nitrate independently as protein supplements to rations providing suboptimum levels of crude protein (experiment 3).

Procedures

Experiment 1

Eighty ewe and wether lambs, previously drenched with thiabendazole and vaccinated for control of enterotoxemia, were allotted on basis of sex, weight and sorted into 8 pens of 10 lambs each (4 ewes and 6 weathers) for four replicated treatments. All lambs were full-fed rations consisting of 3 parts corn silage (67.7% moisture) to 1 part concentrates (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) 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 protein in the rations not containing urea. Before

[1]Taken largely from paper published in the Journal of Animal Science, Vol. 27 (2):557. 1968.

the addition of nitrate, all rations had a crude protein content of 10.8%. 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 to that in the sodium nitrate rations. Trace mineral salt and dicalcium phosphate were also provided free access.

The lambs were started on feed at the rate of 2.0 lb. per head daily. Feed was increased gradually to a full feed over a period of 2 weeks while maintaining the 3:1 ratio of corn silage to concentrates. The lambs were implanted with 3 mg. diethylstilbestrol at the beginning of the experiment. All the concentrate mixes contained 20 mg. of chlortetracycline and 2,000 I.U. of vitamin A per pound.

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 from causes unrelated to the experimental treatments and weight gain data were calculated only for lambs completing the trial. Feed consumption data were adjusted by subtracting an average value for each lamb lost or removed.

Experiment 2

Eighty-eight ewe lambs, previously drenched with thiabendazole and vaccinated for prevention of enterotoxemia, were allotted on basis of weight into 8 pens of 11 lambs each. Four replicated treatments were used as 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 ommitted. Sodium nitrate was then added to the appropriate rations, and feed intake at this time was about 2.2 lb. (air-dry) per lamb daily.

Other procedures were followed as in experiment 1 with few exceptions. The lambs did not receive diethlstilbestrol. The urea source contained 45% nitrogen instead of 42%, but it was added at a level of 1.86% of the concentrate mixture resulting in the same amount of non-protein nitrogen from urea as in the previous experiment. Before the addition of sodium nitrate, the rations had a crude protein content of 10.6%. Methemoglobin and total hemoglobin were determined periodically during the experiment.

Experiment 3

Ninety-six ewe lambs were vaccinated for prevention of enterotoxemia and were brought to a full feed during a 2-week preliminary period on a ration consisting of 3 parts corn silage (65.4% moisture) to 1 part ground corn grain. The lambs were allotted on basis of weight into 8 pens of 12 lambs each for four replicated treatments. A control group continued to receive the pretreatment ration which contained 8.04% crude protein (12% moisture basis) by analysis. 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 these supplements provided additional nitrogen equivalent to 1.5% crude protein in the total air-dry ration. All concentrate mixtures contained 2 mg. diethylstilbestrol and 2,000 I.U. of vitamin A per pound.

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 access. Methods for blood analysis and the calculation of feed intake when losses occurred were as described for experiment 1.

Results

Experiment 1

Lambs fed rations of corn and corn silage with 1% urea (air-dry basis) gained 19.5 (urea-control) and 16.5% (urea-nitrate) less than lambs fed corresponding rations with the same level of crude protein but supplemented with soybean meal (table 1). This level of urea also appeared to reduce feed intake and to increase feed requirements per unit of gain.

When sodium nitrate (2.5% of air-dry ration) was included in the ration, rate of gain was decreased for lambs fed soybean meal but was essentially unchanged for those fed urea. 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.

Experiment 2

In the absence of nitrate, lambs fed urea gained 16.9% less daily than those fed the corresponding soybean meal ration. Gains were 15.5% lower when sodium nitrate was fed in conjunction with soybean meal, but sodium nitrate had almost no effect when fed with urea. Carcass characteristics showed only minor variations between ration treatments.

Results of experiment 2 differ from 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 a 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 the lambs had been brought to a full feed on the control rations. Under these conditions which allowed no gradual adaptation to nitrate, average daily gains for lambs fed the soybean meal nitrate ration was only 0.03 lb. daily during the first 2-week period while lambs fed soybean meal without nitrate gained 0.20 lb. daily. Nitrate added to the urea ration resulted in no reduction in average daily gains during this period. These data indicate that the prior adaptation to urea in the second experiment was probably an important factor in the greater initial tolerance of urea-fed lambs to the nitrate. The methemoglobin data (table 2) tend to support this conclusion. However, there were no visible signs or deaths attributable to nitrate toxicity.

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 requirements commonly recommended 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 0.275 lb. daily. The addition of soybean neal, 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 the protein sources.

Feed consumption was highest for groups of lambs receiving the supplemental sources of protein. There was also an improvement in feed efficiency in comparsion to the control group with lambs fed urea or sodium nitrate having feed requirements slightly less than for soybean meal.

Methemoglobin values were low for all groups of lambs at 2 and 21 days on treatment. Carcass data were similar for the various groups at termination of the experiment.

The similarity in the utilization of soybean meal, urea and sodium nitrate as sources of crude protein in the third experiment differs from the trend established in the first two experiments. The experiments differ 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.

The results of the experiment support the conclusion that nitrate below a toxic level may serve as a source of crude protein comparable to an equivalent amount of nitrogen from soybean meal and urea in finishing rations for ruminants.

Summary

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 lambs fed soybean meal. In these instances, lambs fed urea gained 16.5 to 19.5% less than 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% portein 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 as well as sources of crude protein.

Table 1. Effects of Urea and Nitrate on Lamb Performance (Experiment 1 - 82 days).

	Soybean Meal		Urea	
	Control	Sodium Nitrate	Control	Sodium Nitrate
Number of lambs	19	18	20	19
Init. wt., lb.	75.9	74.4	75.0	76.6
Av. daily gain, lb.	0.328	0.306	0.264	0.255
Av. daily feed, lb.[a]	2.93	3.10	2.73	2.84
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] 12% moisture basis

Table 2. Effects of Urea and Nitrate on Lamb Performance (Experiment 2 - 109 days).

	Soybean Meal		Urea	
	Control	Sodium Nitrate	Control	Sodium Nitrate
No. of lambs	20	21	21	21
Init. wt., lb.	66.0	62.9	65.1	65.1
Av. daily gain, lb.	0.326	0.275	0.271	0.264
Av. daily feed, lb.[a]	3.06	2.73	2.77	2.77
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]12% moisture basis
[b]Marbling score: small, 5; moderate, 6.
[c]Grade score: 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).

	Control	Urea	Soybean Meal	Sodium Nitrate
No. lambs	24	20	22	24
Init. wt., lb.	72.4	72.6	72.6	72.8
Av. daily gain, lb.	0.275	0.334	0.341	0.334
Av. daily feed, lb.[a]	2.55	2.73	2.86	2.64
Feed/lb. gain, lb.[a]	9.34	8.20	8.42	7.92
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]12% moisture basis
[b]Marbling score: small, 5; moderate, 6.
[c]Grade score: good, 8; choice, 11; prime, 14.