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Effects of source and level of energy or protein supplementation on nitrate toxicity in cattle

Abstract

Two experiments were conducted to investigate whether level or source of energy and protein supplementation would reduce the incidence or severity of clinical toxicity in cattle fed forages high in nitrate (NO3). Heavily fertilized sudan hay with 40,000 to 50,000 ppm NO3 was fed in both experiments. The percentage of total blood hemoglobin converted to methemoglobin by nitrate was used to compare treatment effectiveness. Energy supplementation at levels tested in Exp. 1 had no effect on methemoglobin concentration. In Exp. 2, all protein sources (wheat midds, urea, soybean meal) reduced the maximum methemoglobin levels and increased the rate of reconversion to normal hemoglobin.

Keywords

Cattlemen's Day, 1992; Kansas Agricultural Experiment Station contribution; no. 92-407-S; Report of progress (Kansas State University. Agricultural Experiment Station and Cooperative Extension Service); 651; Beef; Nitrate toxicity; Energy; Protein

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EFFECTS OF SOURCE AND LEVEL OF ENERGY OR PROTEIN SUPPLEMENTATION ON NITRATE TOXICITY IN CATTLE[1,2]

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Summary

Two experiments were conducted to investigate whether level or source of energy and protein supplementation would reduce the incidence or severity of clinical toxicity in cattle fed forages high in nitrate (NO_3). Heavily fertilized sudan hay with 40,000 to 50,000 ppm NO_3 was fed in both experiments. The percentage of total blood hemoglobin converted to methemoglobin by nitrate was used to compare treatment effectiveness. Energy supplementation at levels tested in Exp. 1 had no effect on methemoglobin concentration. In Exp. 2, all protein sources (wheat midds, urea, soybean meal) reduced the maximum methemoglobin levels and increased the rate of reconversion to normal hemoglobin.

(Key Words: Nitrate Toxicity, Energy, Protein.)

Introduction

Under certain conditions many forage plants, particularly the sorghum group, accumulate excess nitrate (NO_3). This can be hazardous to livestock when it is reduced to nitrite (NO_2) by microbes in the rumen. Nitrite is absorbed directly into the bloodstream, where it oxidizes the iron in hemoglobin (Hb) and converts it to methemoglobin (mHb), which is unable to carry oxygen. Clinical signs may begin when 40 to 50% of the Hb is converted to mHb. Death from lack of oxygen can occur if mHb levels reach 70 to 90%. The reduction of NO_3 to NO_2 is carried out by an enzyme, nitrate reductase, present in certain ruminal microbes. Alteration of ruminal conditions to those either unfavorable to the NO_3-reducing microbes or to the enzyme itself might protect the animal from toxic effects. We attempted to prevent nitrite accumulation by lowering the rumen pH with energy supplementation or by influencing rumen flora activity by adding alternative nitrogen sources.

Experimental Procedures

In Exp. 1, seven ruminally cannulated, mature, crossbred cows were rotated through a 7×7 Latin Square design in which milo, wheat or soy hulls were fed at 2 and 4 lb along with a non-supplemented control group. Supplements were fed 1 hour before baseline sampling and forage feeding. After the initial samples were taken, high-nitrate sudan (40,000 to 50,000 ppm NO_3) was fed ad libitum. Rumen fluid and whole blood were subsequently collected every 2 hours for 10 hours. Forage intake was equalized after 4 hours by placing ground sudan directly into the

[1]The authors are grateful to Jennifer Bradford and Dr. Ben Brent for their hard work and expertise in blood methemoglobin analysis.

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rumen via the cannula. Any cows displaying severe toxicity symptoms were treated with intravenous methylene blue. The characteristics measured in Exp. 1 were peak methemoglobin (mHb %), hours to peak (peak h), and ruminal pH. Curves showing rate of mHb increase and subsequent decrease were plotted for the duration of the experiment.

In Exp. 2, protein supplementation was examined utilizing seven mature, non-fistulated, crossbred, beef cows, also in a 7 × 7 Latin Square. Wheat midds, milo/urea (16% CP), and milo/soybean meal (16% CP) at 2 and 4 lb levels per head daily were compared again to a non-supplemented control group. All feed not consumed after 4 hours was weighed back. For this experiment, mHb %, peak h, and intake were measured and mHb curves were plotted.

Results and Discussion

In Exp. 1, there were no treatment effects on % mHb or peak h (Table 1) or in mHb curves for the energy sources and levels tested. No ruminal pH differences were detected. In Exp. 2, however, 4 lb milo/urea significantly lowered both mHb % and peak h (P = .01) compared to the control group. When 4 lb wheat midds was fed, mHb % was also decreased (P = .08). All protein sources tested lowered the mHb curve compared to the control group (Figure 1). This decrease appeared to be dose-dependent, with greater reductions seen in the 4-lb than the 2-lb groups for each treatment (Figure 2). No significant differences in forage intake were observed in Exp. 2.

Three cows in Exp.1, one control and two in the 4 lb soy hulls group, developed toxicity symptoms requiring medical intervention. All three were given 300 ml of a 1% methylene blue solution I.V. and complete recovery was apparent within one half hour of treatment. The effectiveness of methylene blue was demonstrated by the control cow, whose mHb level dropped from 73% to 0.5% in 30 minutes. No animals in Exp.2 reached high enough mHb levels to show clinical signs of toxicity.

We conclude that energy supplementation from the sources and at levels tested did not reduce the toxic effects of high nitrate forage. Protein supplementation, however, might prove to be a viable method of protecting cattle from nitrate toxicity. More work needs to be done before specific recommendations can be made.

Table 1. Effects of Energy or Protein Supplementation on Blood Methemoglobin Levels

Exp. 1	Control	Milo grain, lb		Wheat grain, lb		Soy hulls, lb	
		2	4	2	4	2	4
Peak mHb, %	45.1	45.9	35.8	45.9	36.8	52.8	58.1
Peak, h	8.9	8.9	8.4	8.9	7.8	8.2	8.9
Exp. 2	**Control**	**Milo/SBM, lb**		**Milo/urea, lb**		**Wheat midds, lb**	
		2	4	2	4	2	4
Peak mHb, %	30.0	31.9	20.1	21.5	14.1[a]	29.0	19.2[b]
Peak, h	6.6	6.3	5.7	6.9	4.6[a]	6.3	6.3

[a]Differs (P = .01) from control.
[b]Differs (P = .08) from control.

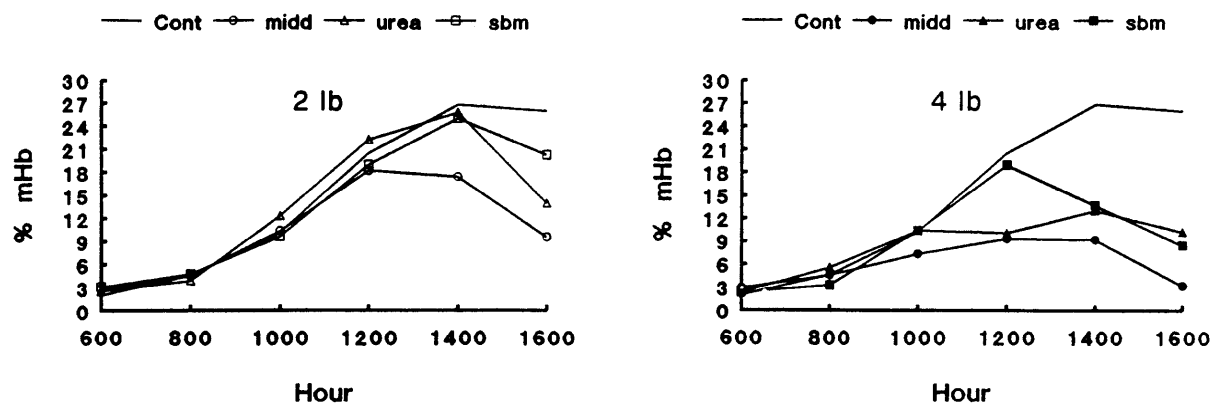

Figure 1. Effects of Source of Protein Supplementation on Blood Methemoglobin Levels - Exp. 2.

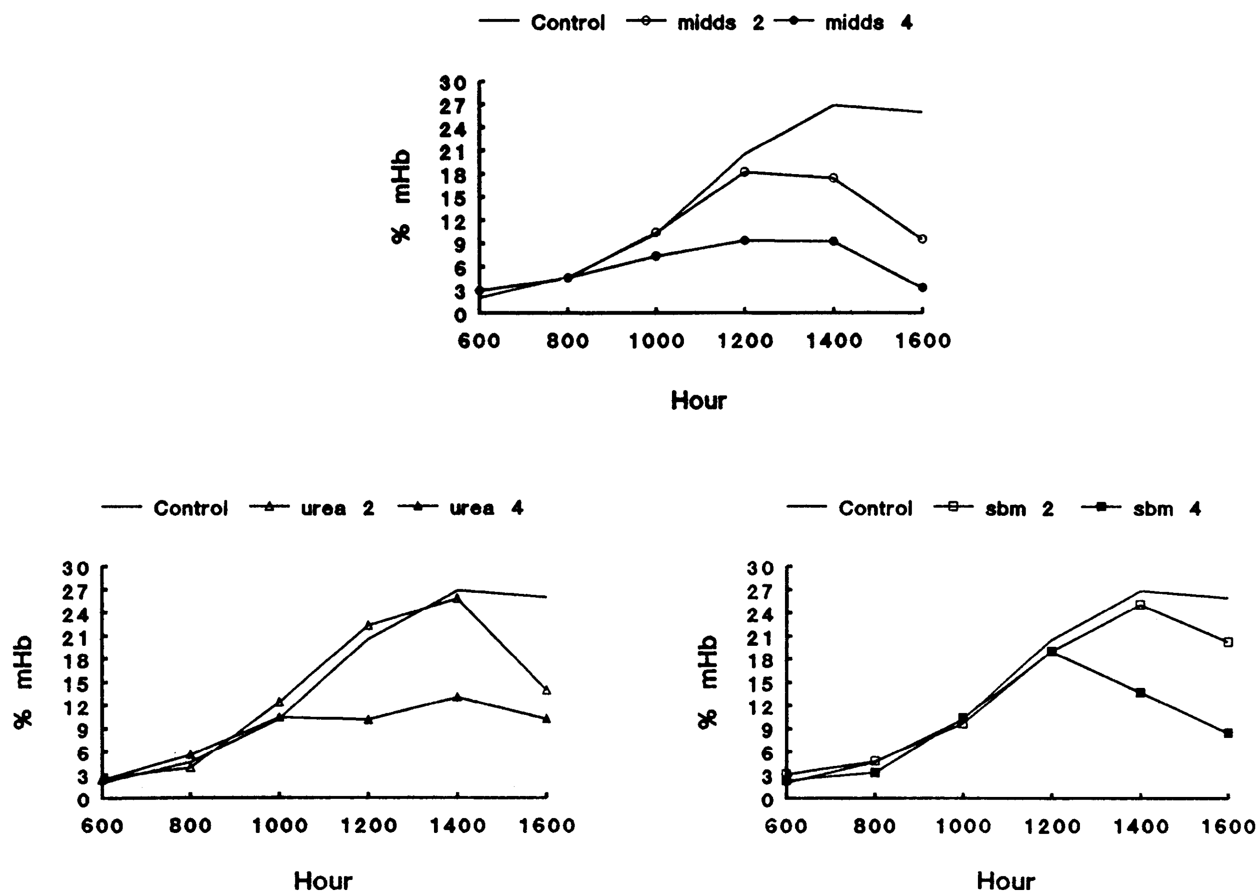

Figure 2. Effects of Level of Protein Supplementation on Blood Methemoglobin - Exp. 2.