Effect of Ammonia Level and Treatment Temperature on Intake and Digestibility of Wheat Straw by Lambs

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Summary

Replicate, covered wheat straw (WS) stacks were treated with 1.5 or 3.0% anhydrous ammonia in three environmental chambers at 37, 68, or 95 F, for 23 days. Then digestibility was measured (wethers). Rations were 88% wheat straw and 12% supplement. The control wheat straw was non-ammoniated but contained 5% urea in the supplement. Stack temperatures increased rapidly within 2.5 hours post-ammoniation, and equilibrated at chamber temperatures for the rest of the treatment period. Both crude protein (CP) and in vitro dry matter digestibility of the WS increased with ammonia level and treatment temperature. Percent of the ammonia recovered increased with temperature and was always higher with the low ammonia level treatment. Ammoniation improved ration intakes and dry matter digestibility, but did not increase CP digestibility which decreased as temperature increased. Ammoniation solubilized the hemicellulose, cellulose, and lignin and increased the digestibility of the fiber components.

Introduction

Increased cost of production has forced cattle and sheep producers to minimize costs wherever possible. Consequently, feeding crop residues has received considerable attention. Kansas produces millions of tons of wheat straw, corn stalks, grain sorghum stover, and soybean residue each year. These residues are low in digestible energy and crude protein, so treatment methods are needed that will improve their nutritive value. Recently, research with anhydrous ammonia treatment has received much attention in the popular press and its use is growing markedly among Kansas farmers and ranchers. Since residues can be treated during the hot summer months, under moderate temperatures of the spring, or during the cold winter months, we evaluated the effects of treatment temperature and ammonia level on nutritive value of wheat straw.

Experimental Procedures

Twelve stacks, each with nine rectangular bales (68 lb avg. wt.) of wheat straw, were probed with thermocouple wires, covered with plastic, and sealed. Replicate stacks then were treated with 1.5 or 3.0% anhydrous ammonia (NH_3) (air dry basis) in three environmental chambers of 3 C (37 F), 20 C (68 F) or 35 C (95 F). The appropriate amount of NH_3 was applied to each stack from an ammonia tank using a John-blue applicator to regulate the flow rate. The applicator was connected to 1 inch x 4 ft pipe that was inserted into the center of the stacks. Temperature was monitored within each stack at 15 minutes before, at 15 minutes after, and at 2.5 hours after treatment and then once a day for 22 days. On day 23, stacks were uncovered, removed from environmental chambers, and aerated for 5 days. Each stack then was tub-ground through a one-inch screen.

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Seven rations, 88% wheat straw and 12% supplement, were formulated to 9.3% crude protein (CP) and to meet NRC requirements of mature wether sheep for calcium, phosphorus, and Vitamin A (Table 16.1). Soybean meal (44% CP) was used as the protein source and grain sorghum (9% CP) was the carrier in the six ammoniated straw supplements. The untreated wheat straw supplement also contained 4.95% urea.

Twenty one mature wether sheep (110 lb avg. wt.), that were fitted with fecal collection bags and housed in individual digestion crates, were used to compare the seven straw rations (3 wethers per ration) in a two-period digestion trial. Each period consisted of a 14-day adaptation period, during which voluntary intake were measured, followed by a 7-days total collection at 90% of voluntary intake.

Results and Discussion

Figure 16.1 shows temperature changes during ammonia treatment. At 15 minutes after application, the temperature had increased rapidly in all stacks. After 2.5 hours, it started to decrease and at 24 hours after treatment, all stacks had returned to the chamber temperatures and remained there for the rest of the 23-day period.

Table 16.2 shows CP content of the straws fed to the wethers, the percent of the applied ammonia that was actually recovered in the straws, and the in vitro dry matter digestibilities (IVDMD) of the straws. Both CP and IVDMD increased with ammonia level and with treatment temperature. The amount of ammonia incorporated in the straws (percent NH_3 recovery) increased with temperature and it was always higher for the low level ammonia treatment at each temperature.

Table 16.3 shows the effects of treatment temperature and ammonia level on ration intakes and their apparent CP and dry matter (DM) digestibilities. Except for the low-temperature and low-ammonia level wheat straw ration, intake was lowest for the untreated straw ration. The highest intake was for the high-temperature and low-ammonia level straw ration. The CP digestibility was not increased by ammoniation and it decreased as temperature increased, indicating that the high temperatures made some of the incorporated nitrogen from the ammonia unavailable to the wethers. Ammoniation increased the DM digestibilities of the rations by an average of 7.0 percentage units (45.6 to 52.6%).

Table 16.2 shows the effects of ammoniation on the fiber components of the straws. When compared with the untreated straw, ammoniation solubilized an average of 7% of the hemicellulose, 3% of the cellulose, and 29% of the lignin.

Ammoniation increased digestibilities of hemicellulose by 24%, cellulose by 15%, acid detergent fiber (ADF) by 10%, and cell walls by 15% (Table 16.3).

Table 16.1. Ingredient Composition (%) of the Supplements Fed With the Straws.

Item	Temperature and NH_3 level (%)						
	37 F		68 F		95 F		
	1.5	3	1.5	3	1.5	3	Untreated
Grain sorghum	27.9	48.0	48.0	64.7	64.7	85.8	21.6
Soybean meal	62.0	41.0	41.0	24.4	24.4	4.0	63.3
Dicalcium phosphate	4.5	5.0	5.0	5.4	5.4	5.9	4.5
Limestone	2.3	2.3	2.3	1.9	1.9	1.8	2.3
Urea	-	-	-	-	-	-	5.0

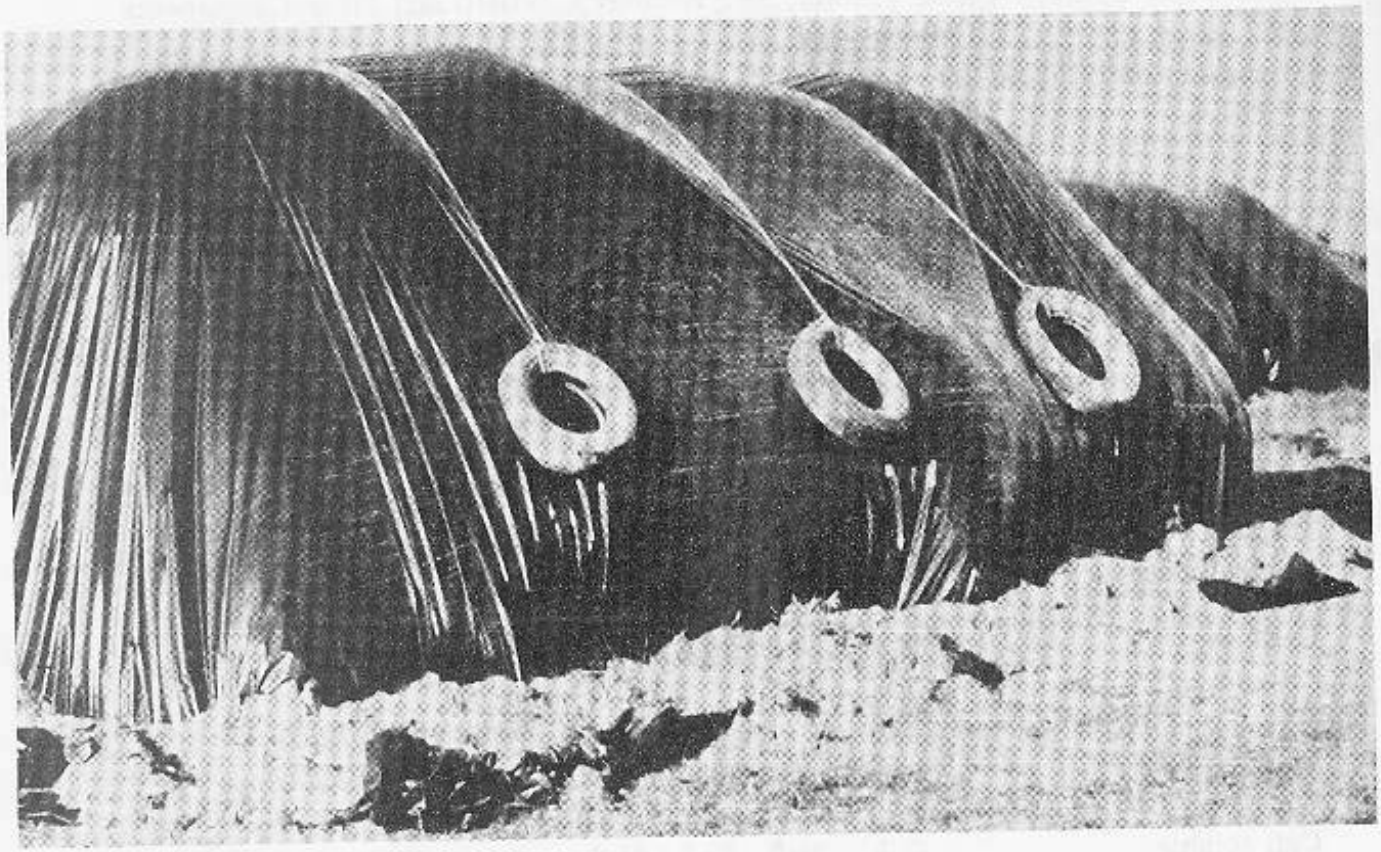
All supplements had the following ingredients: 2% salt, 1.0% tallow, 32 g vitamin A, 3 g vitamin D, 22 g vitamin E, and 227 g of trace mineral mix Z-10.

Table 16.2. Average Crude Protein, NH_3 Recovery, IVDMD and Fiber Components of the Straws.

Item	Temperature and NH_3 level (%)						
	37 F		68 F		95 F		
	1.5	3	1.5	3	1.5	3	Untreated
CP, %	5.8	6.7	7.1	7.8	7.7	8.8	3.9
NH_3 recovery, % of applied	24.7	18.2	41.6	25.3	46.4	31.8	-
IVDMD, %	54.1	55.2	55.7	56.1	57.3	56.7	47.2
Hemicellulose	26.8	24.0	24.8	23.9	24.5	24.8	26.7
Cellulose	38.6	38.8	38.6	39.1	39.9	38.0	39.9
ADF	55.4	56.1	55.2	54.5	56.5	56.3	55.6
Cell wall	82.2	80.0	80.0	78.8	81.0	81.1	82.4
Cell solubles	17.8	20.0	20.0	21.2	19.1	19.0	17.7
Lignin	10.5	10.8	10.2	10.4	10.3	10.8	14.8

Table 16.3. Intakes and Digestibilities of the Straw Rations.

	Temperature and NH_3 level (%)						
	37 F		68 F		95 F		
Item	1.5	3	1.5	3	1.5	3	Untreated
DM intake, gm/day	715	746	776	801	1030	858	717
	digestibility, %						
DM	51.4	52.3	52.1	53.5	53.8	52.7	45.6
CP	65.0	61.6	62.0	60.3	58.6	56.6	66.2
Hemicellulose	61.6	63.3	61.7	66.7	63.3	61.4	43.9
Cellulose	56.9	56.4	56.6	59.7	64.5	55.0	50.6
ADF	47.0	45.3	46.9	48.3	53.2	49.2	43.7
Cell wall	50.8	49.1	49.9	54.0	54.7	46.0	43.5



Ammoniated wheat straw, covered with plastic to reduce ammonia loss.

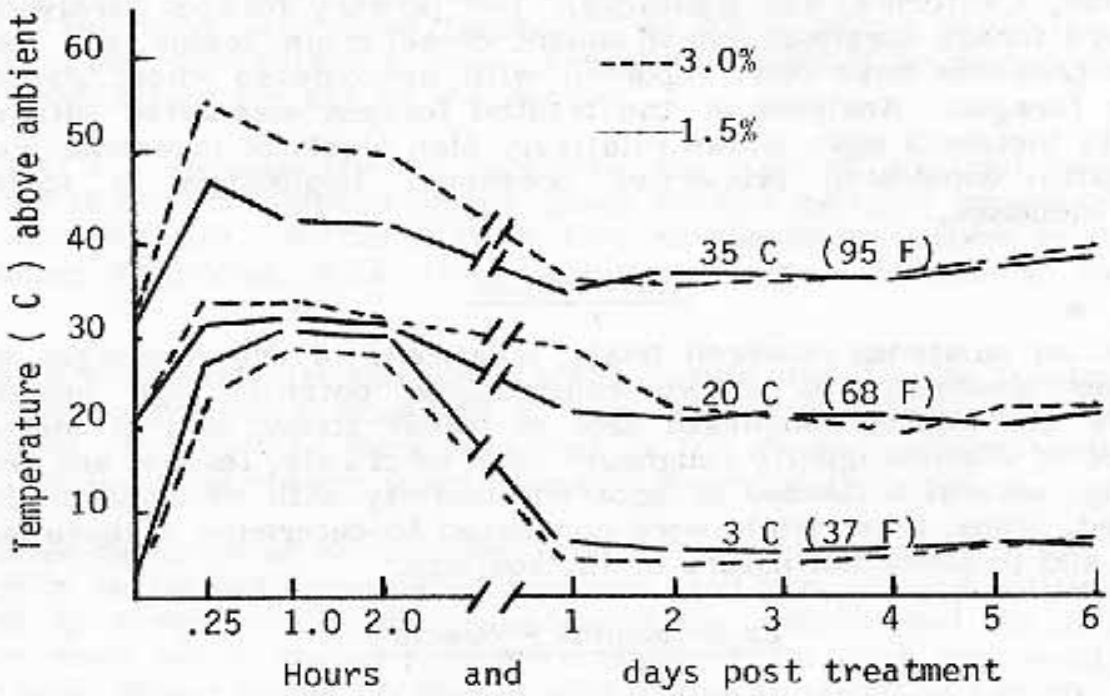


Figure 16.1. Temperature changes within the wheat straw stacks during ammonia treatment.