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Effect of Source of Supplemental Protein and Level of Supplement on Voluntary Intake and Performance of Lambs Fed Ammoniated Wheat Straw Silage[1]

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Story in Brief

Wheat straw was chopped, moistened to 38 percent dry matter (DM), ammoniated with 8.4 percent w/w anhydrous ammonia and stored in an Ag-Bagger. The resultant "ammoniated straw silage" was individually fed *ad lib* to lambs with a negative control supplement containing only molasses and minerals, two levels of a soybean meal-based supplement or two levels of a corn gluten meal-based supplement. Lambs fed the negative control supplement consumed 2.48 percent of their body weight as straw DM and lost 0.07 lb/day. Source of supplemental protein did not affect ($P>.05$) gain or straw consumption. Level of supplement increased ($P<.01$) gains but did not affect ($P>.05$) ammoniated straw DM consumption. Lambs fed the ammoniated straw silage and 0.44 lb/day of a 36-percent crude protein-soybean meal supplement ate more ($P<.01$) and gained faster ($P<.01$) than the control lambs. The ammoniated straw silage contained 2.10 percent of the DM as free ammonia, which was 56.8 percent of the total nitrogen. Acid detergent fiber-bound nitrogen represented 19.7 percent of the total nitrogen. The cellulose content of the silage was 47.3 percent of the DM and was 60 percent digestible *in vivo* when fed with the low level of the soybean meal supplement. The hemicellulose content of the silage was 9.7 percent and was completely digested.

Introduction

Dry treatment of crop residues with anhydrous ammonia has been reported to improve digestibility and voluntary consumption by ruminant animals (Streeter and Horn, 1980). However, few ammoniation studies have been conducted with crop residues that have been moistened to a dry matter (DM) content of 30 to 40 percent so

[1]This work was conducted as a part of Research Agreement No. 58-7B30-9-87 between the USDA (SEA/AR; Southwestern Livestock and Forage Research Station, El Reno, OK) and the Okla. Agr. Exp. Sta.
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that the resultant feed can be stored and handled as silage. Most treated crop residues are lacking sufficient protein and available energy to support performance above maintenance. Supplementation of such treated material with concentrates to improve performance may have a negative effect on fiber digestibility and reduce crop residue consumption. Supplementation with a high rumen by-pass protein might increase performance if there is sufficient ammonia present in the treated residue to support microbial protein synthesis.

It was the objective of this experiment to evaluate the effect of two sources of supplemental protein—soybean meal and corn gluten meal—and two levels of supplement intake on lamb performance and voluntary consumption of ammoniated wheat straw that had been moistened to 38 percent DM during ammoniation.

Materials and Methods

Wheat straw was chopped with a conventional grinder mixer to approximately 1-inch lengths, moistened to 38 percent DM and delivered into the hopper of an Ag-Bagger[3] for storage. Anhydrous ammonia was applied under water on the floor of the Ag-Bagger hopper at 8.4 percent w/w of the straw DM. The straw remained in the Ag-Bag for 30 days prior to feeding and is hereafter termed ammoniated straw silage even though fermentation was limited because of the high pH.

The silage was individually fed *ad lib* to 60 ram or ewe lambs randomly assigned by sex to five supplement treatments. The lambs received their supplements mixed with the silage for 28 days. The daily supplements included: 1) a negative control containing 0.11 lb of liquid molasses and minerals; 2) 0.44 lb of a 36-percent crude protein, soybean meal-based supplement; 3)0.88 lb of an 18-percent crude protein, soybean meal-based supplement; 4) 0.44 lb of a 36-percent crude protein, corn gluten meal-based supplement; or 5) 0.88 lb of an 18-percent crude protein, corn gluten meal-based supplement. The ingredient composition of each supplement is shown in Table 1. Daily supplemental crude protein intake was the same for treatments (2) through (5).

Lamb gain over the 28-day feeding period was calculated from initial and final shrunk weights. *Ad lib* silage DM intake was calculated on the last 6 days of the trial because large daily fluctuation during the early phase of the trial precluded precise intake measurements.

Ruminal fluid was collected via a suction tube from three ram lambs receiving each treatment. Collections were made immediately prior to feeding and 4 hours thereafter on the 28th day of the trial. The ammonia concentration of the ruminal fluid was determined spectrophotometrically using the reagents of Chaney and Marbach(1962).

Table 1. Ingredient composition and crude protein content (DM basis) of supplements fed with ammoniated straw silage

		Source of supplemental protein			
	Negative control	Soybean meal		Corn gluten meal	
Supplement level, lb/day	0.11	0.44	0.88	0.44	0.88
Ground shelled corn, %	X	X	60.5	25.0	68.0
Soybean meal, %	X	75.0	25.0	X	X
Corn gluten meal, %	X	X	X	50.0	17.5
Molasses, %	8.7	4.0	4.0	4.0	4.0
Dicalcium phosphate, %	69.6	16.0	8.0	16.0	8.0
TM salt, %	21.7	5.0	2.5	5.0	2.5
Crude protein, %	X	36	18	36	18

[3]Ag-Bag Corporation, Astoria, Oregon.

The form of nitrogen present in the ammoniated straw silage was determined on a composite sample of silage fed during the last 6 days of the trial. The analysis was conducted on undried frozen samples and included total Kjeldahl nitrogen, nitrogen bound to acid detergent fiber (Goering and Van Soest, 1970) and free ammonia nitrogen as determined by a modification of the magnesium oxide method (Horwitz, 1975). A portion of the same composite was dried at 130°F for 48 hours and ground through a Wiley mill with a 2 mm screen. The neutral detergent fiber, acid detergent fiber and permanganate lignin content of the above sample were measured as described by Goering and Van Soest (1970). Cellulose was assumed to be the difference between acid detergent fiber and lignin, and hemicellulose was calculated from the difference between neutral detergent fiber and acid detergent fiber.

Four different ram lambs weighing 61.6 lb were placed in metabolism crates and fed the same ammoniated wheat straw silage described above and 0.44 lb per day of the soybean meal supplement containing 36 percent crude protein described in Table 1. After 50 days of *ad lib* silage feeding, the silage intake was restricted to 1.49 lb of dry matter for 10 days. During the last 7 days total fecal collections were made and digestibility of dry matter and cell wall constituents determined. Straw DM digestibility was calculated by difference using 64 percent DM digestibility for the supplement. Supplement DM digestibility was calculated from total digestible nutrient values reported by the National Research Council (1976).

Results and Discussion

Lambs fed ammoniated straw silage and a negative control supplement consisting of 0.11 lb of a molasses-mineral mixture consumed 2.48 percent of their body weight as straw DM (Table 2). Source of protein and level of supplement did not affect (P>.05) straw DM consumption. There was also no interaction (P>.15) between source of protein and supplement level with respect to straw consumption. Lambs receiving 0.44 lb/day of the 36-percent crude protein-soybean meal supplement ate 2.79 percent of their body weight as ammoniated straw DM, which was greater (P<.01) than that of lambs fed the negative control supplement. Straw consumption of lambs fed the other three supplements was not different (P>.05) from that of lambs fed the negative control supplement.

Table 2. Effect of source of supplemental protein and level of supplement on straw silage DM intake and average daily gain

		Source of supplemental protein			
	Negative control	Soybean meal		Corn gluten meal	
Supplement level, lb/day	0.11	0.44	0.88	0.44	0.88
Mean body wt., lb	57.9	59.8	60.1	61.8	61.4
Straw silage intake,					
lb/day[abc]	1.43	1.68	1.52	1.54	1.52
% body wt.[abc]	2.48	2.79	2.48	2.51	2.46
Average daily gain,					
lb/day[def]	-0.070	0.120	0.228	0.124	0.219

[a]Main effects of source of protein and supplement level not significant (P>.05).
[b]No interaction (P>.15) between source of protein and supplement level.
[c]Only lambs fed 0.44 lb soybean meal-based supplement ate more (P<.01) straw DM than negative controls.
[d]Main effect of source of protein not significant (P>.05), main effect of supplement level significant (P<.01).
[e]No interaction (P>.15) between source of protein and supplement level.
[f]All supplemented lambs gained more (P<.01) than negative controls.

Lambs fed the negative control supplement lost 0.07 lb/day (Table 2). Source of supplemental protein did not affect (P>.05)gain. If corn gluten meal by-passed the rumen more than soybean meal, it either was not more readily absorbed in the lower tract or did not have as good an amino acid balance. However, energy, not protein, may have been the factor limiting growth.

Level of supplement increased (P<.01) gain as would be expected because of the greater overall consumption of available energy. There was no interaction (P>.15) between source of protein and level of supplement with respect to average daily gain.

The total Kjeldahl nitrogen content of the ammoniated straw silage was 3.70 percent of the DM (Table 3), which is equivalent to 23.1 percent crude protein. The question of the utilization of this nitrogen by the ruminant animal is a difficult one to answer. The nitrogen was present mainly (56.8 percent) as free ammonia with substantial amounts of acid detergent-bound nitrogen (19.7 percent). Ruminal ammonia levels were high at 0 and 4 hours after feeding (Table 4) but were not affected (P>.05) by level or source of supplement. The improvement in weight gain of lambs supplemented with soybean meal or corn gluten meal indicates limited utilization of the nitrogen in the ammoniated straw silage. However, additional energy was also added with supplement, and energy intake may have been first-limiting with respect to growth.

The DM and cell wall constituent contents and digestibilities of the ammoniated straw silage fed in the digestion trial are shown in Table 5. The DM content of the silage was 38 percent, and the DM was 58.9 percent digestible. Cellulose constituted 47.3 percent of the straw DM and was 60.0 percent digestible. The hemicellulose content of

Table 3. Form of nitrogen present in ammoniated straw silage

Form	% of DM	% of Total N
Total Kjeldahl	3.70	100.0
ADF bound	0.73	19.7
Free ammonia	2.10	56.8
Undetermined	0.87	23.5

Table 4. Effect of source of supplemental protein and level of supplement on ruminal ammonia levels (mg%)

Sampling time[a] (hr)	Supplement level, lb/day	Negative control	Source of supplemental protein: Soybean meal		Corn gluten meal	
		0.11	0.44	0.88	0.44	0.88
0		16.3[b]	29.4	29.8	22.8	15.6
4		22.3	45.1	42.2	37.0	34.4

[a]Ruminal samples collected 0 and 4 hr after feeding on last day of trial from three sheep per treatment.
[b]No difference (P>.05) in main effects or interactions and values for supplemented lambs were not different (P>.05) from negative controls.

Table 5. Dry matter and cell wall constituent content and digestibility of ammoniated straw silage

Constituent	Content: As fed	Content: Dry matter	Digestibility
Dry matter, %	38.0	100.0	58.9
Cellulose, %	18.0	47.3	60.0
Hemicellulose, %	3.7	9.7	100.0
Lignin, %	5.1	13.3	34.0

the straw was only 9.7 percent, and digestibility was apparently 100 percent because the acid detergent fiber content of the feces was greater than the neutral detergent fiber content. Lignin was 13.3 percent of the straw DM and had a digestibility of 34.0 percent.

The results of this study would indicate that lambs will not eat enough ammoniated wheat straw silage to maintain body weight. Supplementing the ammoniated straw silage with either soybean meal or corn gluten meal resulted in similar increased silage DM consumption and gain. Doubling the supplement level but maintaining protein intake resulted in a doubling of lamb gain with no effect on silage intake. The ammoniated straw silage DM was 59 percent digestible and contained only 10 percent hemicellulose and 3.70 percent Kjeldahl nitrogen.

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Story in Brief

Lambs were fed a basal ration of wheat straw that had been chopped, moistened to approximately 35 percent dry matter (DM), ammoniated with anhydrous ammonia and ensiled in an Ag-Bagger. Lambs were fed one of three levels of supplement, each with .128 or .256 lb of crude protein per day. Protein level did not affect ($P>.05$) silage DM consumption, but there was significant ($P<.15$) supplement level- by-protein level interaction. Silage dry matter intake decreased as level of supplement increased from .44 to 1.32 lb, regardless of the amount of protein fed. Silage dry matter consumption was only 68 percent of that observed during a previous study. The reduced intake was attributed to the large ammonia intake or less desirable ensiling conditions. Average daily gain was not affected ($P>.05$) by protein level but increased ($P<.01$) with supplement level.

This work was conducted as a part of Research Agreement No. 58-7B30-9-87 between the U.S.D.A. (SEA/AR; Southwestern Livestock and Forage Research Station, El Reno, OK) and the Okla. Agr. Exp. Sta.