



Texas Agricultural Extension Service

HAY AMMONIATION

Tom R. Troxel

Extension Livestock Specialist
The Texas A&M University System

Hay producers strive to produce high quality hay, but weather and other factors frequently prevent harvesting at optimum maturity. The resulting hay is characteristically very mature and low in crude protein, digestibility and energy content. Animals consuming low quality hay cannot achieve optimum performance without costly supplementation.

Treating low quality hay with anhydrous ammonia improves the hay's nutritive value by:

1. Increasing digestibility: Ammoniating low quality roughage will greatly increase its digestibility (5 to 15 percent). This increase in digestibility results from a breakdown of the hay's fibrous parts.

2. Increasing animal intake: In feeding trials, ammoniation of hay has increased animal intake by 15 to 25 percent. This indicates that ammoniated hay is readily consumed by cattle provided the ammoniated hay is allowed to air out for 2 to 3 days before feeding. Because the fiber is more digestible in ammoniated hay, less indigestible fiber builds up in the digestion tract and the rate of passage increases.

3. Increasing crude protein: Anhydrous ammonia adds a non-protein nitrogen source which can be converted by rumen bacteria to protein. Ammoniation will increase the crude protein equivalent by 3 to 8 percentage units. This is particularly important with overly mature grasses and crop residues.

4. Greatly increased energy and protein consumption: The increase in protein and energy content,

along with increased intake, results in a 35 to 45 percent increase in energy and protein consumption.

5. Preservation of forages: Anhydrous ammonia is an excellent fungicide. It kills mold and fungus that cause heating and deterioration in hays and crop residues. This deterioration usually occurs in forages that have been harvested too wet.

6. Increased animal performance: A study with orchardgrass at Purdue University (Table 1) illustrates the effects of feeding ammoniated hay on animal performance.

This study illustrates the improvement in animal gains for ammonia and indicates that the anhydrous ammonia added to the hay may be utilized by the animal well enough to preclude the need for additional protein supplementation.

A study was conducted in Oklahoma where beef cows were fed either ammoniated or untreated wheat straw supplemented with equal protein supplements. In 90 days, cows fed ammoniated hay lost 15.9 pounds while cows fed unammoniated hay lost 89.6 pounds (Lusby, 1982. "Ammoniation Sharply Improves Poor Hay." *Southwest Farm Press*).

In a 40-day test on 57 lactating cows in Jackson County, Texas, cows fed ammoniated coastal and Gordo hay lost 0.48 pounds of weight per day while cows fed non-ammoniated hay lost 0.79 pounds per day (Sprott, L.R., et al., 1984).

Table 1. Effect of anhydrous ammonia treatment and supplementation on daily gain and hay consumption by steers.

Supplement (lb/hd/day)		Hay	Daily Gain (lb/hd)	Hay Consumed (dry matter) (lb/hd/day)
Corn	Soybean Meal			
0	0	Untreated	0.35	8.70
		Ammoniated	0.81	10.47
4.0	0	Untreated	1.00	8.02
		Ammoniated	1.56	9.47
3.0	1.0	Untreated	1.17	7.95
		Ammoniated	1.53	9.80

Source: Lechtenberg, Hendrix and Hertel. "Animal Gains on Ammoniated Hay." Indiana Beef Cattle Day. Purdue University, 1980.

Hay Ammoniation Procedures

Hay ammoniation is sealing hay in a black plastic and then releasing the required amount of anhydrous ammonia. The following recommendations will aid in proper ammoniation of hay.

Type of hay

Hay ammoniation will work on any type of fair to low quality hay. Forage testing is the first step in the hay ammoniation process to compare the nutrient value of the hay to the animal's needs.

Quantity of hay

The quantity of hay is limited only by the amount of hay that can be properly sealed under plastic. For large stacks of hay, anhydrous ammonia should be released in more than one place in the stack. Connecting a PVC pipe with holes drilled at 2- to 3-foot intervals to the anhydrous ammonia outlet hose ensures even uptake by the hay.

Ammoniation after baling

The advantages of immediate ammoniation include no weathering loss prior to ammoniation, higher temperatures speed the ammoniation process and ammoniation acts as a preservative for hay baled slightly moist. The disadvantage is that once ammoniated, hay must remain covered or otherwise protected from the weather until fed.

Amount of anhydrous ammonia to use

Research indicates that increases in feeding value occur at rates of 1, 2 or 3 percent anhydrous ammonia. Some benefits occur at lower rates, but the optimum rate is 3 percent (60 pounds of anhydrous ammonia per ton of hay). There may be some danger in applying more anhydrous ammonia than 3 percent. Additional anhydrous ammonia (above 3 percent) is just adding additional cost because the hay has a maximum level of anhydrous ammonia it can absorb.

Sealing the hay in plastic

It is important that the plastic around the hay is as airtight as possible so more of the ammonia applied will be taken up by the hay. Cost of extra plastic, sand or other materials and labor to ensure a good seal should be weighed against extra benefits. Hay can be placed on the ground and completely covered with 6 millimeter black plastic. The ends and edges can be sealed by laying posts or pipes. Loose sand can be used to seal up areas where anhydrous ammonia is leaking. A 20 x 50 foot piece of plastic will cover 6 to 7 round bales of hay and a 40 x 100 foot piece of plastic will cover a 6 bale pyramid stack, 14 to 15 bales long (84 to 90 bales).

Feeding procedures

Ammoniated hay should be fed like other hays. Increased animal intake and less waste and sorting of coarse hays should occur. Feeding in hay racks is suggested to avoid loss by trampling. Before feeding ammoniated hay from sealed plastic, open the plastic cover for about three days or until the smell of excess anhydrous ammonia leaves.

Penetration time

Seventy-five percent of the increase in fiber digestibility occurs in 1 week and 97 percent occurs in 3 weeks. Time for the anhydrous ammonia to penetrate the hay is somewhat temperature dependent. Use the following general guidelines:

Temperature	Minimum Time for Penetration
above 86°F	1 week
59-86°F	1 to 4 weeks
below 59°F	4 to 8 weeks

A 3 week minimum is usually necessary for ammoniation.

Storage after ammoniation

Treated hay should be protected from the weather. To protect the hay, leave the plastic cover on, cover with hay bonnets or put the hay inside barns until fed. Never treat hay in barns. Anhydrous ammonia is very explosive and corrosive to metal (i.e., nails, tin). The anhydrous ammonia partially breaks down the fiber in the hay for increased digestibility; however, faster spoilage can occur if exposed to the weather. Ammoniated bales are very loose, oblong and lack the ability to shed rainfall.

Dangers from feeding ammoniated hay

There are cautions which need to be considered. Ammoniation of a very low quality roughage (such as rice straw or wheat straw) does not improve its feeding value enough for such feeds to make up the total diet of the animal, especially growing cattle or young mother cows. Certain levels of energy are necessary in the diet for conversion of the ammonia nitrogen to bacterial protein in the cow's rumen. Without adequate energy, non-protein nitrogen (NPN) toxicity is possible, but isn't likely if recommended feeding practices are followed. In many cases some grain or high quality forage will need to be fed along with the ammoniated product. This amount is dependent on the quality of the roughage source and the type of cattle being fed. Proper mineral supplementation, vitamin A and possibly some natural protein supplementation should be considered for certain classes of cattle.

Results from Hay Ammoniation Demonstrations

Forage	% Crude Protein		% Digestible Dry Matter ^a	
	Ammoniation		Ammoniation	
	Before	After	Before	After
Coastal	7.9	15.0	48.6	63.5
Sorghum	5.5	13.7	62.2	66.1
Sudan	5.2	13.4	54.0	64.8
Kleingrass	3.1	8.0	44.7	47.1
Oat Hay	7.2	15.9	59.6	68.2
Fescue Hay	6.6	14.8	39.7	57.7
Crop Residue				
Wheat Straw	3.5	9.0	44.5	52.1
Corn Cobs	4.2	9.3	42.7	47.9
Corn Stover	5.0	11.5	47.4	56.5
Milo Stover	5.4	16.8	46.2	61.3

^aPercent digestible matter in vitro

Cases have been reported where cattle developed problems when fed ammoniated sorghum hay and wheat hay. Nervous, irritable, wild and convulsive behavior has been observed in cows and younger calves. A small percentage of the affected animals died. In some cases, euthanasia was necessary when animals physically injured themselves during fits of wild behavior. When taken off ammoniated hays, the cattle displayed no further symptoms. Under certain conditions, anhydrous ammonia reacts with sugar in sorghum plants to produce a toxin which adversely affects cattle. No problems of this nature have been reported where low-sugar material such as small-grain straw, corn stubble or bermudagrass hay have been ammoniated and fed.

Cost of Hay Ammoniation

Cost of hay ammoniation varies from \$8 to \$14 per ton. This includes \$3.65 per ton for the plastic cover and \$4.40 to \$7.50 for 60 pounds of anhydrous ammonia per ton of hay. The increased feeding value ranges from \$22 to \$25 per ton to as high as \$40 per ton.

Safety Precautions

Remember that anhydrous ammonia is very dangerous. It will burn skin, eyes or throat, can explode and burn and is maintained under pressure. Safety suggestions include:

1. Check valves, hoses and tanks for potential leaks.
2. Check plastic covers for leaks.

3. Wear goggles, rubber gloves, respirator and protective clothing.
4. Work upwind from the hay when releasing anhydrous ammonia.
5. Have fresh water available to wash off any anhydrous ammonia which may come in contact with the skin.
6. Do not smoke near anhydrous ammonia.
7. Fence the treatment area to prevent animals or children from being exposed to the anhydrous ammonia.
8. Remember, anhydrous ammonia is very corrosive to most metals. Do not treat hay near barns, equipment, etc.

Guidelines

1. Anhydrous ammonia can be applied to any forage package—square or large bales, loaves, loose stacks, etc.
2. Apply soon after harvest to prevent weathering feed loss.
 - a. Warm weather speeds up treatment effect.
 - b. Can be applied during cool weather, but takes longer.
3. Cover forage with plastic to seal in ammonia:
 - a. Group bales or stacks together for efficient plastic use.
 - 1) Select a level site with wind protection, if possible.
 - 2) If available, a bunker or pit silo is an excellent site.

- b. Cover with 6 to 8 millimeter black or UV resistant clear plastic.
 - c. Seal well around edges with soil, gravel, etc.
 - d. Plastic is not needed under the forage.
 - e. Example: 1 roll of 40' x 100' plastic will cover a 6 bale pyramid stack 14 to 15 bales long (84 to 90 bales).
4. Apply about 3 percent (60lb./ton) ammonia (50 lb. actual N) to forage:
 - a. Apply ammonia through hose or pipe sealed under plastic.
 - b. Use regulator or gauge for accurate application or under a nurse tank with only the amount of ammonia needed for treatment.
 - c. Apply ammonia slowly to minimize ballooning of plastic—1 to 5 minutes per ton has been used successfully.
 - d. During application some of the ammonia will turn to a cold liquid. A depression or trench under the stack will help to contain it.
 - e. The gaseous ammonia will balloon the plastic for 1 to 3 hours.
 - f. Make sure equipment is in good shape. Work upwind and handle anhydrous ammonia safely.
5. Keep covered for at least 15 to 45 days, depending on temperatures:
 - a. Best to leave covered to prevent weathering until 3 to 7 days prior to feeding.
 - b. After uncovering, aerate 3 to 7 days to allow residual ammonia to escape before feeding.
 - c. Can be tub ground before feeding without loss of treatment effect.
 - d. If forage is to be analyzed for crude protein, label the sample "ammonia treated" so the lab can analyze it correctly.

Acknowledgment

Appreciation is expressed to Drs. David Bade, forage specialist; Jerry Cowley, livestock specialist; and Dale Lovelace, forage specialist, Texas Agricultural Extension Service, for providing information for this publication.

Educational programs conducted by the Texas Agricultural Extension Service serve people of all ages regardless of socioeconomic level, race, color, sex, religion, handicap or national origin.

Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Zerle L. Carpenter, Director, Texas Agricultural Extension Service, The Texas A&M University System.

5M—5-88, Revision

AS1