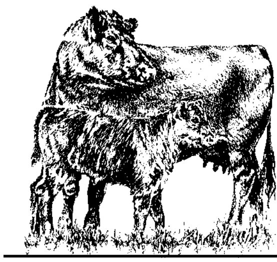

Western Beef Resource Committee *Fourth Edition*

Cattle Producer's Handbook

Nutrition Section 382

Ammoniation and Use of Ammoniated Low-Quality Roughages

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Of all the chemical treatments devised and tested to improve the digestibility and intake of low-quality forages, ammoniation has become the most popular method in practical application. Ammoniation involves sealing forages in polyethylene and injecting anhydrous ammonia through feeder tube(s).

Anhydrous ammonia easily permeates the tissues of low-quality forages and mixes with the water in the forages to form ammonium hydroxide. Treating low-quality forages will usually increase intake by about 17 to 18 percent and digestibility by about 20 percent. This is dependent on forage type.

Advantages of Ammoniation Compared to Other Treatment Methods

Anhydrous ammonia is commonly used as a nitrogen fertilizer. It is widely available, particularly where cereal grains are grown and straw and stalks are available. In addition, most agricultural supply firms are trained and equipped for proper and safe use of the chemical.

Anhydrous ammonia treatment generally increases the crude protein (CP) content of low-quality forages by 1.5 to 2.0 fold. For example, ammoniation of cereal straws typically increases CP from 3-4 to 6-8 percent, however, CP is in the form of nonprotein nitrogen (NPN). The NPN supplies nitrogen required by ruminal microorganisms to ferment fiber, but none of the other raw materials needed by these microorganisms for efficient fiber utilization. As a result, the additional CP from NPN is useful, but not as useful as from natural CP sources.

Ammonia is also effective at neutralizing some toxins, such as those produced by certain molds. For example, ammoniation is a common method of detoxifying feeds that are contaminated with aflatoxin, a powerful carcinogen.

Ammoniation can also preserve feeds by inhibiting the growth of molds, etc. Many household disinfectants contain ammonia for this reason.

Ammoniation does not add high amounts of minerals as do other methods. Although it is generally reported that sodium hydroxide treatment improves low-quality forage utilization more than ammoniation, high levels of sodium intake may eventually reduce animal performance. Calcium hydroxide treatment may also result in high calcium intake that could interfere with the metabolism of several other minerals. These types of treatments are effective but are usually too expensive.

The ammoniation procedure is much more compatible to on-farm treatment than other hydroxide methods that may require grinding, soaking and drying, or specialized equipment for spraying. Low-quality forages can be ammoniated after stacking regardless of the size and shape of the bale package. The size of the stack that can be treated is limited only by the size of the polyethylene stack cover that is available.

Description of the Ammoniation Process

Roughage Sources

A stack of forage should be ammoniated only if it qualifies as low quality. It should be below 6 percent CP and higher than 70 percent neutral detergent fiber (NDF). Ammoniating higher quality grass forages can cause the formation of toxic substances because ammonia reacts with free sugars in the forage. Usually, when forages are over 70 percent NDF, free sugar content is minimal.

Conversely, it is not economical to ammoniate forages that are too low in quality. This category includes forages that are below 3 percent CP or higher than 80 percent NDF. Poor quality forage of this type may result from getting wet and lying in the field too long. Sunlight and other types of weather conditions leach away nutrients from an already limited supply. Although ammoniation will improve the digestibility and intake of these extremely low-quality forages, the improvement will not be economical in most instances.

The type of forage to be ammoniated is also important. The utilization of low-quality forages belonging to the grass family is improved by ammoniation (e.g., mature or weathered grass hay, cereal straws, and corn stalks). The utilization of low-quality legume forages is usually not improved by the ammoniation process. This is thought to be due to complex bonding between lignin and fibrous carbohydrates in most legume forages. As a result, the use of low-quality forages (such as alfalfa or clover straw), soybean straw, lentil straw, or pea straw will not normally be improved by ammoniation.

Moisture Content

During the process, anhydrous ammonia must combine with water to form ammonium hydroxide. Low water content in the forage will result in sub-optimal ammoniation. Low-quality forages should be 15 to 20 percent moisture. Baled cereal straws generally contain 5 to 10 percent moisture. To obtain the desired moisture level, baling with the dew on should be considered.

Furthermore, if straw is being purchased for ammoniation, there is no control of moisture content. Rehydration of low-quality forages should be considered. This method works well with medium and large bale packages where the bales are usually individually stacked. Water can be spread over the top of these larger bales just before stacking.

A concern is that adding water will encourage molding. However, proper ammoniation inhibits mold growth. The amount of water to add to each bale before stacking needs to be considered. Straw bales can be of various weights and sizes. Using a weight of 500 pounds and 8 percent moisture the bale would contain:

500 x .08 = 40 lb of water
and 500 - 40 = 460 lb of DM

If 50 pounds of water are added to each bale it would still contain 460 pounds of DM but 90 pounds of water. The moisture content would be:

90 lb ÷ (460 + 90) lb = .164
or 16.4 percent moisture

By knowing the flow rate of a garden hose you can spread the needed amount of water over the surface of each bale (50 pounds of water is about 6 gallons). If small square bales of low-quality forage are being used, and are hand stacked, an appropriate amount of water can be added with a sprinkler to each tier. However, most small bales are put up using stack wagons of 100 to 170 bales. For these types of stacks, place a sprinkler on top of the stack and allow water to percolate slowly through the stack.

Fairly accurate estimates must be known of how much water is being added to the stack. If too much water is added to the stack it will become top heavy and the bottom bales will soften. As a result, the stack could tip over.

A stack containing nine wagonloads is conveniently ammoniated since a 40 x 100 foot sheet of polyethylene will easily cover the stack. Such a stack would contain about 1,530 small bales. As most small straw bales weigh about 50 pounds, the following is an example of the calculations used to determine how much water should be added to the stack:

1,530 bales x 50 lb/bale =
76,500 pounds total weight

In the previous example it was determined that about 50 pounds of water be added to a 500-pound bale of straw. Therefore, to the stack add:

(76,500 ÷ 500) x 50 = 7,650 pounds of water
or 7,650 ÷ 8.3 = 922 gallons of water

After rehydrating the stack, it should be covered as quickly as possible because moisture can be rapidly lost from the stack in hot weather.

The size or type of bales does not affect the ammoniation process. Loose stacks, round bales, small square bales, and large square bales can be effectively ammoniated.

The most convenient stack size is about 12 feet high, 10 feet wide, and 70 feet long. A stack with these dimensions is easily covered by a 40 x 100 foot sheet of 6 mil black polyethylene with about 3 feet of lap on the ground all the way around the stack.

Mechanics of Ammoniation

Before the stack is covered, supply tubes are placed to inject anhydrous ammonia. Two pieces of 1 to 1.5 inch galvanized pipe work well for this purpose. The pipes should be 16 to 20 feet long (Fig. 1). One end of the pipe should protrude about 2 to 3 feet out of the stack so the anhydrous ammonia supply tank can be attached.

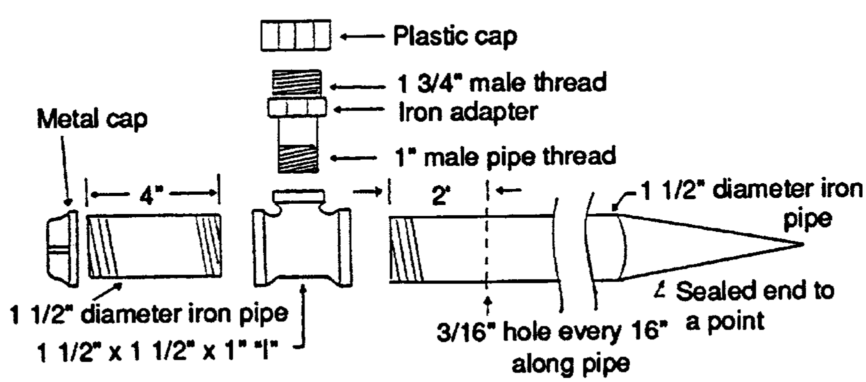

Fig.1. Details of ammoniated pipe about 20 feet long.

The very end of the pipe inside the stack should be sealed with an end cap or it can be hammered flat. It may be advisable to form the end of the pipe into a sharp point so that by using a tractor the pipe can be pushed into the stack. The 3 to 4 feet behind the sealed end of the pipe should be perforated with 3/16 to 1/4 inch holes to allow the ammonia to escape from the tube into the stack.

For stacks being constructed by machine or hand, the supply tube should be placed about 2 to 3 feet from the bottom of the stack as it is being constructed. The tube should be inserted near the bottom of the stack because the anhydrous ammonia will rise.

One supply tube should be placed at each end of a 70-foot long stack. If wagon stacks are being ammoniated, the tubes will have to be pushed into the stack using a tractor. Pointing the end of the pipe greatly aids this process. Seams can usually be found in stacks that allow the tubes to be pushed in rather easily.

Sealing the Stack

After the stack is constructed and the supply tubes are in place, the stack needs to be quickly covered and sealed with at least a 6 ml black polyethylene sheet. About 3 feet of the sheet should lap on the ground around the stack. To anchor and seal the polyethylene sheet, place road-base gravel on the lapping portion of the polyethylene. The road-base gravel works well because it is a mixture of fine gravel, sand and clay, and is fairly dense, yet easy to handle. A front-end loader on a tractor facilitates this job.

When placing the gravel on the polyethylene around the base of the stack make sure the gravel doesn't pull the polyethylene tighter over the stack. If the polyethylene is too tight it will increase the likelihood of coarse stems of the forage ripping or puncturing the plastic. Also, as anhydrous ammonia is being injected into the stack it expands greatly as it changes from a liquid to a gaseous state. Leaving slack in the polyethylene sheet will allow for this expansion.

After anchoring and sealing the polyethylene sheet over the stack, cut a small hole in the plastic to allow exposure of the supply tubes at each end of the stack. Make this hole as small as possible so the plastic fits tightly around the pipe, thus reducing chances of leaking ammonia from the stack. Also, these areas should be reinforced with tape. Tape designed to repair holes in silo-press bags works well for this purpose. Duct tape is not as effective. After the stack is covered and sealed with tape, check for and repair holes or rips.

Amounts of Anhydrous Ammonia to Inject

It is generally recommended to inject anhydrous ammonia at a level equivalent to 3 or 4 percent of the DM. However, injecting at 4 percent of DM tends to be more effective, particularly when the forage is higher in moisture. Using the previous example we determined that the stack contained:

1,530 bales x 50 lb/bale = 76,500 pounds total

If the bales were 92 percent DM (before rehydration), the stack would contain 76,500 x .92 = 70,380 pounds of DM. This would require 70,380 x .04 = 2,815 pounds of anhydrous ammonia into the stack (inject half or 1,408 pounds into the supply tube at one end and the other half or 1,407 pounds into the supply tube at the other end of the stack).

Safety

As a matter of safety, **slowly inject anhydrous ammonia into the stack** because ammonia expands rapidly. Violent ballooning of the polyethylene sheet will occur if the ammonia is injected too rapidly and the sheet could rupture, causing problems with personal safety, the environment, and economic loss.

The supplier of the anhydrous ammonia should provide a "slave tank" that can remain at the site for a couple of days. The supplier's trained personnel should connect the slave tank to the supply tubes protruding from the stack and adjust the flow rate so the proper amount of anhydrous ammonia is injected over a 10- to 12-hour period.

Never leave ammonia running into a stack at night. Shut the tank off and start again the next morning. It is advisable to start the ammonia early in the morning and adjust the flow rate so half of the amount needed for the stack is injected into the stack the first day. Then shut off the tank for the night. The next morning connect the tank to the supply tube at the other end of the stack and release the remaining anhydrous ammonia slowly into the stack throughout the day.

Post "Keep Away" and "Danger" signs around the stack, and never allow children to play around or near when the stack is undergoing ammoniation process.

Time of Year to Ammoniate

The best time of the year to ammoniate low-quality forages is July, August, or September. Ammoniation is a temperature-dependent reaction so the warmer the temperature the faster the reaction takes place. After September, temperatures cool and may be too low for the reaction to occur. Under black polyethylene in July and August the temperature of the stack can be as high as 160°F. With these conditions the reaction will likely require only 7 days. During September, when the temperature begins to moderate, the reaction will probably require about 14 days. Watch for holes during the 3-week process (i.e., cats, raccoons, etc., or holes in the plastic or sealing edge caused by burrowing animals).

Once the reaction has occurred it is permanent, and the effects of ammoniation will not reverse if the polyethylene cover is removed. However, cattle producers should leave the cover on and then remove it gradually as the forage is being used so the polyethylene can protect the remaining forage.

The polyethylene cover should be opened 2 to 3 weeks before the anticipated time the forage will be needed. This will allow aeration of excess ammonia. Otherwise, the forage will be unacceptable for the animals and the feeder. It is best to remove polyethylene from the entire front face of the stack, while leaving the sheet on top of the stack for protection.

When cutting the polyethylene from the face of the stack, always have at least two or three people present. A large amount of volatile ammonia remains under the sheet and will escape rapidly as the cover is cut away. Only about 18 to 25 percent of the ammonia is actually trapped (fixed) in the forage. The remaining will escape as gas.

What Is the Cost of Ammoniation?

The cost of ammoniation is difficult to estimate because costs vary from area to area and from one year to the next. Table 1 shows a range of prices for both anhydrous ammonia and roughage and calculates the cost per ton of ammoniated roughage; it does not include labor and materials costs. This table will allow a quick cost comparison to other forages such as alfalfa hay.

Effect on Intake

Feeding low-quality forages can be economically advantageous particularly as it affects feed intake. Digestibility is improved with ammoniation resulting in improved DM intake. As an example, if 2.7 pounds (DM) of soybean meal were supplemented, intake of forage would increase from 8.2 pounds of non-ammoniated to 10.7 pounds of ammoniated. This could be significant as higher percentages of low-quality forages could then be used, thus stretching feed resources further.

Conclusions

It is recommended that a nutrient analysis of critical nutrients be conducted on all feeds that may be considered for feeding the cowherd. Through ration balancing, projected costs can be determined and whether ammoniation should be considered.

It has been demonstrated that beef cows can be successfully fed diets that include ammoniated low-quality roughages. The ammoniation process is critical, however, to ensure safety and the outcome one desires. Economics of production dictate whether this technique is the best option in a given situation.

Reference

Kernan, J., and J. Knipfel. No date. Ammoniation of Straw and Chaff. Factsheet. Agriculture and Agri-Food Canada Swift Current, SK Research Station.

Table 1. Cost of ammoniated roughage.

	Ammonia/ton @ 3.0%*						
Roughage/ton	**$900.00**	**$950.00**	**$1,000.00**	**$1,050.00**	**$1,100.00**	**$1,150.00**	**$1,200.00**
$30.00	$57.00	$58.50	$60.00	$61.50	$63.00	$64.50	$66.00
$40.00	$67.00	$68.50	$70.00	$71.50	$73.00	$75.50	$76.00
$50.00	$77.00	$78.50	$80.00	$81.50	$83.00	$84.50	$86.00
$60.00	$87.00	$88.50	$90.00	$91.50	$93.00	$94.50	$96.00
$70.00	$97.00	$98.50	$100.00	$101.50	$103.00	$104.50	$106.00
$80.00	$107.00	$108.50	$110.00	$111.50	$113.00	$114.50	$116.00
$90.00	$117.00	$118.50	$120.00	$121.50	$123.00	$124.50	$126.00
$100.00	$127.00	$128.50	$130.00	$131.50	$133.00	$134.25	$136.00
$110.00	$137.00	$138.50	$140.00	$141.50	$143.00	$144.50	$146.00

*60 pounds anhydrous ammonia per ton of roughage = 3.0%

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