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AMMONIA TREATED SILAGES (6.01.92)

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Ammonia Addition to Whole Plant Corn or Stalks. Anhydrous ammonia or water- or molasses-ammonia mixes can be added to whole plant corn and corn stalks at the time of ensiling (Huber et al., 1979). Ammonia additions have resulted in the following benefits (Huber and Kung, 1983):

1. addition of an economical source of crude protein
2. prolonged bunk life during feeding (aerobic stability)
3. less molding and heating during ensiling
4. decreased protein degradation in the silo

Addition of anhydrous ammonia or water-ammonia mixes initially buffers the plant material. With anhydrous ammonia, corn forage will turn bright yellow immediately upon treatment. For example, corn forage may have a pH of 5.9 but treated corn forage will have a pH of about 8.5 to 9.0. We have observed (Kung et al., unpublished data) that ammonia treatment causes an initial delay, followed by stimulation, in growth of lactic acid bacteria. When fermentation in the silo is complete, corn silage treated with anhydrous ammonia usually is 0.1-0.2 units higher in pH, contains 0.5-1.5 % (DMB) more lactic acid, 0.5-1.5% more acetic acid, and less residual water soluble carbohydrates. Forages treated with ammonia have also been shown to be higher in insoluble N (Huber et al., 1979) and true protein (Buchanan-Smith, 1982) primarily because ammonia reduces plant proteolysis (Table 1). Ammonia and ammonium salts have been suggested to be anti-fungal in nature and result in improved aerobic stability (reduced molding and heating) during storage and feedout (Britt and Huber, 1975). However, recent data from our lab (Kung et al., unpublished) would suggest that improved aerobic stability is also due to an increase in acetic acid and decrease in residual water soluble carbohydrates after ensiling, in addition to a direct fungicidal effect from ammonia. In large bunks or pits where rapid feed out and bunk management are difficult, ammonia treatment can improve bunk life of silages.

Ammonia Addition to High Moisture Corn. Ammonia has also been added to high moisture ear corn (Britt and Huber, 1975) and high moisture snapped ear corn (Soderholm et al., 1988). In some instances (Alli et al., 1983 and Phillip et al., 1985) ammonia was added at about 1% of fresh weight. Addition of ammonia to high moisture corn has caused an increase in pH but lowered production of lactic acid. Decreases in plant proteolysis have also been observed. Improvements in aerobic stability have not been consistent. Mowat et al. (1981) reported high levels of free ammonia and reduced animal acceptance in ammonia-treated high moisture corn.

Table 2. Effect of anhydrous ammonia on true protein nitrogen content of corn silage. (Buchanan-Smith, 1982.)

Silage DM:	28%		40%	
Treatment:	Untreated	Ammonia	Untreated	Ammonia
CP, % DM	8.9	12.8	9.8	13.1
True protein N, % DM	0.72	0.94	0.88	0.99

Anhydrous Ammonia Addition to Other Crops. Interest in adding anhydrous ammonia to alfalfa silage has centered around its ability primarily to improve aerobic stability. Certain precautions must be considered for this application. First, alfalfa silage contains excess amounts of rumen degradable protein and added ammonia will compound this problem. Secondly, there is some research that shows when the moisture content of alfalfa is high (more than 70%) ammonia can cause an undesirable clostridial fermentation (Kung et al., 1989) leading to high levels of butyric acid and protein degradation in the silo. Glenn (1990) reported that adding ammonia to low DM alfalfa (20% DM) resulted in a decrease intake of digestible DM and energy whereas ammonia treatment of high DM silage (40%) increased intake of these nutrients. This author would not recommend use of anhydrous ammonia for legume silages.

In grass-legume silages, Moore et al. (1986) reported that anhydrous ammonia applied at 3% of the DM improved digestibility and intake of poor quality grass-legume silage. Moderate levels of ammonia (1.5%) also resulted in high levels of butyric acid in treated silages (an indicator of clostridial fermentation). Such high levels of ammoniation are not recommended for normal corn silage or alfalfa silages.

Whole-crop barley silage has also been successfully treated (1% DM basis) with anhydrous ammonia (Song and Kennelly, 1989).

Application. Ammonia can be added at the chopper, blower, bagger or bunk. Mixed ammonia solutions are bulkier than anhydrous ammonia but retention of ammonia is usually greater. In addition, molasses (to improve palatability and fermentation) and minerals can be added in these solutions. Some ammonia will be lost (between 10 and 30%) and losses will be greater if ammonia is not applied properly or if forage becomes too dry. Ammonia should be added at the end nearest the cutter in a chopper with an

auger system. If no auger is used, ammonia can be added behind the cutter prior to entering the blower. For silage to be stored in a conventional up right silo, ammonia should be applied to the forage before it contacts the blower to minimize losses. Ammonia can also be spiked into bunks between loads and it will disperse into the mass.

Application of anhydrous ammonia should be at approximately 6 to 7 lb of N per 700 lb of forage DM (Table 4). Excess ammonia (> 15 lb per ton) may result in poor silage fermentation (because of a prolonged buffering effect) and may add too much degradable intake protein to the forage. Adding 7 lbs of ammonia (5.7 lbs of N) per ton of 35% DM corn silage will increase the crude protein from about 8% to 12.5% (dry matter basis). Using the Cold-flo method is the simplest way to add ammonia to silage. Gaseous ammonia is super cooled in a converter box and about 80-85% becomes liquid.

Table 4. Addition of ammonia and urea to corn silage.

	Anhydrous Ammonia	Ammonia-molasses mixes	Urea
Nitrogen, %	82	20-23[a]	46
CP equivalent, %	515	125[a]	282
Application, lb/ton of 35% DM forage[c]	7	± 25[a]	10-12[b]

[a]varies based on specific product.

[b]do not add urea to forage over 45% DM.

[c]application rate should vary depending on forage DM. Higher amounts should be applied to drier forage. In all cases, the desired application rate is 6-7 lb of N per 700 lb of forage DM.

Anhydrous ammonia should not be added to corn forage if the DM content is above 40-42% because fermentation is restricted in drier material and binding of ammonia will be less; thus normal fermentation may be disrupted. In instances where forage DM is above 40-42%, water-ammonia mixes or molasses-ammonia mixes should be used. Application for molasses-ammonia mixes should be as recommended by the manufacturer.

Animal Applications. Ammonia-treated corn silage has been fed successfully to lactating dairy cattle (Huber et al. 1980, Kung and Huber 1983) and beef steers (Bolsen et al., 1992) as the primary forage source. Kung and Huber (1983) studied cows in early lactation fed total mixed rations differing in combinations of ammonia-treated corn silage and protein with low rumen degradability (heated SBM). Milk production from cows fed diets containing ammonia-treated corn silage and low degradable protein was equal or superior to diets containing normal SBM or heated SBM without NPN (Table 3). In a companion trial (Kung et al. 1983) non-ammonia nitrogen (NAN) flow to the small intestine was greatest for cows fed diets containing heated SBM and ammoniated silage.

Ammoniated corn stalklage (up to 20% of the DM) has been fed successfully to lactating cows producing moderate amounts (50 to 60 lbs) of milk (Hargreaves et al., 1984) and growing Holstein heifers (about 45% of the diet DM; Lopez-Guisa et al., 1991).

Table 3. Milk production from cows fed NPN and heated soybean meal[1].

Corn Silage:	Normal	Normal	Ammoniated
Protein:	SBM[2]	HSBM[3]	HSBM
Milk, lb/d	75.0	77.7	78.3
Income over feed cost, $/d	6.52	6.94	7.25

Kung and Huber, 1981.

[1] Cows were fed diets from day 21 to 70 of lactation. Ammonia treated silage was 13.5% CP on a dry matter basis and comprised 40% of the dietary dry matter. Each value is a mean of 24 cows; 12 on 14.5% and 12 on 17.5% CP.

[2] soybean meal.

[3] heated soybean meal.

Special Considerations.

Sulfur. When feeding cows ammonia-treated corn silage, special attention should be given to dietary sulfur. Corn silage contains only about 0.08% sulfur and diets for milking cows should contain at least 0.2 to 0.25% sulfur. Milking cow diets should also contain 12 to 15 times more nitrogen than sulfur. When urea or ammonia is added to corn silage, 3 lbs of $CaSO_4$ (gypsum, 18% S) per ton of corn silage improves the N:S ratio or be sure to supplement the diet with S.

Safety. Ammonia is a hazardous gas and should be handled with care. Eye protection should be worn when making connections to pressurized tanks. Water should be available at all times. Ammonia is also corrosive to zinc, copper and brass. Therefore storage of ammonia-treated forage in zinc coated (galvanized) steel silos is not recommended.

Relation to hyper-irritability. Problems with hyper-irritability (bovine bonkers syndrome) in cattle fed ammoniated forages has not been observed in cattle fed ammoniated corn forages.

Nitrates. Addition of ammonia to corn silage has no effect on nitrate levels in corn silage (Li et al. 1992).

Urea additions to corn silage. Urea has been added to corn silage as an economical source of crude protein. However, a beneficial effect of urea on improved bunk life and decrease in proteolysis is doubtful.

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