IMPROVING THE FEEDING VALUE OF HAY BY ANHYDROUS AMMONIA TREATMENT

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HAY AMMONIATION

Procedures are not complicated or costly
(costs approximately $15.00 per ton)

Ammoniation improves hay feeding value:
-increases protein concentration of hay
-increases digestibility of hay
-increases intake and daily gain by cattle

Ammoniated hay plus an energy/natural protein supplement such as molasses-cottonseed meal can provide the nutrition necessary to develop a heifer for breeding as a yearling.

INTRODUCTION

During the winter, many Florida cattle producers graze replacement heifers on Bahia grass or other tropical grass pasture and feed low-quality hay and an energy-protein supplement such as molasses-urea. Historically, this feeding program has not provided the nutrition necessary for developing heifers so they can be bred as yearlings. In a summary of beef-forage practices in south central Florida (Beef-Forage Practices, 1986) and southwest Florida (Beef-Forage-Range Practices, 1990), approximately 50% of livestock producers surveyed indicated that nutrition was the most serious problem limiting reproduction in beef cattle. Approximately 50% of producers indicated that heifers calved their first time at three years of age or older. A primary reason more Florida cattle producers do not attempt to breed heifers as yearlings is low quantity and/or quality of forage (stockpiled pasture, hay) available for the heifer during the first winter following weaning. Also, a greater level of feeding is required for a two-year-old, first-calf heifer so she will rebreed to calve at three years of age, as compared to calving for the first time at three years of age.

Approximately 750,000 acres of permanent, improved grassland are used for hay production in Florida each year, with an average hay yield of 5,000 lbs/acre. Most of this hay is low quality because more emphasis is placed on yield than quality. In the summary of beef-forage practices in south central Florida (Beef-Forage Practices, 1986), 81% of livestock producers indicated they used hay, however only 10% of producers had the hay tested for quality. Results from the University of Florida Extension Forage Testing Program (Brown *et al.*, 1990) indicated that the average crude protein (CP) concentration of Florida-grown hay was 7%, and the average total digestible nutrient (TDN) concentration was 43%. Yearling heifers require a diet that is 11 to 12% CP and 60 to 65% TDN. Low-quality hay plus an energy-protein supplement such as molasses-urea may not provide the nutrients necessary to develop a heifer during her first winter after weaning so that she will be ready to breed as a yearling.

Improved hay quality can be obtained by harvesting a less mature forage. However, many cattle producers will not sacrifice extra yield to obtain better quality hay, and in many cases weather conditions are not favorable for hay making at the optimal harvest time. In these cases, large quantities of low-quality forage accumulate. Chemicals such as sodium or calcium hydroxide and ammonia have been used to improve the feeding value of low quality forages. Increasing interest in ammoniation of hay has developed due to ease of treatment, low cost, and the ability to treat large quantities of hay at once.

PURPOSE

The purpose of this bulletin is to describe how anhydrous ammonia can be used to improve the feeding value of tropical grass hay. Topics discussed include procedures for treating hay with ammonia, the proper concentration of ammonia to use, costs, feeding programs and precautions for ammonia use.

PROCEDURES FOR TREATING HAY WITH ANHYDROUS AMMONIA

An important aspect of hay ammoniation is that there are no complicated procedures to follow. The procedure is simple, not too costly, and can be accomplished with locally-available materials. There are many variations on procedures used for ammoniation, depending upon available equipment. The only requirement is that the hay and ammonia be enclosed in a "container" for about a month before feeding. This "container" is usually a sheet of black plastic used to cover the hay with the edges sealed in the ground to enclose the hay stack with an air-tight seal.

The hay stack should be arranged to minimize costs of materials and labor for each specific situation, and still provide proper conditions for ammoniation. Arrangement of hay bales on the ground depends upon equipment available, size of plastic available and the number of bales to be treated. Some producers have front-end loaders that can stack large round hay bales in a 3-2-1 pyramid configuration, while other loaders can stack in a 2-1 pyramid. Other producers have a spike on the rear of the tractor to move round bales, and can not stack hay. Other producers have square bales. Hay in all these situations can be ammoniated.

An example of how hay is stacked for ammoniation at the Agricultural Research and Education Center-Ona using round bales in a 3-2-1 pyramid is shown in (Figure 1.) As the hay bales are stacked, a small space (2 to 3 inches) is left between cut edges of adjacent bales so that ammonia can circulate within the stack. Note how bales in the middle layer overlap those on the bottom, and bales on the top overlap those in the middle.

About mid-way down the length of the stack, an approximate two-foot-wide space is left on the bottom layer of bales (Figure 2). A PVC pipe (discussed below), which aids in delivery of ammonia from the tank to the stack, is placed into this opening. Round bales shown in Figure 1 are five feet in diameter, and weigh approximately 1000 lbs. These bales can be arranged with 15 rows of three bales on the bottom, 14 rows of two bales in the middle and 13 rows of one bale on the top, for a total of 86 bales. A 40-foot X 100-foot sheet of 6-mil-thickness black plastic will cover this arrangement.

The PVC pipe used to deliver ammonia from the tank to the stack is 2 inches in diameter, approximately 20 feet long and capped on one end (Figure 3). One-quarter to one-half inch diameter holes are drilled along a line beginning at the capped end and continuing for 10 to 12 feet The pipe is positioned in the stack so that the drilled holes are pointing upwards. The open end of the pipe is positioned towards the outside of the stack, and is attached to the hose that comes from the ammonia tank. Use of the pipe is not essential, but it helps to distribute ammonia more uniformly within the stack.

A small trench (1 to 2 feet deep) is dug around the stack to secure the plastic. Some producers own a ditcher, or one can be rented. Five to eight hay stacks can be ditched with a half-day rental of a ditcher. A back-blade positioned at an angle on the back of a tractor also works well. The plastic is placed over the stack, and the edges placed into the trench and covered with soil to seal the stack (Figure 4). Black plastic of at least 6-mil thickness should be used. Clear plastic that does not contain an ultra-violet inhibitor should not be used because it becomes very brittle in a short period due to exposure to the sun. More durable plastics containing an ultra-violet inhibitor or nylon reinforcement can be used; however, these products are expensive and will have to be reused for several years to be cost effective. After the plastic is placed over the hay stack and sealed into the trench, it should be checked for holes such as those caused by hay stems puncturing the plastic during covering. Holes in the plastic can be sealed with duct tape.

The hose from the ammonia tank is then connected to the PVC pipe, or placed under the plastic if no pipe is used (Figure 5). Anhydrous ammonia tanks have a capacity gauge to meter the proper quantity of ammonia into the stack. Ammonia leaves the tank as a liquid and then turns into a gas and fills the area under the plastic. Depending upon how fast the ammonia is allowed to flow into the stack, the plastic can balloon out and become very tight. About five hours are required to apply the proper amount of ammonia to the stack. When ammonia is being applied, the stack should be checked about every hour to make sure the process is proceeding normally.

After 1 to 2 days, the ammonia will be absorbed into the hay. Treatment time depends upon environmental temperature; the warmer the temperature the faster the reaction time. As a general rule, hay should remain sealed under the plastic for about 30 days before feeding. When the hay is ready to feed, the plastic can be cut at ground level to expose only the number of bales to be removed from the stack. Plastic remains over the rest of the hay to help keep it dry.

Anhydrous ammonia is a caustic chemical and can be dangerous if not used properly. Tanks containing ammonia are under pressure, and all connections should be checked before releasing ammonia from the tank. Ammonia will burn the skin and eyes, so fresh water should be available to wash off any ammonia that contacts the skin. Always remain upwind of the hay stack when applying ammonia. Ammonia is very corrosive to most metals.

ANHYDROUS AMMONIA TREATMENT LEVEL

Tropical grass hays such as bahiagrass, bermudagrass, digitgrass, limpograss and stargrass should be treated with anhydrous ammonia at the rate of 4% of the forage dry matter. To determine the amount of ammonia needed to treat a stack of hay, multiply the number of bales in the stack, times the weight of each bale, times the percentage dry matter of the hay, times 0.04. Bale weight and hay dry matter percentage usually will be estimates. Four-foot-diameter bales are typically 800 lbs, and five-foot-diameter bales are typically 1000 lbs. Hay that is dried properly is typically 85% dry matter. For the example above, there were 86 bales, each bale weighed approximately 1000 lbs, and hay dry matter percentage was approximately 85%. The amount of ammonia needed is: 86 x 1000 x 0.85 x 0.04 = 2924 lbs.

The capacity gauge on the ammonia tank can be used to meter the proper amount of ammonia into the stack. Our tank at the AREC-Ona has a maximum capacity of 5000 lbs of ammonia. Tanks are typically filled to only 90% of capacity to allow for expansion of the ammonia as the environmental temperature increases. This equals 4500 lbs of ammonia when the tank is 90% full. In the above example, 2924 lbs of ammonia are required, and with a tank that initially is 90% full (4500 lbs ammonia) there should be

1576 lbs of ammonia (4500 - 2924) in the tank when finished. When finished, the capacity gauge should read approximately 30% (1576 X 90 = 141840/4500 = 31.5).

COSTS OF AMMONIATING HAY

The key is to minimize costs of materials and labor for each ton of hay in each specific situation. In the above example, there were 86 round bales, each bale weighed 1000 lbs, 2924 lbs of ammonia were required, and one sheet of 40-foot X 100-foot, 6-mil-thickness black plastic was used. Total costs (1991) are approximately $570.00 per stack (Table 1). With 43 tons of 15% moisture hay (36.5 tons on a dry matter basis), this equals $13.25 per ton on a 15% moisture basis and $15.62 per ton on a dry matter basis to ammoniate hay.

Table 1. Costs of treating hay with anhydrous ammonia

		Total cost
Plastic ($100.00/roll)		$100.00
Anhydrous ammonia (2924 lbs x $.13/lb)		380.12
Labor (10 hours x $5.00/hr)		50.00
Tractor (1 hour x $20.00/hr)		20.00
Miscellaneous equipment		20.00
	Total cost per stack:	$570.12
(43 tons hay/stack, as-is)	Cost per ton, as-is:	$13.25
(36.5 tons hay/stack, dry matter)	Cost per ton, dry matter:	$15.62
Calculations are based on the following assumptions: 86 round bales, each bale weighs 1000 lbs, hay dry matter is 85%, hay is ammoniated at 4% of the forage dry matter, plastic is a 40 x 100		

foot sheet of 6-mil thickness

NON-NUTRITIONAL BENEFITS OF AMMONIATED HAY

Cattle waste less ammoniated hay than non-treated hay. Losses of 25% or more can be obtained in weathered non-treated hay. Wastes of 10% or less are observed with ammoniated hay. If losses due to waste are considered, ammoniation costs of approximately $15.00 per ton shown in Table 1 are reduced to approximately $9.00 per ton.

Anhydrous ammonia has antimicrobial effects. In several cases livestock producers have ammoniated hay that was baled too wet (about 25% moisture). Ammonia inhibited mold growth, and the hay was fed successfully. In another case a livestock producer baled forage shortly after cutting. The intention was to bale the forage wet and treat it with anhydrous ammonia at 4% of the forage dry matter to inhibit spoilage and mold growth, and improve feeding value. The baled forage was very wet (about 60% moisture). Anhydrous ammonia has a strong attraction for water, and the resulting treated forage had a strong ammonia odor which reduced intake by yearling cattle. Because of potential intake problems, it is recommended that forage greater than 25 to 30% moisture content not be treated with anhydrous ammonia at 4% of the forage dry matter. Hay that is 25 to 30% moisture should be ammoniated shortly after baling to reduce heating that occurs in wet hay.

Some producers treat silage or haylage with anhydrous ammonia at 1% of the forage dry matter. Application of anhydrous ammonia at 1% of the forage dry matter yields different results compared to ammoniation at 4% of the forage dry matter. Treatment at 1% of the forage dry matter limits mold growth and can be used successfully with wet (65% moisture) forage, but does not enhance forage nutritional value to a large extent.

NUTRITIONAL BENEFITS OF AMMONIATED HAY

Table 2 summarizes results from several research trials conducted in Florida comparing non-treated and ammoniated tropical grass hay. Non-treated hays were low in quality, and typical of most hay produced in Florida. Comparison of hays across trials is not valid because hays were produced in different years and were of different maturities.

Ammonia treatment increases the CP concentration of hay (Table 2). The increase in CP concentration is due to non-protein-nitrogen addition from ammonia. This non-protein-nitrogen from ammonia has a protein value similar to that of urea which is found in many liquid and dry supplements. For young growing cattle, utilization of this non-protein-nitrogen is not as good as protein utilization from a natural protein source such as cottonseed meal or soybean meal. Although CP concentration of hay is increased by ammoniation, other nutritional effects are usually more important. From an economical standpoint, however, the increased CP concentration is important because standard molasses at approximately $80.00 per ton can be fed rather than a urea-fortified molasses product at approximately $120.00 per ton. Because of the non-protein-nitrogen contribution from anhydrous ammonia in ammoniated hay, supplemental feeds containing urea should not be fed with ammoniated hay.

Table 2. Chemical composition and in vitro digestion of non-treated and ammoniated hay

		Crude protein,%	Neutral detergent fiber, %	In vitro organic matter digestion, %(a)
Trial 1: Limpograss hay				
Non-treated		3.2	88.9	46.2
Ammoniated		10.3	80.9	62.5
Trial 2: Stargrass hay				
Non-treated		4.4	87.6	35.0
Ammoniated		9.4	80.1	45.7
Trial 3: Bermudagrass hay				
Non-treated		7.5	83.3	40.5
Ammoniated		14.1	79.3	57.2
Trial 4: Bermuda-Bahiagrass hay				
Non-treated		4.2	81.9	42.2
Ammoniated		12.7	81.8	53.3

(a) A measure of digestibility by cattle (related to total digestible nutrients, TDN)

Ammoniation improves feeding value of the forage by a chemical breakdown of plant fibers resulting in a better opportunity for rumen bacteria to attach to the fiber and digest the ammoniated hay. Neutral detergent fiber concentration, which is a measure of the cell wall content of a forage, is reduced by ammoniation (Table 2). This contributes to the greater in vitro organic matter digestion of ammoniated compared to non-treated hay. In vitro organic matter digestion is a measure of the energy content of a forage, and is usually 10 to 15 percentage units greater in ammoniated than in non-treated hay.

Performance of yearling steers fed non-treated or ammoniated hay is shown in Table 3. Mature stargrass hay, typical of that produced in Florida, was used. The non-treated hay was low in CP and IVOMD and high in NDF. One-half of the hay was left non-treated and one-half was ammoniated according to the procedures described above. Ammoniation increased the CP and IVOMD and reduced the NDF of the stargrass hay.

Brahman crossbred steers (435 lbs; 8 months of age) were placed in drylot (3 pens per treatment, 7 head per pen) from January through April, and fed ad libitum quantities of either the non-treated or ammoniated stargrass hay. All steers were fed 2.0 lbs/head/day of a supplement containing corn, cottonseed meal, minerals and vitamins. Steers fed ammoniated hay consumed 20% more hay than those fed non-treated hay (Table 3). Increased digestibility of ammoniated compared to non-treated hay and increased intake of ammoniated compared to non-treated hay are additive, resulting in a large increase in daily gain. Steers fed non-treated hay plus a natural protein-based supplement gained .3 lbs/day, while steers fed ammoniated hay plus a natural protein based supplement gained .9 lbs/day. Daily gains of approximately 1.0 lb/day are typical for yearling cattle fed ammoniated hay plus a natural protein such as cottonseed meal. Cost of gain for steers fed non-treated hay plus the natural protein-based supplement was high, and was decreased for steers fed ammoniated hay plus the natural protein-based supplement.

Table 3. Performance of yearling cattle fed non-treated or ammoniated hay			
Item	Non-treated	Ammoniated	SE(a)
Laboratory analyses			
CP	4.4	8.1	

NDF	87.4	82.2	
IVOMD	30.8	50.6	
Daily feed intake, lbs, as-is			
Hay	9.8(b)	11 .7(c)	.37
Supplement	2.0	2.0	
Total	11.8(b)	13.7(c)	.37
Daily gain, lbs	.3(b)	.9(c)	.07
Feed costs, $/day	.42	.54	
Yardage,$/day	.15	.15	
Total,$/day	.57	.69	
Cost of gain,$/lb	1.90	.77	
CP = crude protein, NDF = neutral detergent fiber, IVOMD = in vitro organic matter digestion.			
Costs are based on $35.00/ton for non-treated hay, $50.00/ton for ammoniated hay, $250.00/ton for supplement.			
(a) SE = standard error of the mean.			
(b),(c)Values in the same row with a different superscript are significantly different (P < 0.05).			

FORAGE MATURITY AND AMMONIATION

A practical question arises whether hay fields should be managed to harvest less mature forage (5-weeks regrowth), or whether grass should be allowed to grow to obtain greater yield,and the resulting mature, low-quality forage ammoniated to improve its feeding value. To answer this question, stargrass hay was harvested after 5- and 10-weeks regrowth. One-half of the bales of each maturity were left non-treated and the remaining one-half were ammoniated. Weaned Brahman crossbred heifers (450 lbs; 8 months of age) were placed on bahiagrass pasture from October through February (3 pastures per treatment, 7 head per pasture) and fed one of the four hays described above. All heifers were fed 1.0 lb supplement/head/day. The supplement contained corn, cottonseed meal, minerals and vitamins.

Non-treated 5-week-regrowth hay was greater in CP and IVOMD than was the non-treated, 10-week-regrowth hay (Table 4). Ammoniation increased the CP and IVOMD of both hay maturities, however the response was greater in the 10-week compared to the 5-week regrowth hay. Heifers fed the non-treated 5-week-regrowth hay plus the natural protein-based supplement ate 57% more feed and gained much more weight than heifers fed the non-treated 10-week-regrowth hay plus the natural protein-based supplement. Ammoniation of the 5-week-regrowth hay did not improve hay intake or daily gain to a large degree compared to non-treated, 5-week-regrowth hay. Heifers fed ammoniated, 10-week-regrowth hay plus the natural protein-based supplement consumed 83% more hay and gained much more weight than those fed the non-treated, 10-week-regrowth hay plus the natural protein-based supplement.

Table 4. Performance of heifers fed stargrass hay at two regrowth intervals either non-treated or ammoniated					
	5 week regrowth		10 week regrowth		
	Non-treated	Ammoniated	Non-treated	Ammoniated	SE (a)
Laboratory analyses					
CP	10.6	14.4	4.4	9.4	
NDF	85.0	74.0	87.6	80.1	
IVOMD	46.5	58.2	35.0	45.7	
Daily feed intake, lbs as-is					
Hay	10.2(c)	11.7(c)	6.5(b)	11.9(c)	.75
Supplement	1.0	1.0	1.0	1.0	
Total	l 1.2(c)	12.7(c)	7.5(b)	12.9(c)	.75

Daily gain, lbs	.5(c)	.8(d)	.0(b)	.7(d)	.09
Feed costs, $/day	.39	.51	.24	.43	
Yardage, $/day	.15	.15	.15	.15	
Total, $/day	.54	.66	.39	.58	
Cost of gain, $/lb	1.08	.83	-	.83	
CP = crude protein, NDF = neutral detergent fiber, IVOMD = in vitro organic matter digestion.					
Costs are based on $50.00/ton for non-treated 5 week regrowth hay, $65.00/ton for ammoniated 5 week regrowth hay, $35.00/ton for non-treated					
10 week regrowth hay, $50.00/ton for ammoniated 10 week regrowth hay, $250.00/ton for supplement.					
(a) SE = standard error of the mean.					
(b),(c),(d) Values in the same row with a different superscript are significantly different ($P < 0.05$).					

Daily gain and cost of gain by heifers fed the ammoniated, 10-week-regrowth hay plus the natural protein-based supplement was better than that by heifers fed the non-treated, 5-week-regrowth hay plus the natural protein-based supplement. This suggests that harvest of some hay fields can be delayed to obtain additional yield, and the resulting low-quality hay ammoniated to provide a hay of at least similar feeding value to that of a less mature, non-treated hay. Also, if wet weather prevents harvest of high-quality hay, ammoniation of more mature hay would be an alternative to supplementation. Daily gain by heifers fed ammoniated hay plus a natural protein-based supplement is probably not acceptable for developing heifers to be bred as yearlings, but economics may favor energy supplementation of ammoniated compared to non-treated hay.

SUPPLEMENTATION OR AMMONIATION

Another practical question arises as to whether an energy/protein supplement should be purchased and fed with non-treated hay, or non-treated hay should be ammoniated. To answer this question, two trials were conducted to evaluate ammoniation or molasses supplementation of mature forage. In both trials steers were housed in drylot and fed one of the following three treatments: (1) non-treated forage (2) non-treated forage plus molasses or (3) ammoniated forage. In trial 1 the forage was mature limpograss hay, and in trial 2 the forage was rice straw. In trial 1, Brahman crossbred steers averaging 500 lbs and 8 months of age were used, and in trial 2, Brahman crossbred steers averaging 600 lbs and 12 months of age were used. In trial 1, all steers were fed 1.0 lb supplement/head/day, and steers fed molasses received 4.0 lbs molasses/head/day. In trial 2, all steers were fed 1.5 lb supplement/head/day, and steers fed molasses received 4.5 lbs molasses/head/day. In both trials, the supplement contained corn, cottonseed meal, minerals and vitamins.

Limpograss hay used in trial 1 was very low in CP, high in NDF fiber and low in IVOMD (Table 5). Rice straw produced in Florida is generally greater in CP than that produced in other parts of the country because of the high organic matter content of south-Florida soils. Ammoniation increased the CP and IVOMD and reduced the NDF of both forages.

In trial 1, steers on all treatments performed better than expected (Table 5). In both trials, steers fed ammoniated hay plus the natural protein-based supplement ate more hay, gained more weight and had a less expensive cost of gain than did steers fed non-treated hay plus the natural protein-based supplement. Steers fed non-treated hay plus molasses-natural protein had reduced hay intake compared to steers fed non-treated hay plus the natural protein-based supplement. This response is termed a substitution effect, and must be considered when supplementing forage-based diets. Steers fed non-treated hay plus molasses-natural protein gained more weight and had a less expensive cost of gain compared to steers fed non-treated hay plus the natural protein-based supplement.

Contrasting the performance obtained from non-treated hay plus molasses-natural protein compared to that obtained from ammoniated hay plus the natural protein-based supplement is important. Steers fed ammoniated hay plus natural protein had a greater daily gain in trial 1, and a similar daily gain in trial 2 compared to steers fed non-treated hay plus molasses-natural protein. This indicates that cattle fed ammoniated hay plus natural protein perform at least as well as cattle fed non-treated hay plus molasses-natural protein. Steers fed non-treated hay plus molasses-natural protein consumed 4.0 and 4.5 lbs of molasses per day which is typical for cattle of that age and weight. Therefore, if additional daily gain is desired from cattle fed non-treated hay plus molasses-natural protein, then additional supplement or another type of supplement would have to be fed. Steers fed ammoniated hay plus natural protein were not supplemented with additional energy. Performance of cattle fed ammoniated hay plus natural protein may be enhanced by energy supplementation.

Table 5. Performance of steers fed limpograss hay (trial 1) or rice straw (trial 2), either supplemented with cane molasses or ammoniated

	Trial 1, limpograss hay				Trial 2, Rice straw			
	Nontreated	Nontreated + molasses	Ammoniated	SE(a)	Nontreated	Nontreated + molasses	Ammoniated	SE(a)
Laboratory analyses								
CP	3.2		10.3		5.6		11.0	

NDF	88.9		80.9		76.9		72.7	
IVOMD	46.2		62.5		37.0		54.4	
Daily feed, lbs as-is								
Hay	9.7(b)	8.4(b)	11.7(c)	.95	11.7(c)	10.5(b)	15.0(d)	.51
Supplement	1.0	1.0	1.0		1.5	1.5	1.5	
Molasses		4.0				4.5		
Daily gain, lbs	.6(b)	.9(c)	1.2(d)	.20	.5(b)	.9(c)	.9(c)	.09
Feed costs, $/day	.30	.44	.42		.39	.55	.57	
Yardage, $/day	.15	.15	.15		.15	.15	.15	
Total, $/day	.45	.59	.57		.54	.70	.72	
Cost of gain, $/lb	.75	.66	.48		1.08	.78	.80	
CP= crude protein, NDF = neutral detergent fiber, IVOMD = in vitro organic matter digestion								
Costs are based on $35.00/ton for nontreated forage, $50.00/ton for ammoniated forage, $250/ton for supplement, $80.00/ton for molasses								
(a) SE = standard error of the mean.								
(b),(c),(d) Within a trial, values in the same row with a different superscript are significantly different ($P < 0.05$).								

FEEDING PROGRAMS INCLUDING AMMONIATED HAY

Performance of cattle fed ammoniated hay may be increased by protein and/or energy supplementation of ammoniated hay. To evaluate this, a growth trial was conducted to evaluate molasses and cottonseed meal (CSM) supplementation of ammoniated hay. Brahman crossbred steers (480 lbs; 8 months of age) were placed on bahiagrass, pasture from October through February and fed ammoniated stargrass hay plus the following four supplementation treatments: (1) control (no supplement), (2) ad libitum quantities of standard molasses, (3) 1.0 lb CSM/head/day and (4) ad libitum quantities of standard molasses plus 1.0 lb CSM/head/day. For the ammoniated hay plus molasses-CSM diet, molasses and CSM were mixed into a slurry. Molasses alone, CSM alone, and the molasses-CSM slurry were fed on Monday, Wednesday and Friday.

Steers supplemented with molasses or molasses-CSM had reduced hay intake compared to steers fed ammoniated hay alone (Table 6). Molasses intake was increased when CSM was added (5.9 vs 7.0 lbs).

Steers fed ammoniated hay alone gained .5 lbs/day. This hay was adequate to meet maintenance requirements plus provide a small amount of gain, and formed a base to which supplementation programs could be applied. Both molasses and CSM supplementation improved daily gain and cost of gain, but the response to protein (CSM) was greater than the response to energy (molasses). Crude protein concentration of the hay before ammoniation was 6%, and after treatment was 11%. The increase was due to non-protein-nitrogen addition from ammonia which is similar to nitrogen from urea. This demonstrates the importance of feeding natural protein (cottonseed meal, soybean meal, feather meal) to cattle with high nutrient requirements such as developing heifers. Steers fed ammoniated hay plus molasses-CSM slurry gained 1.7 lbs/day. The cost of gain ($.55/lb) is attractive in today's markets for either developing heifers or backgrounding steers. Even though the research was conducted with steers, this feeding program (ammoniated hay plus molasses-natural protein slurry) can provide the level of performance necessary to develop a weaned heifer so that she can be bred as a yearling.

Table 6. Performance of steers fed ammoniated stargrass hay alone or supplemented with molasses and/or cottonseed meal

	Ammoniated hay alone	Ammoniated hay+molasses	Ammoniated hay + CSM	Ammoniated hay+molasses +CSM	SE(a)
Daily feed intake, lbs as-is					
Hay	14.4(c)	10.0(b)	13.4(c)	12.2(b)	.43
Molasses		5.9(b)		7.0(c)	.26
CSM			1.2	1.2	
Daily gain, lbs	.5(b)	.8(c)	1.0(c)	1.7(d)	.10
Feed costs, $/day	.36	.49	.52	.77	
Yardage, $/day	.15	.15	.15	.15	
Total, $/day	.51	.64	.67	.92	
Cost of gain, $/lb	1.11	.83	.65	.55	

Costs are based on \$50.00/ton for ammoniated hay, \$80.00/ton for molasses,
\$300.00/ton for cottonseed meal.
(a) SE = standard error of the mean.
(b),(c),(d) Values in the same row with a different superscript are significantly different (P < 0.05).

PRECAUTIONS FOR THE USE OF AMMONIATED HAY

Recently, reports have surfaced concerning toxic effects in cattle fed ammoniated hay. Symptoms include restlessness, impaired vision, loss of balance, sudden stampeding and running in circles. Some deaths have been reported, primarily in young calves (less than 1 month old) nursing cows that were fed ammoniated hay. Earlier reports suggested that ammoniated hay toxicity occurred in high-quality forages, forages that were high in moisture, or in hay that was treated with high levels (3% or greater) of ammonia. Recent research shows that this problem is not dependent on ammoniation level, moisture level, kind or quality of hay, but is dependent upon prolonged high temperatures during the ammoniation process. It appears that high temperatures in the hay stack at the time of treatment sometimes causes a toxic compound to be formed. This compound is not always produced during ammoniation. If the toxic compound is produced, in most cases it is not present in large enough quantities to produce symptoms in yearling cattle or mature cows, but can be transferred through the milk to affect the calf.

Although this syndrome has dramatic symptoms, it has developed in only a few situations. We have fed approximately 1000 head of yearling cattle over six years at the AREC-Ona and not observed any toxicity symptoms. In the one cow/calf trial conducted at the AREC-Ona and the four cow/calf trials conducted on Florida ranches, no toxicity symptoms were observed. Two producers reported a higher than expected death rate in young calves from cows fed ammoniated hay. It was not determined if ammoniated hay caused the deaths directly, but it remains a possibility.

At this time, limited information is known about this syndrome or the compound that is responsible. Because of the possibility of toxicity symptoms in young calves, we recommend that ammoniated hay not be fed to lactating cows. Ammoniated hay should be reserved for feeding to developing heifers, herd bulls or cull cows that are held over the winter to obtain a greater price in the spring market.

RECOMMENDATIONS

1. Procedures for treating hay with anhydrous ammonia can be adapted for each situation. An air-tight seal to keep the ammonia from escaping is essential. The key is to minimize costs of materials and labor for each specific situation.

2. Tropical grass hay should be treated with anhydrous ammonia at 4% of the forage dry matter. Hay should remain sealed for 30 days before feeding.

3. Hay harvested after 5 to 6 weeks regrowth should be fed non-treated. If harvest is delayed, then feeding value of the resulting mature forage can be increased to that of a 5-week-regrowth forage by ammoniation.

4. Only a portion of the hay produced or purchased should be ammoniated. Non-treated hay should be fed to lactating cows, while ammoniated hay can be fed to developing heifers, herd bulls or cull cows.

5. A diet consisting of ammoniated hay plus molasses-natural protein can provide the nutrition necessary to develop a heifer during her first winter after weaning so that she will be ready to breed as a yearling.

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FIGURE 1

FIGURE 2

FIGURE 3

FIGURE 4