Wheat Straw Improved by Half-Rate Application of Anhydrous Ammonia

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Introduction

Many tons of crop residues and other low-quality forages are produced in Kansas each year. Use of these forages often is limited by their low nutrient content and poor digestibility. The process of applying anhydrous ammonia to low-quality forages enhances their feeding value by increasing crude protein content and dry matter digestibility. In the summer of 2012, the persistence of drought conditions throughout Kansas reduced forage supplies and resulted in a dramatic increase in forage prices. In an effort to aid livestock producers, the K-State Beef Extension Specialist Team, in conjunction with the Livestock Production Program Focus Team, conducted wheat straw ammoniation demonstrations at 6 locations across Kansas. The objectives of these demonstrations were to: (1) demonstrate the process of using anhydrous ammonia to treat low-quality roughages, and (2) determine if the recommended rate of 3% anhydrous ammonia application (dry weight) could be decreased as a cost-saving measure. The effects of two anhydrous ammonia application rates (1.5 and 3.0% dry matter weight of stack, equivalent to 30 or 60 lb anhydrous ammonia/ton of dry forage) on subsequent forage quality and digestibility were evaluated.

Experimental Procedures

Approximately 130 to 140 round bales of wheat straw were arranged in two separate stacks (3-2 configuration) at six independent locations. Stacks were assigned randomly at each location to one of two anhydrous ammonia application rate treatments. Anhydrous ammonia application rate treatments were 1.5% (HALF) and 3.0% (FULL) of estimated stack dry matter content. Stacks were covered with 6-mil black plastic and sealed with approximately 12 in. of soil along the bottom edge of the stack. Anhydrous ammonia was released into the stacks via three 30-foot, 1/2-in. braided-polyvinyl anhydrous hoses connected to a 3/4-in. black iron cross that was adapted to fit an anhydrous ACME fitting (Fairbank Equipment, Wichita, KS). The lines were inserted under the plastic and secured at approximately equal distances along the length of the stack. Forage samples were obtained prior to and 14 days after anhydrous application. Forage samples were submitted to a commercial laboratory (SDK Laboratories, Hutchinson, KS) and analyzed for contents of dry matter, crude protein, acid detergent fiber, and total digestible nutrients. Subsamples also were submitted to the New Mexico State University Nutrition Lab (Las Cruces, NM) for *in vitro* dry matter disappearance analysis, which is used to estimate digestibility.

The effects of anhydrous ammonia application rate on dry matter, crude protein, acid detergent fiber, total digestible nutrients, and *in vitro* dry matter disappearance were evaluated using PROC MIXED in SAS (SAS Institute, Cary NC). Least-squares means are presented, and differences were considered significant at $P \leq 0.05$.

Results and Discussion

Dry matter, acid detergent fiber, and total digestible nutrient concentrations were unaffected by anhydrous ammonia application rate ($P = 0.68$; Table 1). Crude protein and *in vitro* dry matter disappearance both were affected by anhydrous ammonia application rate ($P < 0.01$). The relative improvement in both crude protein and *in vitro* dry matter disappearance were greatest at the HALF (1.5%) application rate compared with pretreatment values. Crude protein content was increased by 5.3 units at the HALF (1.5%) application rate, and by an additional gain of 2.2 percentage units with the FULL (3.0%) application rate (quadratic, $P < 0.05$). *In vitro* dry matter disappearance increased linearly ($P < 0.01$) as application rate increased, but also exhibited a tendency ($P = 0.10$) toward a quadratic response. The observed quadratic response in crude protein content and the tendency for a quadratic response for *in vitro* dry matter disappearance suggests that response to anhydrous ammonia diminishes as anhydrous ammonia application rate increased from the HALF to the FULL rate.

Implications

The feeding value (crude protein and *in vitro* dry matter disappearance) of wheat straw may be improved by anhydrous ammonia application rates as low as 1.5% dry matter weight of the stack (30 lb anhydrous ammonia/dry ton forage).

Table 1. Mean acid detergent fiber, crude protein, and *in vitro* dry matter disappearance of wheat straw before (pretreatment) and following application of 1.5 (HALF) or 3.0% (FULL) anhydrous ammonia on a dry basis

		Ammoniation rate[1]			
Item	Pretreatment	HALF	FULL	SEM	*P*-value
Dry matter, %	92.1	91.0	91.1	1.01	0.68
Crude protein, %[2]	3.3[a]	8.6[b]	10.8[c]	0.50	<0.01
Acid detergent fiber, %	51.0	51.9	52.1	1.34	0.84
Total digestible nutrients, %	33.2	32.5	32.3	1.90	0.93
IVDMD, %[3]	31.0[a]	42.0[b]	46.2[c]	1.60	<0.01

[1] Treatment with 1.5% (HALF) or 3.0% (FULL) of anhydrous ammonia on a dry weight basis.
[2] Linear effect, $P < 0.01$; quadratic effect, $P = 0.02$.
[3] *In vitro* dry matter disappearance; linear effect, $P < 0.01$; quadratic effect, $P = 0.10$.
[a,b,c] Within a row, means without a common superscript are different ($P \leq 0.10$).

Evaluation of Ammoniated Wheat Straw in Receiving and Growing Diets

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Introduction

Drought conditions in the past have created a shortage of prairie hay and other grass hays that are used as roughage sources for growing beef diets. Ammoniated wheat straw historically has been available for purchase at a lower than prairie hay. Although some research has been conducted using ammoniated wheat straw as a feedstuff for mature cows, little information is available on the use and outcome its inclusion in beef cattle receiving and growing diets. Our objective was to compare the performance outcomes of newly arrived and growing calves fed total mixed rations containing either ammoniated wheat straw, wheat straw, or a traditional blend of prairie hay and alfalfa hay.

Experimental Procedures

Crossbred beef steers (n = 301; initial body weight 598 lb) were purchased from three separate sources (Lindsborg, KS; Boliver, MO; and Seymour, TX) via online live auctions. Cattle arrived at the Kansas State University Beef Stocker Unit over a 3-day period (June 4–6, 2013). Upon arrival, all calves were weighed, ear-tagged, moved to pens with *ad libitum* access to long-stemmed prairie hay and water, and held overnight. The following day, calves were vaccinated with Bovi-Shield Gold 5 (Zoetis, Exton, PA), Nuplura (Novartis Animal Health, Larchwood, IA), and Bar-Vac 7 (Boehringer Ingelheim, St. Joseph, MO); mass-medicated with Zuprevo (Merck Animal Health, Summit, NJ); and dewormed using Safe-Guard (Intervet, Millsboro, DE) oral drench. Animals were revaccinated on day 28 with Bovi-Shield Gold 5, Bar-Vac 7, and Nuplura. Each load was blocked by arrival date and randomly assigned to treatment for a total of 24 pens with 12 cattle in each pen. A portion of the cattle (13 animals) was excluded from the trial due to pre-existing health conditions. All animals were observed daily for clinical signs of disease, any abnormalities or signs of illness were documented, and cattle so identified received appropriate therapeutic treatments as described by standardized operating procedures for the facility. Experimental treatments consisted of diets containing 30% (dry basis) of either wheat straw, ammoniated wheat straw, or a blend of prairie hay and alfalfa hay. Diets (Table 1) were balanced to contain comparable energy content and to meet or exceed the nutrient recommendations for receiving calves as listed in Nutrient Requirements of Beef Cattle (NRC, 7th revised edition, 1996 update).

Feed bunks were evaluated at approximately 7:00 a.m. and feed was delivered at approximately 9:00 a.m. each day in amounts sufficient to allow for approximately 0.25 lb/animal daily of feed refusals the following morning. Feed was weighed into the bunk and the remaining feed in the bunk from the prior day was estimated and recorded daily. Unconsumed feed remaining in the bunk was weighed back on days 28, 56, and 70. Total mixed ration feed samples were taken weekly and ingredient samples were taken at arrival for each load to determine nutrient content and dry matter content.

Calves were fed their respective diets for 56 days, after which they were fed a common diet (control) for an additional 14 days to equalize gut fill. Weights were taken on days 0, 28, 56, and 70. Dry matter intakes, average daily gains, and feed efficiencies were calculated for each period for each pen of calves. Body weights taken after Day 0 were analyzed separately in a mixed model using the MIXED procedure in SAS (SAS Institute, Cary, NC) with treatment as a fixed effects factor, day-0 bodyweight as a fixed covariate, and source of cattle as a random effect. Resulting least squares treatment means for these ANCOVA models were computed at the mean of the day-0 bodyweights. All other response variables were analyzed in a mixed model with treatment as a fixed effect and source of cattle as a random effect.

Results and Discussion

Growth performance is shown in Table 2. No effects of straw ammoniation were observed compared with the wheat straw diet. Final body weight and average daily gain were not different between ammoniated wheat straw and wheat straw ($P > 0.60$). Our results suggest that in diets containing 40% wet corn gluten feed, feeding 30% of diet dry matter as wheat straw yields performance similar to that obtained by feeding ammoniated wheat straw.

Implications

Feeding wheat straw at 30% inclusion on a dry matter basis during the receiving and growing period has the same performance as ammoniated wheat straw at a decreased cost.

Table 1. Composition of diets fed to crossbred beef steers during the receiving and growing phase (100% dry matter basis)

	Diet		
Ingredient, % of dry matter	Control	Straw	Ammoniated straw
Dry-rolled corn	23.57	23.57	23.57
Supplement	6.43	6.43	6.43
Alfalfa hay	15.00		
Prairie hay	15.00		
Wheat straw		30.00	
Ammoniated wheat straw			30.00
Wet corn gluten feed	40.00	40.00	40.00
Nutrient content			
Dry matter, %	73.0%	73.4%	72.2%
Crude protein, %	15.73	14.63	14.50
Calcium, %	0.91	0.72	0.71
Phosphorus, %	0.56	0.52	0.52
Salt, %	0.32	0.32	0.32
Potassium, %	1.22	1.10	1.10
Magnesium, %	0.26	0.27	0.25
Fat, %	3.04	2.74	2.65
Acid detergent fiber, %	16.20	21.84	21.24
NE maintenance, Mcal/100 lb	81.84	81.54	83.34
NE gain, Mcal/100 lb	52.55	46.40	50.00

Table 2. Growth performance of crossbred steers fed diets containing wheat straw, ammoniated wheat straw, or a blend of prairie hay and alfalfa hay (Control) at 30% inclusion during the receiving and growing periods

Item	Control	Wheat straw	Ammoniated wheat straw	SEM	*P*-value
Initial weight, lb	616	616	617	23	0.64
Day 28 weight, lb	696	698	698	2.5	0.78
Day 56 weight, lb	800[a]	780[b]	782[b]	3.5	<0.001
Final weight (day 70), lb	827[a]	812[b]	810[b]	3.1	<0.001
Dry matter intake, lb/day					
Day 0 to 28	16.54	16.85	16.53	0.32	0.52
Day 0 to 56	18.76	18.37	18.60	0.38	0.60
Day 0 to 70	19.69	19.02	19.28	0.62	0.19
Day 56 to 70	23.42[a]	21.58[b]	22.00[b]	0.43	<0.001
Average daily gain, lb					
Day 0 to 28	3.08	3.15	3.16	0.12	0.78
Day 0 to 56	3.45[a]	3.09[b]	3.14[b]	0.14	<0.001
Day 0 to 70	3.13[a]	2.91[b]	2.89[b]	0.07	<0.001
Day 56 to 70	1.88	2.18	1.89	0.28	0.39
Feed:gain, lb/lb					
Day 0 to 28	5.35	5.34	5.21	0.05	0.73
Day 0 to 56	5.45[a]	5.94[b]	5.94[b]	0.15	<0.001
Day 0 to 70	6.28[a]	6.53[b]	6.67[b]	0.16	0.01
Day 56 to 70	12.30	9.79	11.40	1.89	0.19

[a,b,c]Means in a row without a common superscript are different, $P < 0.05$.