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UREA-AMMONIATION AND(OR) SUPPLEMENTATION STRATEGIES TO IMPROVE THE NUTRITIVE VALUE OF TALL FESCUE STRAW FOR BEEF CATTLE PRODUCTION[1]

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ABSTRACT

Two studies were conducted to determine the effects of urea-ammoniation and(or) supplementation on tall fescue straw. In Exp. 1, 10 Hereford x Angus ruminal cannulated steers (avg wt = 272 kg) were used in a 5 x 5 dual latin square evaluating a control plus 2 x 2 factorial arrangement of treatments: 1) meadow hay plus supplement; 2) tall fescue straw; 3) tall fescue straw plus supplement; 4) ammoniated tall fescue straw; 5) ammoniated tall fescue straw plus supplement. In Exp. 2, 72 Hereford x Angus weaner steers (avg wt = 188 kg) were allotted randomly to three replications of the same treatments as above, except the tall fescue straw treatment was omitted. The basal diet of hay or straw in both studies was fed ad libitum and supplemental sun-cured alfalfa pellets were fed at .45% of BW. In Exp. 1, forage DMI of meadow hay was greater (P<.01) than all tall fescue straw diets. Within straw treatments, supplementation of nonammoniated straw did not effect (P>.05) DMI, whereas supplementation of ammoniated straw depressed DMI (P<.05). Meadow hay DM digestibility (DMD) was lower (P<.01) than all straw diets. Steers consuming meadow hay had lower (P<.05) DM fill than steers consuming nonsupplemented diets. In Exp. 2, forage DMI was highest (P<.05) for supplemented meadow hay, intermediate for supplemented straw and supplemented ammoniated straw, and lowest for steers receiving only ammoniated straw (.47, .33, .38, .17 kg, respectively). In summary, urea-ammoniation did not appear as effective as supplementation in improving the nutritive value of tall fescue straw.

(KEY WORDS: Ammoniation, Supplementation, Crop Residue, Beef Cattle, Intake.)

Introduction

Recent concerns over environmental issues may lead livestock producers to find alternative feed resources for wintering livestock, as well as grass seed producers to find alternatives to burning grass seed residues. Although the concept of using grass seed straw as a potential winter feed resource is not a new one, very little grass seed residues are used as livestock feed. One primary problem which limits the use of grass seed residues as livestock feed is nutrient quality of the residues. Grass seed residues are high fiber, low protein roughages and, as a result, low intake and digestibility are a common occurrence. Chemical treatment such as anhydrous ammoniation of low quality forages has been shown to increase their nutritive value and digestibility (Ward and Ward, 1987; Chestnut et al., 1988). However, anhydrous ammonia treatment requires the need for air-tight storage, possess potential danger in handling ammonia gas and may not be a technique readily available in many areas of the pacific northwest. Recently, urea has been used as a source of ammoniation with similar improvements in digestibility (Chestnut et al., 1988; Craig et al., 1988; Hunt et al., 1990). Likewise, protein supplementation has been shown to increase intake and use of low quality forages (Church and Santos, 1981; McCollum and Galyean, 1985; Krysl et al., 1987; DelCurto et al., 1990ab). However, few studies have related protein supplementation to urea ammoniation as strategies to improve the nutritive value and utilization of low quality forages. Therefore, the objects of this research was to determine the effects of urea ammoniation versus supplementation on intake, digestibility, digesta kinetics, and performance of beef steers consuming tall fescue straw.

Materials and Methods

Harvesting and Treatment of the Residue. Treated and control tall fescue straw (untreated; Houndog turf-type variety) was selected on an alternate windrow basis. A 50%, weight to volume, water/urea solution was sprayed on the windrows just prior to baling at a 6% rate (volume to forage weight). Moisture content of the treated straw was maintained at 15 to 30%, and when the moisture content dropped below 15%, harvesting was stopped. This was necessary to insure the proper conditions to facilitate the urea ammoniation reaction, specifically the conversion of urea to ammonia. In addition, a whole soybean extract (1% of urea/water solution) was added to provide a source of urease. Bales weighed 45 to 60 kg and were placed into truck hauling units immediately after harvesting. Bales were stored in stacks until chopping and feeding occurred. Hay and straw were chopped on a weekly basis and stored in covered feed wagons (ammoniated straw) or covered hay sheds (hay and straw).

Exp. 1. Ten ruminal cannulated Hereford x Angus steers (avg wt 272 kg) were used in a 5 x 5 dual latin square evaluating a control plus 2 x 2 factorial arrangement of treatments. A basal diet of hay or straw was fed in both experiments and supplemental sun-cured alfalfa pellets were fed at .45% of BW. Treatments for Exp. 1 were 1) meadow hay plus supplement (MHS); 2) tall fescue straw (TF); 3) tall fescue straw plus supplement (TFS); 4) ammoniated tall fescue straw (ATF); and 5) ammoniated tall fescue straw plus supplement (ATFS). Five, 28 d periods occurred from September to January. Each 28 d period consisted of a 14 d diet adaptation followed by 6 d intake, 6 d total fecal collections, 1 d rumen profile and 1 d rumen evacuations, respectively. Intake and orts were measured daily throughout the entire 28 d period. However, beginning on d 14 daily feed subsamples and 10% of orts were taken to determine DM intake and nutrient content of diet. On d 20 of each period, steers were fitted with a fecal harness and bag. Bags were weighed, emptied and replaced every 24 h. A 2.5% subsample was taken from emptied contents, dried and ground to pass a 1 mm Wiley mill screen. Also on d 20 at 1800 (96 h), a nylon bag[4] (20.0 x 10.0 cm; pore size 53 ± 10 μm) containing a 3 g sample of each steers corresponding diet was suspended in the rumen. Subsequent bags were suspended in the rumen at 72, 48, 36, 24, 12 and 6 h. All bags, including 0 h bags, were taken out of the rumen at 0 h and immediately rinsed until the water was clear. Bags were then frozen until further laboratory analysis. On d 28 at 0800 and 1300, each steer was emptied of all reticulo-rumen contents. Rumen contents were weighed, thoroughly mixed, and subsampled in triplicate to determine DM and digesta kinetics.

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TABLE 1. CHEMICAL COMPOSITION[a] OF BASAL DIETS AND ALFALFA PELLET SUPPLEMENT (EXP. 1 AND 2).

Item	Meadow Hay	Tall Fescue Straw	Ammoniated Tall Fescue Straw	Alfalfa Pellets
CP, %	6.76	5.75	14.82	18.69
ADIN[b], %	29.6	23.6	12.64	18.26
NDF, %	62.8	71.2	69.8	47.8
ADF, %	39.3	44.6	43.5	35.5
ADL, %	4.15	4.57	4.27	7.78

[a] Chemical composition expressed on a DM basis.
[b] ADIN = acid detergent insoluble nitrogen. Expressed as % of total nitrogen.

Exp. 2. Seventy-two Hereford x Angus weaner steers were stratified by weight and allotted randomly to three replications of four treatments (6 steers/pen). Treatments were the same as in Exp. 1 except the tall fescue straw (TF) treatment was omitted. Treatments with a supplement component were fed sun-cured alfalfa pellets at .45% BW (.91 kg $hd^{-1}d^{-1}$). Pens of steers were fed chopped forage daily and refusals were measured and sampled weekly. Steer weights were obtained on a 28 d basis following a 16 h shrink.

Laboratory Analysis and Calculations. Feed, ort, fecal and rumen evacuation samples were dried in a 60° C forced-air oven. Equal portions of daily feed and supplement samples and a percentage of orts were composited with respect to period and ground to pass a 1 mm screen of a Wiley mill. Duplicate ground feed and supplement samples were analyzed for DM and Kjeldahl N (AOAC, 1984) and ADF, NDF and ADL as described by Goering and Van Soest (1970). Acid detergent insoluble N was determined by Kjeldahl N analysis of ADF residue (Goering and Van Soest, 1970). Frozen nylon bags were thawed and dried in a 60° C forced-air oven and analyzed for DM. In situ rate on DM disappearance was calculated using natural log transformation methodology described by Mertens and Loften (1980).

Statistical Analysis. In Exp. 1, intake, DM digestibility (DMD), and in situ rate and extent of digestion were analyzed as a randomized complete block design with a control plus a 2 x 2 factorial arrangement of treatments using the Statistical Analysis Program for personal computers (SAS, 1987). Digesta fill variables were analyzed as a randomized complete block design, split plot in time with respect to corresponding evacuation times. Where there was treatment x evacuation time interaction, means were analyzed within evacuation times (Steel and Torrie, 1980). Means were separated using contrast statements for comparison of control vs straw diets, ammoniation main effects, supplementation main effects and the interaction of ammoniation by supplementation. In Exp. 2, intake, ADG, and feed/gain ratios were analyzed as a randomized complete block design. Means were separated by the least significant difference procedure following a significant F-test.

Results and Discussion

Exp. 1. Improvements of crude protein (CP) in tall fescue straw with urea ammoniation (5.75, 14.82% CP; TF, ATF, respectively; Table 1) are similar to other chemically treated forages (Nelson et al., 1985; Chestnut et al., 1987; Hunt et al., 1990). Acid detergent insoluble N, NDF, ADF and ADL were decreased with urea ammoniation of tall fescue straw. Depressions in fibrous fractions were expected (Fahey and Berger, 1986) and suggest that the conversion of urea to ammonia was, at least, partially successful.

Forage DM intake (DMI) of MHS was greater ($P<.05$; Table 2) than any tall fescue straw diets. Forage DMI also exhibited a supplementation x ammoniation interaction ($P<.05$). Supplementation of tall fescue straw with urea-ammoniation depressed forage intake by 13%, whereas, supplementation of untreated tall fescue had no effect on forage intake. Nelson et al. (1985) reported that ammoniation or protein supplementation of ammoniated low quality forages had no effect on forage DMI. Total DMI for MHS was greater ($P<.05$) than any tall fescue straw diet and with the addition of the supplement, intakes for supplemented diets were greater ($P<.05$) than nonsupplemented diets. Total DMI, when expressed in terms of %BW, indicates that steers were consuming approximately 2% of BW for the straw diets and greater than 2.5% of BW for MHS.

Consistent with intake results, apparent DMD (ADMD) was lower ($P<.05$) for MHS, which had higher intakes than any tall fescue straw diet (Table 2). Likewise, steers receiving supplements displayed a decrease ($P<.05$) in ADMD. However, ammoniation had a depressing ($P<.05$) effect on ADMD. In contrast, Ward and Ward (1987) reported that ammoniation of warm season grasses increased DMD.

Digested DM (kg) was higher ($P<.05$) for MHS than for tall fescue straw treatments. Data for digested DM also indicates that with the addition of supplement, digested DM increased ($P<.05$).

In situ lag time of DMD (h) exhibited a supplementation effect in which the addition of the supplement increased ($P<.05$; Table 3) lag time of DMD. Rate of DMD was increased with ammoniation of straw ($P<.10$). In addition, supplementation tended ($P=.12$) to increase rate of DMD. Extent of in situ DMD (96 h) exhibited an increase ($P<.01$) in DMD for MHS vs straw treatments. Urea ammoniation of tall fescue straw increased ($P<.05$) extent of in situ DMD. In contrast, Chestnut et al. (1988) reported that urea ammoniation of tall fescue hay failed to alter extent of in situ fiber digestion, yet increased rate of NDF digestion was observed.

Digesta fill variables (DM and liquid) displayed a treatment by evacuation time interaction ($P<.05$). Dry matter digesta fill was altered ($P<.05$) by supplementation in which supplementation lowered DM fill at 0800. However, DM fill at 1300 was not altered by main effects. Liquid volume was altered ($P<.05$) by supplementation at 0800, but not altered at 1300. Liquid volume was lower at 0800 and 1300 ($P<.01$) for MHS vs tall fescue straw diets. Urea ammoniation of tall fescue straw decreased ($P<.05$) liquid volume at 1300.

Exp. 2. As in Exp. 1, forage DMI and total DMI for MHS was increased ($P<05$; Table 4) over tall fescue straw treatments. Forage DMI was lowest ($P<.05$) for ATF and ATFS, and intermediate for TFS, which differed ($P<.05$) from MHS, ATF and ATFS. Total DMI was different ($P<.05$) among all treatments, with MHS as the

TABLE 2. THE INFLUENCE OF UREA-AMMONIATION AND(OR) SUPPLEMENTATION ON DRY MATTER INTAKE AND TOTAL TRACT DIGESTION OF TALL FESCUE STRAW BY BEEF STEERS

		Treatments				
		Tall Fescue Straw		NH_3 Tall Fescue Straw		
Item	Meadow Hay + Supplement	No Supplement	Supplement	No Supplement	Supplement	SE[a]
Dry Matter Intake, kg						
Forage[b,c]	6.43	5.80	5.76	6.14	5.35	.17
Total[b,d]	7.81	5.80	6.96	6.14	6.58	.19
Dry Matter Intake, % BW						
Forage[b,c]	2.20	1.97	2.00	2.10	1.85	.06
Total[b,d]	2.66	1.97	2.41	2.10	2.28	.07
Apparent DMD, %[b,d,e]	46.1	52.6	50.5	50.8	48.5	1.0
Digested DM, kg[b,d]	3.61	3.08	3.51	3.12	3.19	.11

[a]Pooled standard errors, N = 10.
[b]Meadow hay + supplement differs from all straw treatments ($P<.05$).
[c]Supplementation by ammoniation interaction ($P<.05$)
[d]Supplementation main effect ($P<.05$).
[e]Ammoniation main effect ($P<.05$).

TABLE 3. THE INFLUENCES OF UREA-AMMONIATION AND(OR) SUPPLEMENTATION ON THE DIGESTIVE KINETICS OF BEEF STEERS CONSUMING TALL FESCUE STRAW

		Treatments				
		Tall Fescue Straw		NH_3 Tall Fescue Straw		
Item	Meadow Hay + Supplement	No Supplement	Supplement	No Supplement	Supplement	SE[a]
In Situ						
Lag Time, h[b]	4.32	4.16	4.47	4.09	4.33	.13
Rate, %/h[d]	4.31	3.36	3.47	3.58	4.66	.38
Extent, 96 h[c,d]	75.0	64.6	65.1	66.4	66.9	.7
Digesta Fill[e]						
DM, kg						
0800[b,c]	5.80	7.17	6.67	7.40	6.76	.25
1300	8.58	8.68	9.23	8.41	8.71	.27
Liquid, ℓ						
0800[b,c]	43.1	56.3	50.1	53.4	50.3	1.2
1300[c,d]	57.5	65.1	64.9	59.0	60.6	2.0

[a]Pooled standard errors, n = 10.
[b]Supplement main effect ($P<.05$).
[c]Meadow hay + supplement differed from straw treatments ($P<.10$).
[d]Ammoniation main effect ($P<.05$).
[e]Digesta kinetics were based on rumen evacuations just prior to feeding (0800) and 5 h post-feeding (1300).

highest and ATF as the lowest intake. Likewise, Hunt et al. (1990) reported that DMI was greater for beef steers consuming untreated hay vs urea treated hay.

Average daily gains were similar ($P>.05$) for steers consuming MHS, TFS and ATFS. Average daily gain for the ATF treatment was lowest ($P<.05$) among treatments. Feed/gain ratios were lowest for MHS and ATFS, which were similar ($P>.05$), and highest for TFS and ATF, which were similar ($P>.05$). Feed/gain ratios were also similar ($P>.05$) among TFS and ATF. In a similar study, feed/gain for beef steers consuming grass hay were lower for untreated grass hay vs urea treated grass hay (Hunt et al. 1990).

Implications

Under the conditions of this study, the use of urea-ammoniation appears to not be an effective technique to improve the nutritive quality of grass seed residues. Intakes of urea-ammoniated straws, in general, were lower then untreated straw and meadow hay. This may suggest that the urea based ammoniation process may cause some palatability problems with the basal forage. Although the ammoniation procedure presented some palatability problems, supplemented grass seed straw does show promise as an alternative winter forage resource for beef cattle production.

TABLE 4. PERFORMANCE DATA FOR GROWING STEERS CONSUMING TALL FESCUE STRAW WITH OR WITHOUT UREA AMMONIATION AND SUPPLEMENTATION, AND MEADOW HAY WITH SUPPLEMENTATION.

Item	Treatments: Meadow Hay+Supplement	Straw+Supplement	NH_3-Straw: No Supplement	NH_3-Straw: Supplement	SE[a]
Forage Intake (kg)	4.74[b]	4.35[c]	4.13[d]	4.12[d]	.14
Total Intake (kg)	5.60[b]	5.22[c]	4.13[d]	4.67[e]	.14
Average Daily Gain (kg)	.47[b]	.33[b]	.17[c]	.38[b]	.06
Feed/gain (kg)	5.42[c]	7.34[bc]	11.37[b]	6.08[c]	1.98

[a] n = 3

[b-e] Row means without common superscript letters differ (P<.05)

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