1-1-1979

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WHEAT STRAW AND SODIUM HYDROXIDE TREATMENT IN BEEF COW RATIONS[1]

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Summary

Two cow drylot wintering trials and a lamb digestion trial were conducted to evaluate wheat straw in maintenance diets for gestating beef cows. Wheat straw or sodium hydroxide (NaOH) treated wheat straw, when fed *ad libitum* with one-third alfalfa hay, supported gestating cow weight gains equivalent to a limit-fed alfalfa-bromegrass diet. Cows fed NaOH treated wheat straw supplemented with soybean meal and minerals gained less weight ($P<.01$) than cows on the other treatments. Calf birth weights, calving difficulty and subsequent reproductive performance of the cows were similar for all treatments. Apparent digestibility of wheat straw was increased ($P<.01$) by 4% NaOH treatment in a lamb digestion trial but was not altered by balancing the sodium intake with other specific minerals. The increase in digestibility of wheat straw due to NaOH treatment was greater *in vitro* than *in vivo*.

(Key Words: Wheat Straw, Sodium Hydroxide, Beef Cows.)

Introduction

The increasing production costs of high quality forages and growing pressure to use grains for human consumption has stimulated interest in the use of crop residues in ruminant diets. Wheat straw is the most commonly available crop residue throughout the world and is usually produced in geographic areas where beef cows are also found.

The low digestible energy and protein content of wheat straw suggests use in diets for gestating beef cows. Dinusson (1969) concluded from a 4-year study that two-thirds of a conventional grass-hay wintering diet for gestating beef cows could be replaced with wheat straw if supplemental protein was supplied. Alfalfa, because of its relatively high protein content, has been used to supplement cow diets composed primarily of straw (McKee *et al.*, 1977; Hackett *et al.*, 1975; Maeng *et al.*, 1971). Other research indicates that gestating beef cows can be wintered with wheat straw alone if they can withstand moderate weight loss (Arnett and McChord, 1927; Taylor *et al.*, 1977).

To meet the energy requirement of a gestating beef cow with only wheat straw it would be necessary to increase straw digestibility. Recent reviews by Klopfenstein (1978) and Jackson (1977) indicate that treatment with sodium hydroxide (NaOH) will increase digestibility of wheat straw. The objectives of this study were to measure the performance of gestating beef cows on diets containing wheat straw and to evaluate the effect of NaOH treatment of the straw.

Experimental Procedure

Trial 1. Eighty mature crossbred (Angus × Hereford) cows were randomly assigned to four dietary treatments (table 1) with two replications of 10 cows per treatment. Cows weighed 509 kg and were in mid-gestation at the start of the trial conducted during the winter of 1976–77.

Wheat straw, for treatments 3 and 4, was treated with 4% NaOH on a dry matter (DM) basis 20 days before the initiation of the trial. Straw was chopped to a length of approximately 4 cm and brought to about 50% moisture. NaOH was added to supply 4 g NaOH/100 g DM in a manner similar to the spray treatment of Wilson and Pidgen (1964). The treated straw was stored in a bunker silo. Chopped alfalfa was mixed with NaOH treated straw at feeding time for treatment 3, while treatment 4 consisted of a soybean meal (SBM)-mineral supplement

[1] Published with the approval of the Director as Paper No. 5670 Journal Series, Nebraska Agr. Exp. Sta.

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TABLE 1. DIET COMPOSITION FOR COW TRIAL 1

Ingredient[a]	Internat'l Ref. No.	Dietary treatment 1[b]	2[c]	3[c]	4[c]
Alfalfa hay, %	100059	33.3	33.3	33.3	...
Bromegrass hay, %	100888	66.7	...	...	...
Wheat straw, %	105175	...	66.7	...	...
NaOH treated wheat straw, %		...	...	66.7	100
SBM-mineral mix[d], kg/day		...	...	...	1.26
Dicalcium phosphate[e], g/day	601080	...	63.5	63.5	...
Vitamin A premix, g/day[f]		1	1	1	1

[a]Ingredients on a DM basis.

[b]Limit-fed at 8.2 kg DM/day.

[c]*Ad libitum* fed.

[d]Fed at a constant rate with NaOH treated straw fed free choice.

[e]Fed at a constant rate to supply phosphorus requirements of gestating beef cow.

[f]30,000 IU/gram.

addition to treated wheat straw (tables 2 and 3).

Supplement for treatment 4 (table 2) was formulated to supply the NRC (1976) suggested crude protein (CP) requirement for a 500 kg gestating beef cow. Minerals were added to the SBM based supplement to overcome mineral imbalance that may occur from high intakes of sodium (Moseley and Jones, 1974). Mineral ratios, as described by Lesoing (1977), were maintained. This supplement was fed at a constant rate of 1.26 kg/day with NaOH treated wheat straw fed *ad libitum* for treatment 4.

The trial consisted of a 100-day winter drylot feeding program and an additional 5 days where all cows received 6.7 kg of corn silage on a DM basis. This additional 5 days was to equalize rumen fill due to different rates of digestion and water consumption for diet treatments. Initial, 100-day and 105-day weights were obtained after holding animals without feed and water for 16 hours. Average daily gain (ADG), daily feed intake and gain to feed ratios were calculated. Calf birth weights and calving difficulty were observed and subsequent reproductive performance was evaluated.

Trial 2. Trial 2 was conducted the winter of 1977–78 with a design similar to trial 1. Eighty crossbred cows weighing 490 kg were assigned to the four treatments shown in trial 1 except 1.38 kg of a reformulated SBM-mineral mix

TABLE 2. COMPOSITION OF SBM-MINERAL MIX FOR COW TRIAL 1[a]

Ingredient	% of DM
SBM	74.49
Potassium chloride	9.23
Limestone	9.17
Dicalcium phosphate	4.76
Magnesium oxide	2.06
Trace mineral premix[b]	.29

[a]1.26 kg DM fed/hd/day. Formulated to supply .93 kg SBM/hd/day, .30% P and the following ratios of minerals: Na:k, 1:1; Na:Ca, 2:1; Na:Mg, 6:1; Na:Cl, 1.7:1.

[b]10% Mn, 10% Fe, 10% Zn, 1% Cu, .3% I, .1% Co.

TABLE 3. COMPOSITION OF SBM-MINERAL MIX FOR COW TRIAL 2[a]

Ingredient	% of DM
SBM	67.36
Potassium chloride	13.56
Limestone	10.78
Dicalcium phosphate	5.60
Magnesium oxide	2.36
Trace mineral premix[b]	.34

[a]1.38 kg DM fed/hd/day. Formulated to supply .93 kg SBM/hd/day, .30% P and the following ratios of minerals: Na:K, 1:1; Na:Ca, 2:1; Na:Mg, 6:1; Na:Cl, 1.7:1.

[b]10% Mn, 10% Fe, 10% Zn, 1% Cu, .3% I, .1% Co.

(table 3) was fed to each cow that received treatment 4. The new supplement was formulated to supply additional minerals to maintain the ratios described for trial 1 without increasing protein supplementation. This was necessary in anticipation of an increased intake of NaOH treated straw resulting in a larger intake of sodium.

NaOH treatment was performed on a weekly basis to eliminate heating and spoilage of the straw that had occurred during storage in trial 1. For trial 2, wheat straw was chopped as described in trial 1, weighed into a mixer wagon, brought to about 50% moisture and dry NaOH was added to supply 4 g NaOH/100 g straw DM. After thorough mixing, treated straw was allowed to react for 24 hr before feeding. Procedures for feeding, weighing and performance evaluations were the same as trial 1.

Statistical analysis of trials 1 and 2 was conducted according to analysis of variance procedure outlined by Steel and Torrie (1960). Orthogonal comparisons were performed to evaluate treatment differences for ADG. These two trials were then pooled and analyzed to further evaluate treatment differences.

Trial 3. A lamb digestion trial was conducted to evaluate NaOH treatment of wheat straw. Twenty-four crossbred wether lambs were assigned to six treatments (table 4) in a completely randomized design. Lambs were housed in digestion stalls and fitted with canvas fecal collection bags.

Forages were ground through a 1.3 cm screen with particle length generally from 1/2 to 2 cm and mixed prior to a daily feeding. NaOH treatment of wheat straw was similar to cow trial 2. Treated material was packed in 208 liter barrels and allowed to react for 48 hr before feeding. Treatments 1, 2, 3 and 4 were supplemented with 6.2 g of monosodium phosphate to insure adequate phosphorus. Four grams of salt daily were added to treatments 1, 2 and 3. All lambs were given 30,000 IU of vitamin A 2 days prior to the collection period. Lambs were prefed *ad libitum* for 11 days and then restricted to 600 g DM per day for an additional 3 days. Daily grab samples of all forages were taken and stored for subsequent analyses. At the end of this 14-day prefeeding period a 7-day total fecal collection was initiated. Lambs were reallotted and again prefed before a second 7-day fecal collection period.

Total fecal collection for each lamb was composited and frozen until subsamples could be taken for DM, organic matter (OM) and Cl analyses. Feed refusal was weighed daily and sampled for subsequent analyses. DM was obtained by drying for 48 hr at 65 C and then 24 hr at 105 C in a forced air oven. OM percentage on a DM basis was calculated by subtracting DM ash percentage (600 C for 3 hr) from 100. Protein determinations were performed on a wet sample using the Kjeldahl method (AOAC

TABLE 4. DIET COMPOSITION FOR LAMB DIGESTION STUDY

Ingredient[a]	Internat'l Ref. No.	Dietary treatment 1	2	3	4	5	6[d]
		(%)					
Alfalfa hay	100059	100	33.33	33.33	33.33	...	...
Bromegrass hay	100888	...	66.67	...	...	...	...
Wheat straw	105175	...	...	66.67	...	...	...
NaOH treated wheat straw[b]		...	...	...	66.67	89.08	84.36
SBM		...	...	...	...	10.10	10.64
Dicalcium phosphate[c]	601080	...	...	...	...	.82	.83
Potassium chloride		...	...	...	...	...	1.92
Magnesium oxide		...	...	...	...	...	.36
Limestone		...	...	...	...	...	1.73
Trace mineral premix		...	...	...	...	...	.05
Percentage CP		17.5	13.6	8.9	8.4	8.9	8.9

[a]Ingredients on a DM basis.

[b]4 g NaOH/100 g straw.

[c]To supply .30% P in the diet.

[d]Minerals added to supply the following ratios: Na:K, 1:1; Na:Ca, 2:1; Na:Mg, 6:1; Na:Cl, 1.7:1.

1970). *In vitro* DM digestibility and *in vitro* OM disappearance was obtained using the Moore modification of the two-stage Tilley-Terry procedure as reported by Harris (1970). This procedure was further modified by using a rumen fluid to buffer ratio of 30:70. One gram of urea was added per liter of buffer before rumen fluid addition. Analysis of variance and orthogonal comparisons as described by Steel and Torrie (1960) were performed on these parameters.

Results

Trials 1 and 2. Cows fed NaOH treated wheat straw supplemented with a SBM-mineral mix gained less weight ($P<.05$) than did cows fed the other three diets (table 5). When treated or untreated wheat straw was mixed with alfalfa hay (treatments 2 and 3) and fed *ad libitum* cows gained as much weight as the limit-fed control diet composed of alfalfa and bromegrass hays. These data are in agreement with Dinusson (1969) who concluded that up to two-thirds of a conventional beef cow hay diet could be successfully replaced with wheat straw while maintaining adequate performance and minimizing possibilities for rumen compaction.

Research has shown that NaOH treatment of wheat straw will increase intake (Klopfenstein, 1978). In this trial due to spoilage observed as heating and mold growth, NaOH treated wheat straw intake was lower (10.0 kg daily in treatment 3) than for untreated straw (11.8 kg daily in treatment 2). Although consumption was 1.8 kg higher for the untreated straw treatment, daily gain and gain to feed ratios favored the two-thirds treated straw diet.

Switching all treatments to corn silage for 5 days after the 100-day dietary treatment period reduced apparent ADG. When comparing 100-day and 105-day ADG the apparent reduction was .10, .08, .10 and .06 kg daily for treatments 1, 2, 3 and 4, respectively. This observation suggests that at the 100-day weighing cows had a considerable amount of rumen fill even after being held without feed and water for 16 hours. Feeding corn silage, which is more rapidly digested, gave a better measure of actual cow weight change over the feeding period by eliminating a portion of the rumen fill differences.

There were no differences in subsequent calving difficulty or calf birth weight for the four winter-diets. Reproductive performance was satisfactory with no differences associated with the feeding of wheat straw.

Performance of cows on all treatments in trial 2 was not as good as in trial 1 (table 5) which may have been due to the severity of the weather during trial 2. There were no significant differences in 105-day ADG with 105-day gains being lower than were observed in trial 1 (table 5). Cows fed NaOH treated wheat straw supplemented with the SBM-mineral mix tended to gain slightly less weight, but with some improvement in feed efficiency. Treatment of straw tended to improve performance when fed with alfalfa as had been seen in trial 1. In this experiment the limit-fed alfalfa bromegrass hay treatment appeared to support greater weight gains than the two-thirds wheat straw diets.

Weekly NaOH treatment of wheat straw to eliminate spoilage in storage appeared to improve consumption of treated straw over that observed in trial 1. In this trial, cows fed NaOH treated wheat straw with alfalfa consumed 12.4 kg of DM compared to 10.9 kg of untreated straw and alfalfa. The increased intake did not further increase gains for the alfalfa and treated straw treatment. This may be because of a decrease in digestibility due to increased intake or a higher sodium intake from NaOH treated straw as observed by Berger (1978).

Feeding corn silage for 5 days reduced apparent ADG for treatments 1, 2, 3 and 4 by .04, .18, .07 and .05 kg, respectively. The reduction in apparent ADG for treatment 2 was much larger than the other treatments. This observation suggests that more rumen fill existed for cows fed untreated wheat straw at the 100-day weighing because of its slower rate of digestion.

Calf birth weights for treatments 1, 2, 3 and 4 were 35.6, 35.2, 36.3 and 37.6 kg, respectively, however, differences were not significant. Calving difficulty was similar for all treatments. Reproductive performance was not altered by the winter dietary treatments.

Trials 1 and 2 (pooled). Since trial 1 and 2 had identical experimental designs and similar treatments they were pooled for statistical analyses (table 6). These analyses show a lower ($P<.01$) 100-day and 105-day ADG for cows that received treated straw supplemented with SBM and minerals. This lower performance may have resulted from high sodium intake from the NaOH treatments (Berger, 1978; Paterson *et al.*, 1978) or from a lower protein content of the diet. All treatments exceeded the minimum level of protein suggested by NRC (1976), how-

TABLE 5. PERFORMANCE OF COWS IN DRYLOT WINTERING TRIALS 1 and 2

Dietary treatment	Trial 1 (Winter 1976 to 1977)				Trial 2 (Winter 1977 to 1978)			
	100-day ADG, kg[a]	105-day ADG, kg[bc]	Avg daily feed, kg[d]	Gain to feed ratio[f]	100-day ADG, kg[b]	105-day ADG, kg[c]	Avg daily feed, kg[d]	Gain to feed ratio[f]
1. 1/3 alfalfa, 2/3 bromegrass	.40	.30	8.2[e]	.037	.24	.20	8.2[e]	.024
2. 1/3 alfalfa, 2/3 wheat straw	.35	.27	11.8	.023	.29	.11	10.9	.010
3. 1/3 alfalfa 2/3 treated wheat straw	.44	.34	10.0	.034	.22	.15	12.4	.012
4. Treated wheat straw, SBM-mineral	.23	.17	9.9	.017	.14	.09	12.2	.007

[a] 4 *vs* 1, 2, 3 significant ($P<.01$).

[b] 4 *vs* 1, 2, 3 significant ($P<.05$).

[c] 100 days on respective diets plus 5 days of corn silage.

[d] DM basis.

[e] Limit-fed.

[f] Calculated using 105-day ADG.

TABLE 6. PERFORMANCE OF COWS IN DRYLOT COW WINTER TRIALS – 2-YEAR AVERAGE

Dietary treatment	100-day ADG, kg[a]	105-day ADG, kg[bc]	Avg daily feed, kg[de]	Gain to feed ratio[f]
1. 1/3 alfalfa, 2/3 bromegrass	.32	.25	8.2	.030
2. 1/3 alfalfa, 2/3 wheat straw	.32	.19	11.4	.017
3. 1/3 alfalfa, 2/3 treated wheat straw	.33	.25	11.2	.022
4. Treated wheat straw, SBM-mineral	.19	.13	11.1	.012

[a] 4 *vs* 1, 2, 3 significant (P<.01).

[b] 4 *vs* 1, 2, 3 significant (P<.01); 2 *vs* 3 significant (P<.10).

[c] 100 days on respective diets plus 5 days of corn silage.

[d] DM basis.

[e] Limit-fed.

[f] Calculated using 105-day ADG.

ever, treatment 4 was slightly below the minimum suggested by Church (1977). The direct comparison of NaOH treated straw and untreated straw when fed with alfalfa (treatments 2 and 3) showed an advantage (P<.10) for the NaOH treated straw when 105-day ADG was calculated.

Trial 3. Apparent dry matter digestibility (DMD) and organic matter digestibility (OMD) of wheat straw in lambs was increased (P<.01) by 4% NaOH treatment (table 7). When NaOH treated straw was fed with alfalfa, a lower (P<.01) apparent nitrogen digestibility (ND) resulted when compared to untreated straw and

TABLE 7. DIGESTIBILITY COEFFICIENTS FOR LAMB DIGESTION STUDY

Dietary treatment	Daily intake, g[a]	DMD[b]	OMD[b]	ND[bc]
		(%)		
1. Alfalfa hay	590.1	49.5	50.3	68.5
2. 1/3 alfalfa, 2/3 bromegrass	594.4	55.2	56.9	60.9
3. 1/3 alfalfa, 2/3 wheat straw	496.7	47.8	50.2	56.0
4. 1/3 alfalfa, 2/3 treated wheat straw	579.3	55.7	56.6	51.8
5. Treated wheat straw, soybean meal	581.6	62.6	63.7	60.6
6. Treated wheat straw, SBM-mineral	593.4	61.3	61.8	58.7

[a] DM basis, all lambs were offered 600 g DM/day.

[b] 1 *vs* 2, 3, 4, 5, 6; 3, 4 *vs* 5, 6; 3 *vs* 4 significant (P<.01).

[c] 2 *vs* 3, 4, 5, 6 significant (P<.01).

alfalfa. Alfalfa hay had the highest ND ($P<.01$).

A relatively low OMD value was obtained for the alfalfa hay treatment when compared to the other treatments. This observation may have been due to a slower rate-of-passage for the straw diets and higher than expected digestibility of these diets. Also, the alfalfa used was mature with a low leaf-to-stem ratio. Intake of the untreated straw diet was lower than the 600 g offered which may have been an advantage due to lowered intake and rate of passage (Lesoing, 1977).

Assuming the OMD of the one-third portion of alfalfa hay in treatments 2 and 4 as determined by difference to be the same as the all alfalfa diet, digestibility for untreated and treated straw was 50.1 and 59.7%, respectively. *In vitro* OM for 4% NaOH treated wheat straw was 62.7%. The somewhat higher *in vitro* than *in vivo* digestibility is in agreement with other research (Rexen and Thomsen, 1976; Levy *et al.*, 1977; Berger, 1978).

Addition of supplemental minerals to the NaOH treated wheat straw diet did not alter DMD, OMD or ND. This observation agrees with work by Paterson *et al.* (1978) who showed little change in digestibility when minerals were added to NaOH treated corn cob diets. An improvement in the metabolic balance of these minerals may occur (Paterson *et al.*, 1978) that could account for an improvement in performance observed by Lesoing (1977) in growing calves.

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