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Gary Lesoing
University of Nebraska-Lincoln, glesoing2@unl.edu

Ivan G. Rush
University of Nebraska-Lincoln, irush1@unl.edu

Terry Klopfenstein
University of Nebraska-Lincoln, tklopfenstein1@unl.edu

John Ward

WHEAT STRAW IN GROWING CATTLE DIETS[1]

Gary Lesoing[2], Ivan Rush[3], Terry Klopfenstein and John Ward

University of Nebraska[4], Lincoln 68583

Summary

Three cattle growth trials were conducted to evaluate the use of untreated and alkali-treated wheat straw as energy sources for ruminants. In trial 1, daily gain decreased as level of untreated wheat straw increased in the diet. A 14% decrease in gain occurred when the level of straw was increased from 30 to 40% of the diet. In trial 2, cattle fed 4% NaOH-treated wheat straw at the 30 or 60% level had better daily gains and feed efficiencies ($P<.05$) than those fed untreated wheat straw. In trial 3, when the effect of balancing for specific mineral ratios on the alkali-treated straw diets was evaluated, steers fed 78% treated wheat straw with added minerals gained faster ($P<.05$) than those receiving 80% treated wheat straw with no mineral additions (.65 kg/day *vs.* .54 kg/day). In addition, in this trial, cattle fed 50% treated wheat straw gained faster ($P<.05$) than those fed 50% untreated wheat straw (.74 kg/day *vs.* .62 kg/day).

(Key Words: Wheat Straw, Sodium Hydroxide-Treated Straw.)

Introduction

Each year approximately, 229.5 million ha of wheat are grown worldwide. After the grain is harvested, much of the straw is left in the field. Wheat straw may be used as an ingredient in cattle growing diets to help producers attain maximum utilization from their higher quality feedstuffs. The relatively low available energy value of wheat straw has restricted its use to gestating beef cow diets (Arnett and McChord, 1927; Dinusson, 1969) or as a roughage source for finishing cattle (Thomas and Jordan, 1957). Use of the wheat straw in growing calf diets has been minimal because calves cannot consume enough straw to meet their energy needs. For wheat straw to be more fully utilized, its energy availability must be improved. Treatment with sodium hydroxide (NaOH) has been effective in increasing the digestibility of cereal grain straws (Ololade *et al.*, 1970; Klopfenstein and Woods, 1970; Rexen and Thomsen, 1976). Singh and Jackson (1971) reported an increase in digestible organic matter intake when cattle were fed 3.3% NaOH-treated wheat straw rather than untreated straw. This increase in digestible organic matter intake should improve rate of gain. Lambs fed 4% NaOH-treated wheat straw gained faster and more efficiently than those fed untreated wheat straw (Hasimoglu, 1972). While treated and untreated wheat straw have been compared in cattle digestion and intake trials and lamb growth trials, little research has been conducted to evaluate the inclusion of wheat straw in cattle growing diets.

Experimental Procedure

Three cattle growth trials were conducted to evaluate wheat straw as a component of cattle growing diets. In trial 1, one hundred steers (average weight 242 kg) were randomly allotted to five treatments (two pens per treatment) in this 81-day trial. Cattle were group-fed in outside pens with round bottom concrete feed bunks. Untreated wheat straw was ground through a 7-cm screen and fed as: (1) 0, (2) 10, (3) 20, (4) 30 or (5) 40% of the diet dry matter. The remainder of the diet consisted of corn silage, soybean meal, dicalcium phosphate and limestone (table 1). Diets were formulated to contain 11.5% crude protein, .4% Ca and .3% P. The diets were fed *ad libitum*, and trace mineralized salt blocks were provided at all times. Vitamin A was fed once weekly to meet the animal's requirements (2,200 IU/kg diet). Samples of wheat straw, corn silage and soybean meal were collected weekly for dry matter determination for monitoring of feed intake. Dry matter determinations were made by

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[2] Present address: Exp. Sta.

[3] Panhandle Station, Scottsbluff, NE 69361.

[4] Dept. of Anim. Sci.

TABLE 1. COMPOSITION OF DIETS FOR CATTLE GROWTH TRIAL 1[a]

Ingredient	Internat'l. Ref. No.	Wheat straw level 0%	10%	20%	30%	40%
Wheat straw	1-05-175	0	10	20	30	40
Corn silage	3-08-154	91.19	80.02	68.86	57.69	46.52
Soybean meal	5-04-604	8.53	9.64	10.74	11.84	12.94
Dicalcium phosphate	6-01-080	.19	.24	.30	.35	.41
Limestone	6-01-069	.09	.10	.11	.12	.13

[a]Dry matter basis.

drying samples in a forced air oven (60 C) to a constant weight. Calves were weighed at the outset of the trial after a 16-hr shrink without feed and water. At the conclusion of the trial, calves were weighed full, with their final weight adjusted by applying a 4% shrink.

In trial 2, treated and untreated wheat straw was fed at three different levels in growing diets. One hundred steers (average weight 298 kg) were randomly allotted to five treatments (two pens per treatment) in this 114-day trial. Cattle were again group-fed in outside pens with round bottom concrete feed bunks. The diets offered were: (1) corn silage-0% wheat straw, (2) corn silage-30% untreated wheat straw, (3) corn silage-60% untreated wheat straw, (4) corn silage-30% treated wheat straw and (5) corn silage-60% treated wheat straw. Diets were formulated to contain 11.5% crude protein, .4% Ca and .3% P, with corn silage, soybean meal and dicalcium phosphate provided in addition to the wheat straw (table 2). Salt, trace minerals and vitamin A were provided as in trial 1, diets were again fed *ad libitum*. The wheat straw used in the trial was ground as in trial 1. Approximately one-half of the ground wheat straw was then chemically treated with 4% NaOH (4 kg of NaOH/100 kg of wheat straw dry matter) by the method described by Waller (1976). A 20% NaOH solution and enough water to increase the moisture content of the wheat straw to 60% were applied. The straw was then mixed, packed into a bunker silo and allowed to react for a minimum of 5 days before feeding. Black vinyl plastic was used to cover the wheat straw to help prevent spoiling and drying.

Dry matter was monitored as in trial 1. *In vitro* dry matter disappearance (IVDMD) was determined on wheat straw samples for purposes of comparing treated and untreated wheat straw; determinations were made by the two-stage digestion technique described by Tilley and Terry (1963). Calves were weighed initially after a 16-hr shrink without feed and water. On the 110th day of the trial, cattle were removed from their treatments and fed equal amounts of a standard corn silage and soybean meal diet for 4 days. They were then weighed after a 16-hr shrink.

In trial 3, treated and untreated wheat straw, with minerals added to some of the treated straw diets to balance for high sodium intake, were fed in growing steer diets. One hundred and twenty steers (average weight 201 kg) were randomly allotted to five treatments (two pens per treatment) in this 109-day growth trial. Steers were group-fed in outside pens with square bottom concrete feed bunks. The steers were fed: (1) 0% wheat straw, (2) 50% untreated wheat straw, (3) 50% treated wheat straw plus mineral additions, (4) 80% treated wheat straw with no mineral additions or (5) 78% treated wheat straw plus mineral additions. Diets were formulated to contain 11.5% crude protein and at least the minimum mineral requirements (table 3). On the basis of data reported by Mosely and Jones (1974), the diets with mineral additions were balanced to the following mineral ratios: Na:K, 1:1; Na:Cl, 1.7:1; Na:Ca, 2:1, and Na:Mg, 6:1. These ratios were used to provide a more favorable mineral balance for the steers fed the chemically-treated wheat straw diets. All diets were fed *ad libitum*, and trace mineralized salt was provided free choice to animals fed the treatments with no mineral additions. Vitamin A was fed once weekly to all cattle to meet their requirements. Wheat straw was ground, treated and fed as in trial 2, with the chemical treatment 3.15% NaOH and 1.19% potassium hydroxide (KOH). Dry matter and IVDMD were monitored as in trial 2. Cattle

TABLE 2. COMPOSITION OF DIETS FOR CATTLE GROWTH TRIAL 2[a]

Ingredient	Internat'l. Ref. No.	Wheat straw level 0%	30%	60%	30%	60%
		(%)				
Wheat straw	1-05-175	0	30	60	0	0
NaOH-treated wheat straw[b]		0	0	0	30	60
Corn silage	3-08-154	91.14	57.60	24.08	57.60	24.08
Soybean meal	5-04-604	8.53	11.84	15.15	11.84	15.15
Dicalcium phosphate	6-01-080	.34	.56	.77	.56	.77

[a]Dry matter basis.

[b]Wheat straw was treated with 4 kg NaOH/100 kg of dry matter.

were weighed at the outset after a 16-hr shrink without food and water. On the 103rd day of the trial, cattle were taken off their treatments and fed equal amounts of a standard corn silage and soybean meal diet for 6 days. They were then weighed after a 16-hr shrink without food and water.

Individual gain and pen intake and feed efficiency data from trials 1, 2 and 3 were analyzed by analyses of variance as described by Steel and Torrie (1960). Orthogonal comparisons were conducted to evaluate treatment mean differences. Comparisons made were: 1 *vs* 2,3,4,5; 2, 3 *vs* 4,5; 2 *vs* 3, and 4 *vs* 5.

Results and Discussion

In trial 1, as the level of straw in the diet increased, average daily gain decreased (table 4). This finding agrees with a report by Forbes *et al.* (1969) in which increasing levels of barley straw in cattle diets decreased average daily gain. As expected, cattle fed a diet of corn silage and soybean meal gained significantly faster and more efficiently than those fed wheat straw. The decrease in daily gain was particularly evident at the 40% straw level. Steers fed 30% wheat straw gained .11 kg/day faster than those receiving 40% straw. Although feed intakes were not significantly different, intake was highest for steers fed the 30% wheat straw diet. These data suggest that wheat straw stimulates intake up to a certain point, but that at higher levels, it depresses intake. Kay *et al.* (1970) found that dry matter intake increased when barley straw was included as 35% of a

TABLE 3. COMPOSITION OF DIETS FOR CATTLE GROWTH TRIAL 3[a]

Ingredient	Internat'l. Ref. No.	Wheat straw level 0%	50%	50%[b]	80%	78%[b]
		(%)				
Wheat straw	1-05-175	0	50	0	0	0
NaOH-treated wheat straw[c]		0	0	50	79.81	78.22
Corn silage	3-08-154	91.13	34.02	33.32	0	0
Soybean meal	5-04-604	8.53	15.27	15.47	19.28	19.36
Calcium chloride		0	0	.29	0	1.17
Dicalcium phosphate	6-01-080	.34	.71	.98	.91	1.03
Magnesium oxide	6-02-757	0	0	.04	0	.22
Trace mineral[d]		0	0	.05	0	.05

[a]Dry matter basis.

[b]Plus mineral additions.

[c]Wheat straw was treated with 3.15 kg NaOH and 1.19 kg KOH/100 kg dry matter.

[d]Composition of the trace mineral mix: 7% Mn, .2% I, 1% Cu, .1% Co, 8% Zn, 10% Fe, 7% Mg and 15% Ca.

TABLE 4. PERFORMANCE OF STEERS IN GROWTH TRIAL 1[a]

Item	Treatment 1 0% wheat straw	2 10% wheat straw	3 20% wheat straw	4 30% wheat straw	5 40% wheat straw	Standard error
No. of steers	20	20	20	20	20	
Initial wt kg	240.9	243.6	243.2	246.4	237.3	
Daily gain, kg[b,c]	1.13	.97	.91	.88	.77	.026
Daily intake kg	8.02	7.59	8.20	8.49	7.21	.62
Feed conversion[b,d]	7.29	7.73	8.89	9.53	9.52	.23

[a](Two pens/treatment); 81 days; least-square means adjusted for pen, treatment breed with initial weight used as a covariant.

[b]Treatment differences ($P<.05$) (1 *vs* 2, 3, 4, 5); (2, 3 *vs* 4, 5).

[c]Treatment differences ($P<.05$) (4 *vs* 5).

[d]Treatment differences ($P<.05$) (2 *vs* 3).

cattle growing diet but decreased at the 50% level. The increase in intake observed at the 30% level in trial 1 did not increase average daily gain. Diets containing wheat straw at the 10 and 20% levels were utilized significantly more efficiently than were those with straw at the 30 or 40% level.

Trial 2 evaluated treated and untreated wheat straw fed as 30 or 60% of the diet dry matter. As level of straw increased in the diets, average daily gain decreased (table 5). As in trial 1, steers receiving no wheat straw gained significantly faster and more efficiently than steers that were fed straw. Chemical treatment of wheat straw with 4% NaOH tended to improve average daily gain of cattle at both straw levels. Steers fed 30 and 60% chemically treated wheat straw gained 11 and 25% faster than those fed 30 and 60% untreated wheat straw, respectively. As in trial 1, the 30% wheat straw diets were consumed in the greatest quantities.

Feed efficiencies were also affected by chemical treatment and level of untreated straw in the diet. Steers fed 30 or 60% treated wheat straw were significantly more efficient than those fed untreated straw at the same levels. Untreated wheat straw fed as 60% of the diet

TABLE 5. PERFORMANCE OF STEERS IN GROWTH TRIAL 2[a]

Item	Treatment 1 0% wheat straw[b]	2 30% wheat straw[b]	3 60% wheat straw[b]	4 30% treated wheat straw[b]	5 60% treated wheat straw[b]	Standard error
No. of steers	20	19	20	20	20	
Initial wt, kg	296.8	300.5	302.7	294.5	297.3	
Daily gain, kg[c]	.97	.73	.52	.81	.65	.11
Daily intake, kg	9.97	11.15	9.74	11.96	9.61	1.95
Feed conversion[c,d]	10.40	15.29	18.54	14.97	14.88	1.84

[a](Two pens /treatment); 114 days, least-squares means adjusted for pen, treatment with initial weight used as a covariant.

[b]IVDMD of 4% NaOH-treated wheat straw and untreated wheat straw used in the growth trial were 57.42 and 41.56%, respectively.

[c]Treatment differences ($P<.05$) (1 *vs* 2, 3, 4, 5; 2 *vs* 3).

[d]Treatment differences ($P<.05$) (2, 3 *vs* 4,5).

induced significantly poorer feed efficiency than did the 30% untreated straw diet. Observations throughout the trial indicated some of this difference may have been due to a large amount of waste on the 60% untreated straw diet. Some of this difference can be reduced by feeding twice daily and using square bottom bunks. A problem that developed with the feeding of the NaOH-treated straw diets was muddy lots, which was caused by high water intakes and high urine outputs induced by the high sodium content of the diets. This is a problem that producers must be aware of if they are to feed treated wheat straw, and management decisions should be made accordingly.

Two important factors were noted from trial 2. First, the cattle might have been too heavy to utilize this type of high roughage diet effectively. Second, animals fed the treated straw diets outperformed those fed the untreated straw diets early in the trial by much more than they did near the conclusion. This may have been due to a mineral imbalance in the animals consuming the NaOH-treated straw. Mosely and Jones (1974) reported that high Na levels decreased retention of Na, K, Mg, P and N and increased excretion of these minerals and Ca.

Trial 3 was conducted to compare treated and untreated wheat straw fed at the same rate to growing cattle and to test the effect of balancing for specific mineral ratios in treated wheat straw diets. Results indicate that average daily gain of cattle was significantly affected by level of straw in the diet, chemical treatment of wheat straw and mineral additions to treated straw diets (table 6). As in trials 1 and 2, steers receiving no wheat straw gained significantly faster and more efficiently than those receiving straw. Cattle fed 50% treated wheat straw plus mineral additions gained 19% faster than those fed the 50% untreated straw diet. Balancing for the specific mineral ratios in the 78% treated wheat straw diet, increased ($P<.05$) steer gain by .11 kg/day over that obtained with the 80% treated wheat straw diet with no mineral additions. Intake was similar for cattle on all treatments. Feed efficiencies were improved by chemical treatment and balancing for minerals. Cattle fed chemically-treated wheat straw plus mineral additions as 50% of the diet utilized feed 14.7% more efficiently than animals fed untreated wheat straw at the same rate. Balancing for minerals in the 78% treated wheat straw diet improved feed efficiency by 14% over the 80% treated straw diet. In trial 2, feed efficiencies at the 30% wheat straw levels were virtually the same for animals fed untreated and treated wheat straw. Much of the difference in feed efficiencies between the untreated and treated wheat straw diets at the 60% level was due to waste of untreated straw. In trial 3, waste was not a problem and efficiencies were improved, possibly because of balancing for the specific mineral ratios.

TABLE 6. PERFORMANCE OF STEERS IN GROWTH TRIAL 3[a]

	Treatment					
Item	1 0% wheat[b] straw	2 50% wheat[b] straw	3 50% treated wheat straw[b] + minerals	4 80% treated wheat straw[b]	5 78% treated wheat straw[b] + minerals	Standard error
No. of steers	24	24	24	24	24	
Initial wt, kg	202.3	200.9	196.8	200.5	204.5	
Daily gain, kg[c,d]	1.05	.62	.74	.54	.65	.018
Daily intake, kg	6.14	5.53	5.83	5.32	5.51	.76
Feed conversion[c]	5.86	9.10	7.76	9.93	8.54	.32

[a](Two pens /treatment); 109 days, least-squares means adjusted for pen, treatment, breed with initial weight used as a covariant.

[b]IVDMD of 3.15% NaOH:1.19 KOH-treated wheat straw and untreated wheat straw used in the growth trial were 68.69 and 49.31%, respectively.

[c]Treatment differences ($P<.05$) (1 *vs* 2, 3, 4, 5).

[d]Treatment differences ($P<.05$) (2, 3 *vs* 4, 5; 2 *vs* 3; 4 *vs* 5).

Results of the three cattle growth trials show the relative merits of using untreated or treated wheat straw in growing diets. Maximum utilization was obtained when treated wheat straw was fed alone with a protein source and minerals. While addition of minerals improved performance of cattle fed the treated straw diets, the effect was not clearly understood. Although chemical treatment appears promising, more research and technology is needed before it will become an economically feasible practice. Price and availability of grain, protein source and higher quality forage sources will determine the extent to which wheat straw will be employed in ruminant diets in the future.

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