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Summary

A digestibility trial measuring intake, digestibility, ruminal nutrient disappearance, and ruminal pH was conducted to determine the effects of wheat middlings on utilization of mature prairie hay. Treatments included supplements used in a previous winter grazing trial at the SDSU Cottonwood Research Station that were balanced to provide the following amounts of crude protein (lb) and metabolizable energy (Mcal) per cow daily: 1) soybean meal .75 and 2.40, 2) low wheat middlings .75 and 4.76, 3) corn-soybean meal 1.50 and 9.40, and 4) high wheat middlings 1.50 and 9.40. These supplements were fed to the steers in proportional amounts based on $BW^{.75}$. Steers receiving the low wheat middlings supplement had similar hay and total diet intake but lower digestible dry matter intake than steers receiving soybean meal. High wheat middlings supplementation decreased hay intake and digestible hay and total diet intake compared to corn-soybean meal and low wheat middlings. The high level of wheat middlings and corn-soybean meal reduced ruminal pH at 4 and 8 hours post-supplementation. The high level of wheat middlings depressed overall ruminal disappearance of hay dry matter and NDF compared to the corn-soybean meal supplement and the low level of wheat middlings. This study indicates that wheat middlings may depress utilization of mature, low protein forages compared to soybean meal or corn-soybean meal supplements balanced to provide the same level of protein.

Key Words: Mature Prairie Hay, Supplements, Wheat Middlings, Soybean Meal, Corn

Introduction

Protein is typically the first limiting nutrient for cattle consuming mature, low protein forages. The use of all natural high protein supplements has been shown to increase cow weight change by improving forage intake and digestibility. The use of high starch grain-based supplements can be detrimental to cow performance due to a reduction in intake and digestibility of the base forage. High fiber low starch by-product feeds, such as wheat middlings, soybean hulls, brewers grains, and sugar beet pulp have the potential to provide supplemental protein and energy without the detrimental effects of the starch in grains on forage utilization. The objective of this study was to determine the effects of wheat middlings on intake, digestibility, ruminal nutrient disappearance, and ruminal pH of steers consuming mature prairie hay.

Materials and Methods

Four, mature ruminally fistulated steers (1687 lb) were used in a 4 x 4 Latin square. The trial consisted of four 20-day periods. Each period included a 7-day adaptation phase, a 7-day intake measurement phase, and a 6-day phase with total fecal collections, ruminal nutrient disappearance and ruminal pH being measured. Steers were individually housed indoors in a continuously lighted, climate controlled room (68° F) with slatted floors (6 x 8 foot pens) and had continuous access to water, trace mineral salt, and prairie hay.

Supplements used in this trial were used in a previous winter grazing trial conducted at the SDSU Cottonwood Range and Livestock

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Research Station (Table 1). A soybean meal supplement (SBM) was used as a base to provide .75 lb crude protein per cow daily. A low wheat middling supplement (LWM) was balanced to provide the same amount of protein daily. A high wheat middling supplement (HWM) was balanced to provide twice the amount of energy as the low wheat middlings supplement. A corn-soybean meal supplement (CS) was balanced to provide the same amount of protein and energy as the high wheat middlings supplement. Supplements were pelleted (3/16 in. diameter) and balanced to exceed NRC (1984) requirements for phosphorus and potassium. Steers were fed supplements in proportional amounts on a metabolic body weight basis ($BW^{.75}$) to what cows received in the winter grazing trial (Table 2). Supplements were fed at 0700 and were consumed within 20 minutes. Mature prairie hay (Table 3) harvested in October was ground through a tub grinder (2 in. screen) and offered twice daily at 130% of each steer's previous day's hay intake.

During the intake and fecal collection phases, individual orts were weighed and sampled (10% aliquots) at each hay feeding and refed at the next hay feeding. Hay was sampled daily and composited by period. Supplement and orts were composited by steer. Hay supplement and orts were weighed, subsampled, oven dried in a forced air oven at 140° F for 48 hours, ground through a Wiley mill (1-mm screen), and stored in air tight containers. Samples were analyzed for crude protein (CP), neutral detergent fiber (NDF), acid detergent fiber (ADF), and ash content. Hay samples were also analyzed for acid detergent lignin. Supplement samples were also analyzed for starch, ether extract, phosphorus, and potassium.

An in situ dacron bag technique was used to determine ruminal nutrient disappearance. Approximately 5 g of the dried hay (ground in a Wiley mill with a 2-mm screen) was placed in each dacron bag (10 x 20 cm) and heat sealed. On day 15 of each period, duplicate hay samples and empty bags (blanks) were soaked in warm tap water (102° F) for 15 minutes to hydrate prior to incubation and then placed in unanchored lingerie bags (43 x 53 cm) inside the rumen. Bags were introduced into the rumen at the same time and removed at 0, 4, 8, 12, 24, 48, and 72 hours post-supplementation. Zero hour bags were only hydrated in the tap water for 15 minutes. Bags were individually rinsed with tap water until rinse water was clear and then frozen for later analysis. Bags were thawed and oven dried at 140° F for 12 hours, allowed to air equilibrate for 3 hours, and weighed. Samples were analyzed for NDF content. The apparent extent of dry matter and NDF disappearance was calculated from residues remaining after incubation. Blank bags were used to adjust for influx and outflux of particles from the dacron bag.

Steers were fitted with fecal bags and harnesses on day 15 of each period for 5-day total fecal collections. Fecal bags were emptied three times daily and contents were weighed and sampled (10% aliquots) and stored in air tight containers at -1° F for later analysis. Samples were composited by steer, oven dried in a forced air oven at 140° F for 72 hours, and stored in air tight containers. Fecal samples were analyzed for CP, NDF, ADF, and ash.

On day 19 of each period rumen fluid samples were taken from the ventral sac of the rumen at 0, 4, 8, 12, 16, 20, and 24 hours post-supplementation. Ruminal fluid samples were analyzed for pH at the appropriate sampling time.

Dry matter digestibility of mature prairie hay was calculated by difference, assuming the digestibility of soybean meal, corn, and wheat middlings to be 84%, 90%, and 79%, respectively (NRC, 1984).

Intake and digestibility data were analyzed using the GLM procedure of SAS appropriate for a 4 x 4 Latin square. Main effects included steer, period, and treatment. Statistical analysis for the ruminal pH and in situ data was analyzed in a 4 x 4 Latin square split-plot in time design with repeated measures using the GLM procedure of SAS. Pre-planned comparisons were used to compare LWM vs SBM, HWM vs CS, and LWM vs HWM.

Table 1. Supplemental treatments[a]

Item	Supplement			
	Soybean meal	Low wheat middlings	Corn-soybean meal	High wheat middlings
Ingredients				
Soybean meal	88.62	—	32.20	—
Corn	—	—	64.68	—
Wheat middlings	—	97.83	—	97.83
Beet molasses	2.24	2.17	2.21	2.17
Dicalcium phosphate	9.14	—	.91	—
Composition				
Dry matter	87.77	87.92	86.44	86.40
Crude protein	44.34	18.30	23.74	18.23
Starch	7.90	18.17	45.48	18.17
Ether extract	.43	3.40	1.33	3.40
Neutral detergent fiber	7.82	37.81	10.50	38.19
Acid detergent fiber	5.29	11.75	4.35	11.60

[a]Percentage on a dry matter basis.

Table 2. Composition of average daily supplemental intake per steer

Item	SBM	LWM	CS	HWM
Dry matter, lb	2.57	5.11	8.74	11.10
Crude protein, lb	1.14	.94	2.07	2.02
Metabolizable energy, Mcal[a]	3.25	6.64	12.46	14.43
Phosphorus, lb	.019	.056	.072	.122
Potassium, lb	.054	.068	.096	.132

[a]Calculated values (NRC, 1984).

Table 3. Chemical composition of mature prairie hay[a]

Item	Composition
Dry matter, %	95.8
Crude protein, %	4.9
Neutral detergent fiber, %	76.8
Acid detergent fiber, %	44.5
Acid detergent lignin, %	6.6
Ash, %	6.2

[a]Percentage on a dry matter basis.

Results and Discussion

Hay and total diet intake and digestibility were similar for low wheat middlings (LWM) and soybean meal (SBM) supplemented steers (Tables 4 and 5). Digestible hay intake was reduced by LWM ($P=.08$) but total diet digestible intake was not affected.

Compared to the corn-soybean meal (CS) supplement, high wheat middlings (HWM) depressed hay ($P<.01$) and total diet ($P=.02$) intake but did not affect hay or total diet digestibilities. This resulted in a depression of digestible hay ($P=.02$) and total diet ($P=.08$) intake.

Increasing the level of supplement from LWM to HWM depressed hay intake ($P<.01$) and total diet digestibility ($P=.02$) and digestible hay ($P<.01$) and total diet ($P=.02$) intake.

Apparent ADF and NDF digestibility of the total diet was similar for LWM and SBM and for HWM and LWM. Supplementation with HWM increased apparent ADF ($P=.05$) digestibility over CS.

Supplementation with LWM decreased ($P=.04$) CP digestibility compared to SBM. HWM and CS had similar CP digestibilities. Increasing the level of wheat middlings from low to high increased ($P=.01$) CP digestibility.

Ruminal pH measurements indicated that higher levels of supplementation (CS and HWM) resulted in dramatic decreases in ruminal pH, levels that remained below the critical 6.2 limit for 8 hours post-supplementation (Table 6). Increasing the level of supplement from LWM to HWM decreased ruminal pH at 4 and 8 hours post-supplementation.

The LWM supplement did not improve apparent in situ hay dry matter or NDF disappearance over SBM (Tables 7 and 8). HWM decreased dry matter ($P=.10$) and NDF ($P=.04$) disappearance over CS. The HWM supplement decreased apparent dry matter ($P=.04$) and NDF ($P=.07$) disappearance compared to LWM.

The results from this digestibility trial demonstrate that soybean meal slightly increased forage utilization compared to low wheat middlings. Supplementation with wheat middlings decreased forage intake and utilization compared to a corn-soybean meal supplement providing the same level of protein and energy. Increasing the level of supplement from low to high wheat middlings decreased forage utilization indicated by the reduced digestible hay and total diet intakes.

This research suggests that wheat middlings will decrease the utilization of mature, low protein forage. Increasing the level from low to high wheat middlings will result in detrimental effects on intake and digestibility.

Table 4. Daily intake of mature prairie hay and total diet of steers receiving supplements

Item	Supplement				SE[a]	Comparisons[b]		
	SBM	LWM	CS	HWM		LWM vs SBM	HWM vs CS	LWM vs HWM
DM								
Hay, lb	20.5	19.0	17.0	10.8	.34	.19	<.01	<.01
Hay, % BW	1.2	1.1	1.1	.6	.05	.33	<.01	<.01
Total diet, lb	23.2	24.0	25.8	21.8	.38	.47	.02	.12
Digestible DM								
Hay, lb	9.0	7.3	6.2	3.5	.27	.08	.02	<.01
Total diet, lb	11.5	12.6	11.5	9.0	.35	.39	.08	.02

[a]Standard error of the mean.
[b]Probability of a greater F-value.

Table 5. Apparent digestibility coefficients

Item	Supplement				SE[a]	Comparisons[b]		
	SBM	LWM	CS	HWM		LWM vs SBM	HWM vs CS	LWM vs HWM
DM	49.9	52.1	44.2	41.8	2.29	.51	.48	.02
Hay DM	44.4	38.7	35.9	32.5	2.85	.21	.43	.18
NDF	54.4	50.0	49.2	53.2	1.98	.17	.20	.29
ADF	50.7	45.0	35.8	46.8	3.28	.26	.05	.71
CP	59.8	46.1	60.8	64.6	3.65	.04	.49	.01

[a]Standard error of the mean.
[b]Probability of a greater F-value.

Table 6. Ruminal pH measurements of steers consuming low quality hay and supplements

Hour	Supplement				SE[a]	Comparisons[b]		
	SBM	LWM	CS	HWM		LWM vs SBM	HWM vs CS	LWM vs HWM
0	6.25	6.48	6.46	6.53	.05	.02	.37	.50
4	6.10	6.05	5.81	5.72	.10	.74	.54	.06
8	6.17	6.17	5.95	5.83	.07	.96	.30	.02
12	6.12	6.27	6.16	6.12	.07	.17	.69	.15
16	6.14	6.35	6.34	6.44	.07	.09	.37	.40
20	6.17	6.38	6.45	6.55	.04	<.01	.12	.02
24	6.42	6.65	6.72	6.62	.07	.05	.34	.76
Overall	6.20	6.34	6.27	6.26	.04	.06	.86	.25

[a]Standard error of the mean.
[b]Probability of a greater F-value.

Table 7. Apparent in situ disappearance of hay dry matter

Hour	Supplement				SE[a]	Comparisons[b]		
	SBM	LWM	CS	HWM		LWM vs SBM	HWM vs CS	LWM vs HWM
4	11.1	11.6	10.0	10.5	.64	.64	.59	.28
8	14.2	13.5	14.4	13.6	1.00	.62	.58	.95
12	18.7	17.2	16.2	14.0	1.02	.33	.18	.07
24	37.3	31.6	31.8	25.4	1.79	.06	.05	.05
48	55.2	52.5	50.8	44.4	3.28	.58	.22	.13
72	60.2	60.6	58.4	53.1	2.21	.92	.14	.06
Overall	9.4	28.2	27.2	24.2	1.08	.46	.10	.04

[a]Standard error of the mean.
[b]Probability of a greater F-value.

Table 8. Apparent in situ disappearance of hay NDF

Hour	Supplement				SE[a]	Comparisons[b]		
	SBM	LWM	CS	HWM		LWM vs SBM	HWM vs CS	LWM vs HWM
4	28.7	27.5	29.0	27.9	.98	.39	.44	.75
8	31.6	29.2	32.1	30.0	.98	.13	.17	.57
12	35.6	32.5	34.4	30.2	1.23	.12	.05	.23
24	52.4	46.0	47.5	40.1	1.80	.05	.03	.06
48	67.5	64.9	63.8	55.8	3.04	.58	.11	.08
72	70.9	71.2	69.0	64.0	1.87	.91	.11	.03
Overall	44.8	42.5	43.3	39.0	1.15	.21	.04	.07

[a]Standard error of the mean.
[b]Probability of a greater F-value.