1993

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EFFECTS OF LEVEL OF CONCENTRATE ON UTILIZATION OF MATURE PRAIRIE HAY BY STEERS

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CATTLE 93-4

Summary

A trial involving total tract digestibility and ruminal in situ disappearance was conducted to determine effects of level of concentrate supplement on utilization of mature prairie hay by beef steers. Supplemental treatments included CONTROL (no supplement) and combinations of corn and soybean meal to provide .66 lb of ruminally degradable protein from increasing amounts of concentrate supplement (LOW = 2.16 lb/day, MEDIUM = 6.28 lb/day, and HIGH = 10.38 lb/day). Steers receiving higher levels of concentrate supplements (MEDIUM and HIGH) exhibited decreased intake ($P<.01$) and digestibility ($P<.01$) of mature prairie hay. Supplementation with the low level of high crude protein supplement (LOW) resulted in improved dry matter intake ($P<.01$) and digestibility ($P<.02$) of mature prairie hay. Apparent dry matter digestibility of the total diet increased ($P<.05$) as level of concentrate supplement increased. Supplementation with the high level of concentrate supplement (HIGH) decreased disappearance of dry matter ($P<.05$) and neutral detergent fiber ($P<.05$) from the rumen and depressed ruminal pH ($P<.01$) at 4, 8, and 12 hours post-supplementation. Results of this trial confirm the benefits of low levels of high crude protein, all natural supplements on utilization of mature forages and indicate that high levels of high starch supplements will depress utilization of mature prairie hay.

Key Words: Beef Cattle, Intake, Digestibility, Supplement, Mature Forage

Introduction

Protein is considered the most limiting nutrient in mature, low quality forages. Protein supplementation has been found to improve performance of cows by enhancing utilization through improved intake and digestibility. Research examining effects of high starch energy supplements such as corn on performance of beef cows consuming low quality forages has shown little benefit and in some cases, detrimental effects. Lack of improved performance or decreased performance from supplementation with high starch energy supplements such as corn has been shown to decrease utilization of forage as a result of decreased forage intake and fiber digestion. The objective of this study was to determine the effect of level of concentrate supplement on intake, digestibility, nutrient disappearance from the rumen, and ruminal pH of steers consuming mature prairie hay similar to native pastures used in grazing studies at the SDSU Range and Livestock Research Station near Cottonwood.

Materials and Methods

Four ruminally fistulated Angus steers (1257 lb) were used in a 4 x 4 Latin square design to examine effects of level of supplementation on intake, total tract digestibility, nutrient disappearance from the rumen and ruminal pH when fed mature prairie hay. The trial consisted of four 20-day periods. Each period included a 7-day adjustment phase, a 7-day intake measurement phase, and a

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6-day phase in which total fecal collections were made and ruminal nutrient disappearance and pH were measured. Steers were housed indoors in a continuously lighted, controlled temperature room (68^{o} F) with slatted floors (6 x 8 foot pens) and had continuous access to water and prairie hay. Iodized trace mineral salt was top dressed each time hay was offered to meet NRC recommendations for sodium in the diet.

Supplements fed in this trial were used in a previous winter grazing trial conducted at the SDSU Range and Livestock Research Station near Cottonwood (Table 1). The supplements were formulated to provide .51 lb of ruminally degradable protein to cows grazing dormant winter range. Supplements were pelleted (3/8 in. diameter) and balanced so that the total diet would exceed NRC requirements for calcium, phosphorus, and potassium. Steers were fed supplements at proportional amounts on a metabolic body weight basis ($BW^{.75}$) to what cows received in the winter grazing trial (Table 2). Supplements were fed daily at 0700 and were consumed within 30 minutes. Mature prairie hay (Table 3), harvested in late August near Midland, SD, was ground through a tub grinder (2 in. screen) and offered twice daily during intake, and total collection phases at 130% of each steer's hay intake during the adjustment phase.

During the intake and total collection phases, individual orts were weighed and refed in the mornings and collected each night with 10% aliquots kept for later analysis. Hay and supplement samples were taken each night. Feed and ort samples were dried in a forced air oven at 140^{o} F for 48 hours, weighed, composited by steer, ground through a Wiley mill (1 mm screen), subsampled, and stored in air tight containers. Hay, ort, and supplement samples were analyzed for ash content, acid detergent fiber (ADF), neutral detergent fiber (NDF), and crude protein content. Hay samples were also analyzed for acid detergent lignin.

Table 1. Supplemental treatments[a]

Item	LOW	MEDIUM	HIGH
Soybean meal	81.35	21.28	8.44
Corn		71.18	86.40
Dicalcium phosphate	6.23	1.17	.09
Potassium chloride	9.91	3.86	2.56
Molasses	2.51	2.51	2.51

[a]Percentage on a dry matter basis.

Ruminal nutrient disappearance of mature prairie hay was estimated by an in situ technique. A representative sample of the mature prairie hay was ground through a Wiley mill (2 mm screen), oven dried (212^{o} F for 48 hours), and stored in an air tight container. Approximately 5 grams of the representative sample were placed in dacron bags (approximately 10 x 20 cm) and sealed with #8 rubber stoppers and rubber bands. On day 15 of each period, duplicate hay samples in

Table 2. Composition of average daily supplemental intake per steer

Item	LOW	MEDIUM	HIGH
Dry matter, lb	2.16	6.28	10.38
Crude protein, lb	.89	1.20	1.43
Ruminally degraded protein, lb[a]	.66	.65	.67
Metabolizable energy, Mcal[b]	2.50	8.52	14.80
Calcium, lb	.035	.024	.009
Phosphorus, lb	.039	.038	.038
Potassium, lb	.142	.178	.218

[a]Calculated values (NRC,1985).
[b]Calculated values (NRC,1984).

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

Item	Composition
Dry matter, %	94.2
Crude protein, %	5.6
Ash, %	7.6
Calcium, %	.41
Phosphorus, %	.10
Potassium, %	.93
Neutral detergent fiber, %	68.2
Acid detergent fiber, %	40.2
Acid detergent lignin, %	5.3

[a]Dry matter basis.

dacron bags along with duplicate empty bags were hydrated in warm water (102° F) for 15 minutes and placed in unanchored lingerie bags (43 x 53 cm) inside of the rumen. Sample incubation times used were 0, 4, 8, 12, 24, 48, and 72 hours. Bags to be incubated in the rumen for 72 hours were placed in first followed by the remaining samples in reverse order. Zero hour bags were only allowed to hydrate in warm water for 15 minutes. Following incubation, all samples were removed from the rumen at the same time and hand rinsed in water filled buckets until rinse water was clear. Samples were then oven dried (140° F) for 12 hours, allowed to air equilibrate for 3 hours to room temperature, weighed, and analyzed for NDF content. Apparent dry matter and NDF disappearance from the rumen was then calculated from residues remaining after incubation. Blank bags were used to adjust for influx of particles into dacron bags.

Steers were fitted with harnesses and fecal bags on day 16 to determine total tract digestibility. Fecal collection lasted 5 days. Individual fecal bags were emptied twice daily and contents were weighed, thoroughly mixed, subsampled (10% aliquot), and frozen (-13° F). Fecal samples were later thawed, composited by steer, and subsamples were taken for dry matter analysis. Samples were oven dried (140° F) for 72 hours or until they reached a constant weight and were stored in air tight containers. Fecal samples were analyzed for total nitrogen, ash, NDF, and ADF.

Ruminal fluid samples were obtained from the steers at 0, 4, 8, 12, 16, and 24 hours postsupplementation on day 19. Approximately 300 ml of ruminal fluid were taken from each steer at respective sampling times. Ruminal fluid pH was immediately analyzed with a combination electrode.

Dry matter digestibility of mature prairie hay was calculated by difference assuming TDN values from NRC were equal to dry matter digestibility and were 90% and 86%, respectively, for corn and soybean meal. Apparent dry matter, nitrogen, ADF, and NDF digestibility coefficients were calculated by subtracting amount recovered in feces from the intake amount and dividing by the intake amount. Digestible dry matter intake was calculated by multiplying the digestion coefficient for each steer by its dry matter intake. Digestibility and intake data were analyzed by the GLM procedure of SAS appropriate for a 4 x 4 Latin square design. Orthogonal contrasts were used to test for linear, quadratic, and cubic treatment effects. Nonorthogonal contrasts were used to test CONTROL vs (LOW + MEDIUM + HIGH)/3, CONTROL vs LOW, and CONTROL vs HIGH.

Effects of concentrate supplements on in situ disappearance of dry matter and NDF were analyzed in a Latin square split plot design using the GLM procedure of SAS. Main effects in the whole plot included steer, period, and treatment with steer x period used as the error term. Incubation time, steer x incubation time, period x incubation time, and treatment x incubation time were included in the split plot with residual error used as the error term. Where significant treatment by hour interactions existed, data were analyzed within time. Orthogonal contrasts were used to test for linear, quadratic, and cubic treatment differences. Nonorthogonal contrasts were used to compare CONTROL vs (LOW + MEDIUM + HIGH)/3, CONTROL vs LOW, and CONTROL vs HIGH.

Results and Discussion

Dry matter intake of hay decreased (P<.01) in a cubic manner as level of supplement increased in the diet (Table 4). Supplementation with LOW increased (P<.01) dry matter intake while supplementation with HIGH decreased (P<.01) dry matter intake. Hay digestible dry matter intake paralleled hay dry matter intake. In contrast, total digestible dry matter intake increased (P<.01) quadratically as level of supplement increased in the diet.

Apparent diet dry matter digestibility increased (P<.05) quadratically as level of supplement increased in the diet (Table 5). This result would be expected since corn and soybean meal are much more digestible than hay. Apparent ADF and NDF digestibilities responded in a quadratic manner (P<.05 and P<.01, respectively) by decreasing as level of supplement increased in the diet. Apparent NDF digestibility was increased (P<.01) with LOW supplementation and decreased (P<.05) with HIGH supplementation. Apparent ADF digestibility was not affected by HIGH supplementation but was increased (P<.02) by LOW supplementation. Supplementation improved (P<.01) apparent nitrogen digestibility. Hay dry matter digestibility, which was calculated by difference assuming constant digestibilities of soybean meal and corn, decreased in a quadratic manner (P<.01) as level of concentrate supplement increased. Dry matter digestibility of hay was increased (P<.02) with LOW supplementation and decreased (P<.01) with HIGH supplementation.

Table 4. Daily intake of mature prairie hay and total diet of steers receiving different levels of concentrate supplement

	Treatments						Contrasts[d]		
Item	Control	Low	Med	High	SE[a]	P	1	2	3
DM intake/day									
Hay, lb	21.6	25.9	22.0	17.6	.71	.0009[b]	NS	.01	.01
Hay, % BW	1.5	1.9	1.6	1.3	.05	.0010[b]	NS	.01	.03
Total diet, lb	21.6	27.8	27.8	27.3	.68	.0024[b]	.01	.01	.01
Digestible DM intake									
Hay, lb	8.4	11.2	8.6	5.7	.33	.0179[c]	NS	.01	.01
Total diet, lb	8.4	13.0	14.1	14.6	.44	.0026[b]	.01	.01	.01

[a]Standard error of the mean.
[b]Probability of a quadratic response.
[c]Probability of a cubic response.
[d]Contrast 1 = Control vs (Low + Medium + High) / 3; Contrast 2 = Control vs Low; Contrast 3 = Control vs High; NS = nonsignificance (P>.10).

Table 5. Digestibility coefficients of diets containing mature prairie hay and different levels of concentrate fed to steers

	Treatments						Contrasts[d]		
Digestibility, %	Control	Low	Med	High	SE[a]	P	1	2	3
Apparent NDF	43.4	48.3	45.9	40.3	.86	.0009[b]	NS	.01	.05
Apparent ADF	39.9	46.1	41.2	39.3	1.35	.0238[b]	NS	.02	NS
Apparent nitrogen	26.0	49.8	44.5	46.5	1.53	.0019[c]	.01	.01	.01
Apparent dry matter	39.0	46.9	50.6	53.8	.71	.0157[b]	.01	.01	.01
Hay dry matter[e]	39.0	43.4	39.6	33.2	.92	.0011[b]	NS	.02	.01

[a]Standard error of the mean.
[b]Probability of a quadratic response.
[c]Probability of a cubic response.
[d]Contrast 1 = Control vs (Low + Medium + High) / 3; Contrast 2 = Control vs Low; Contrast 3 = Control vs High; NS = nonsignificance (P>.10).
[e]Based on constant digestibility of supplement using TDN values (NRC, 1984).

Supplementation with the high level of corn which was high in starch (HIGH) caused a depression in ruminal pH at 4, 8, and 12 hours following supplementation (Figure 1). Ruminal pH fell below 6.1 at 4 hours postsupplementation. Ruminal pH levels below 6.2 may inhibit growth of cellulolytic microorganisms which are responsible for fiber digestion in the rumen. The HIGH supplement depressed dry matter disappearance from the rumen (Figure 2). The LOW supplement did not improve dry matter disappearance from the rumen. NDF disappearance from the rumen was decreased at 4, 8, and 24 hour incubation times by HIGH supplementation (Figure 3). The LOW supplement did not improve ruminal NDF disappearance.

Crude protein levels in the diet less than 6.25% have been found to limit voluntary intake. The mature prairie hay used in this trial was analyzed at 5.6% crude protein so we would expect relatively low dry matter intake due to insufficient crude protein. Many researchers have observed benefits from providing low levels of high crude protein, all natural supplements to cattle consuming mature, low protein forage. This trial demonstrates that a small amount of supplemental protein enhances utilization of mature prairie hay through increased dry matter intake, digestible dry matter intake, and dry matter digestibility of hay.

Recent energy supplementation research has shown high levels of supplemental corn may be detrimental to the performance of cows consuming mature forages, even when protein requirements are met. Hay intake, digestibility, and ruminal disappearance of dry matter and NDF were decreased with additions of supplemental corn to the diet. Decreases in ruminal pH caused by high levels of starch in corn may have contributed in part to these depressions. Results of this trial illustrate the negative effects of high starch supplements such as corn on utilization of mature forages.

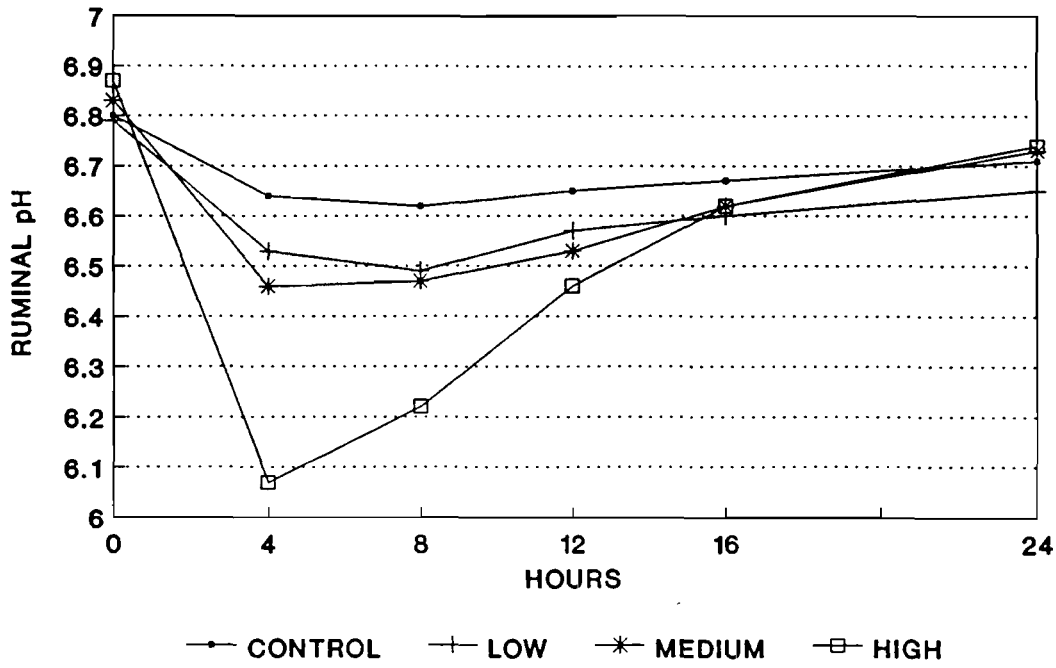

Figure 1. Ruminal pH measurements of steers consuming mature prairie hay and different levels of concentrate supplement over time. (The HIGH supplement differs ($P \leq .01$) from CONTROL at 4, 8, and 12 hours postsupplementation.)

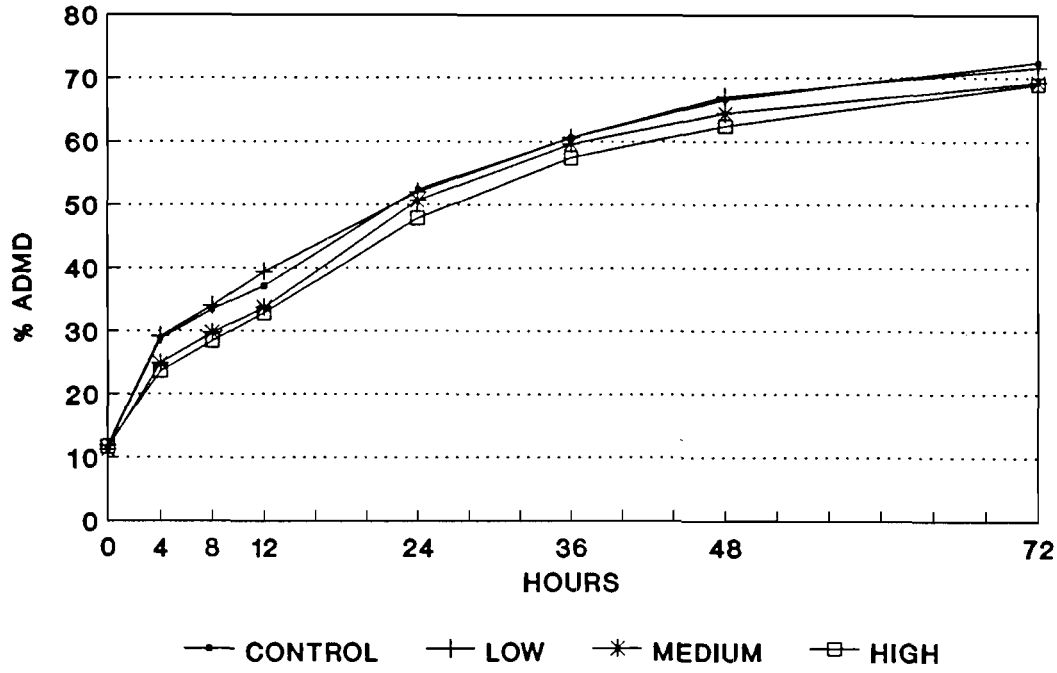

Figure 2. Apparent in situ disappearance of dry matter from dacron bags suspended in the rumen over time. (The HIGH supplement differs ($P \leq .05$) from CONTROL at 4, 8, 12, 24, 36, and 72 hour incubation times.)

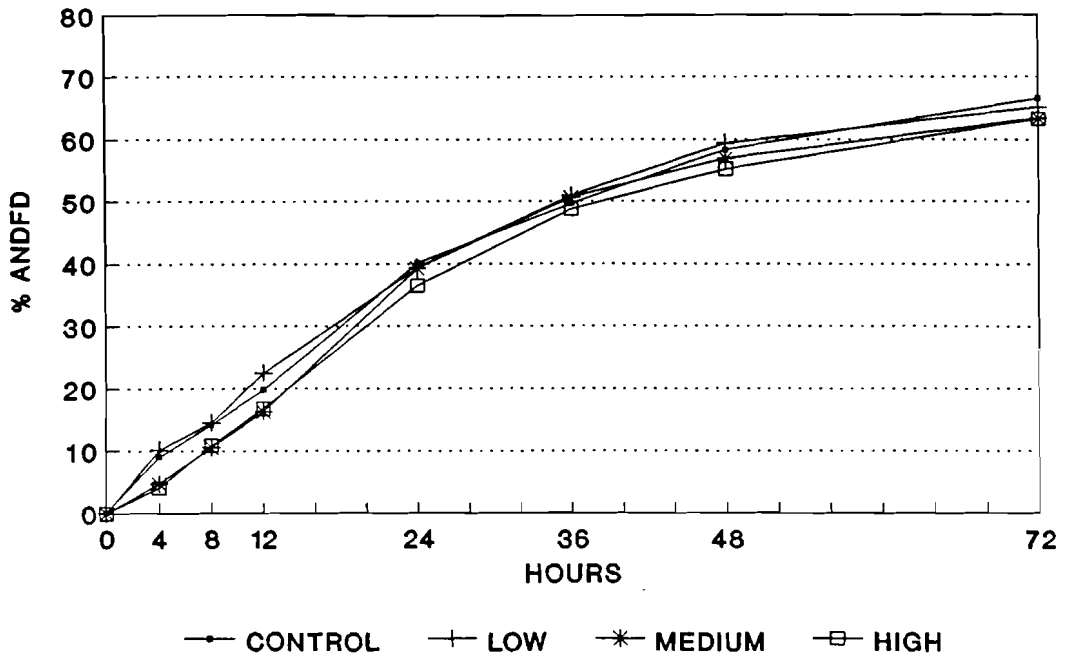

Figure 3. Apparent in situ disappearance of neutral detergent fiber from dacron bags suspended in the rumen over time. (The HIGH supplement differs ($P \leq .05$) from CONTROL at 4, 8, and 24 hour incubation times.)