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EFFECTS OF SUPPLEMENTING PRAIRIE HAY WITH TWO LEVELS OF CORN AND FOUR LEVELS OF DEGRADABLE INTAKE PROTEIN. II. RUMINAL PARAMETERS OF STEERS

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Authors:

T.N. Bodine, H.T. Purvis II and C.J. Ackerman

Story in Brief

Supplementing low-quality forages with either energy or protein will often alter forage intake and utilization, which may partly be explained by changes in ruminal fermentation. Ruminally cannulated steers were used to determine the effects on ruminal fermentation and rate of ruminal digesta removal when prairie hay was fed with two levels of corn and four increasing levels of soybean meal. Variables measured included ruminal pH, fluid and particulate passage rates, rate of ruminal disappearance, ruminal capacity and concentrations of ammonia nitrogen and volatile fatty acids. Ruminal pH was reduced post-feeding by corn supplements. Adding degradable intake protein (DIP) decreased pH quadratically for both levels of corn. Fluid passage rates were faster for corn treatments and showed linear increases as DIP increased while treatments without corn showed quadratic increases with soybean meal addition. Particulate passage rates were faster for corn treatments and exhibited a quadratic increase as soybean meal was added. Ruminal fill of organic matter was similar for treatments with or without corn and increased linearly with increases in level of protein. Ruminal volume was less for corn treatments and increased linearly with increasing protein. Quadratic increases were found in ruminal NH_3N for treatments with and without corn as soybean meal was added. Balancing corn-based supplements with ruminally degradable protein increased ruminal removal rates while creating minimal negative physiological effects in ruminal fermentation.

Key Words: Grain, Degradable Intake Protein, Ruminal Parameters

Introduction

Supplementation of forage-fed beef cattle is a common practice in Oklahoma. However, supplementation can greatly influence forage intake and utilization. Effects of supplementation on ruminal fermentation and removal can result in changes in intake, digestion and consequently animal performance. This experiment was undertaken to quantify changes in ruminal parameters that may alter intake and digestion of beef steers fed prairie hay and supplemented with two levels of corn and four increasing levels of ruminally degradable protein.

Materials and Methods

Animals, Diets and Laboratory Analysis. Cannulated steers (699 ± 55 lb) were fed two levels of corn (CORN, NOCORN) and four increasing levels of DIP (0, 33, 66 or 100%) based on NRC (1996) requirements, as described in Bodine et al. (1999b). Laboratory procedures for DM, ash, CP, ADF, cobalt (Co) and NH_3N concentrations were similar to those outlined in Bodine et al. (1999a, b).

Markers. Co-EDTA was dosed via ruminal cannula for determination of fluid passage rate. Particulate passage rate was estimated using acid detergent insoluble ash (ADIA) as an indigestible internal marker.

Sample Collection and Preparation. Feed, fecal and ruminal samples were handled as described in Bodine et al. (1999a, b). Ruminal fluid samples were collected and strained through eight layers of cheesecloth at 0, 2, 4, 8, 12, 16 and 24 h post supplementation. Ruminal fluid pH was determined prior to acidification and samples were frozen for later analyses. Ruminal contents were removed via ruminal cannula, weighed and measured for volume, mixed and subsampled prior to being replaced at 0 and 4 h post-supplementation.

Statistical Analysis. Variables were analyzed as a 2 x 4 factorial using the MIXED procedure of SAS (1996) with repeated measures in time for pH. Main effects included in the model were level of corn (0 or .75% BW), level of DIP (100, 66, 33, 0), time (when necessary), steer and period.

Results and Discussion

Ruminal pH. Ruminal pH exhibited an interaction (P<.01; Figure 1) between level of corn and time post-supplementation as well as between level of corn and level of DIP (P<.01; Figure 2). Following supplementation, ruminal pH was reduced (P<.02) for CORN vs NOCORN diets. Increasing DIP resulted in quadratic decreases (P<.01) in ruminal pH for CORN and NOCORN treatments while pH was similar (P>.35) at the lowest level of DIP and was lower (P<.05) for CORN treatments at the three highest levels of DIP. However, the range of pH values observed in this trial would not be expected to reduce fiber digestion. Forage intake was relatively high resulting in adequate fiber intake, which, along with rapid fluid and particulate passage rates, may have maintained a stable ruminal pH.

Ruminal Ammonia Nitrogen. Concentrations of ruminal NH_3N (Table 1) exhibited (P<.01) an interaction between levels of corn and DIP. Increasing DIP resulted in quadratic (P<.01) increases for CORN and NOCORN treatments, respectively, in ruminal NH_3N. Levels of NH_3N were similar (P>.35) for CORN and NOCORN at the highest and lowest levels of DIP. Low ruminal pH and NH_3N levels are often cited as causing negative associative effects. Our findings would indicate that balancing DIP:TDN can reduce or eliminate those negative associative effects observed in low-quality forages.

Ruminal Fill. Amounts of ruminal OM fill (Table 1) had a linear decrease (P<.01) as DIP increased. These observations support the increases in digestibility, passage and disappearance associated with increasing DIP. Decreases in ruminal fill as DIP increases indicate reduced ruminal retention time of digesta. This is in agreement with increases in passage and disappearance rates and may be indicative of an increase in rate of digestion. Fill of ADF (Table 1) was lower (P<.01) for CORN vs NOCORN fed steers and had a quadratic decrease (P<.06) as DIP increased. Ruminal volume (Table 1) was greater (P<.01) for NOCORN treatments and decreased quadratically (P<.01) as DIP increased in the supplements. These results point to the importance of dilution rate in controlling ruminal fill. Consequently, passage rates also relate to how intake and rate of digestion alter extent of digestion.

Ruminal Kinetics. Fluid passage rates (Kpf, Table 2) exhibited an interaction (P<.01) between levels of corn and DIP and responded with a linear increase (P<.05) for CORN and a quadratic increase (P<.10) in NOCORN treatments as DIP increased. Particulate passage rates (Kpp, Table 2) were faster (P<.03) for CORN vs NOCORN supplements and exhibited a quadratic (P<.06) rise as DIP increased. Ruminal disappearance rates (Kt, Table 2) of OM from digestion and passage were more rapid (P<.01) for corn-containing treatments and had a quadratic (P<.02) increase from DIP addition. Disappearance of ADF (Table 2) exhibited linear (P<.01) and quadratic (P<.01) increases for CORN and NOCORN treatments, respectively, in rate of removal as DIP was added to supplements. These results support the observed increases in intake, as rate of throughput can greatly alter rate of ingestion.

Ruminal VFA. Increasing DIP resulted in a linear increase (*P*<.01) in total VFA (Table 1) across both levels of corn. Cattle fed CORN supplements had greater (*P*<.01) total VFA and butyrate concentrations than NOCORN. Addition of DIP quadratically increased (*P*<.01) acetate and acetate:propionate ratios while quadratically decreasing (*P*<.01) propionate for CORN treatments. NOCORN supplements resulted in no effect (*P*>.11) from DIP addition on acetate, propionate or acetate:propionate ratios.

Feeding starch-based supplements to cattle consuming low-quality prairie hay will alter ruminal kinetics. The importance of DIP is reflected by its large effects on rates of disappearance, particulate passage and fluid passage from the rumen for supplements with and without corn. Importance of balancing total diet DIP:TDN ratio when high-starch supplements are being fed is essential. It would appear that when adequate DIP is present to allow for fermentation of both starch and fiber, negative associative effects on forage intake and digestion that may be related to ruminal fermentation and kinetics are not observed.

Literature Cited

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Table 1. Ruminal NH_3N, VFA, fill and volume measurements of selected dietary constituents.

	Degradable protein (DIP)				
Ruminal measure	0	33	66	100	Effect[1]
NH_3N (mg/dl)					
CORN	.59	.37	1.08	2.34	Q
NOCORN	.33	1.04	2.57	2.62	L
Total VFA(mmol/L)					DIP, L
CORN[a]	88.52	98.11	110.72	115.81	
NOCORN[b]	76.52	95.70	102.25	113.74	
OM fill (lb)					DIP, L
CORN	21.51	19.67	18.35	15.55	

NOCORN	20.87	19.15	17.94	17.16	
ADF fill (lb)					DIP, q
CORN	10.40	8.71	7.67	6.03	
NOCORN	11.36	8.85	7.94	7.29	
Volume (gal)					DIP, q
CORN	16.88	16.90	16.02	14.97	
NOCORN	17.29	17.58	16.72	16.09	

[1]L = linear, Q = quadratic (*P*<.01), or q = quadratic (*P*<.10) trends across level of DIP; DIP = effect for level of DIP averaged across both levels of corn.

[a,b]Values for specific effect measured without common superscripts differ (*P*<.03) between levels of corn.

Table 2. Rumen passage and disappearance rates (%/hr).

	Degradable protein (DIP)				
Rate of removal	0	33	66	100	Effect[1]
Fluid (Kpf)					
CORN	9.87	9.78	10.37	10.97	l
NOCORN	6.12	8.80	8.53	9.81	q
Particulate(Kpp)					DIP, q
CORN[a]	2.58	3.08	3.25	3.79	
NOCORN[b]	1.93	3.01	3.30	3.52	
OM (Kt)					DIP, q
CORN[a]	3.00	3.87	4.29	5.15	
NOCORN[b]	2.20	3.65	4.03	4.32	
ADF (Kt)					
CORN	2.29	3.17	3.56	4.34	L
NOCORN	2.14	3.65	4.05	4.27	Q

[1]L = linear, Q = quadratic (*P*<.01); l = linear, or q = quadratic (*P*<.10) trends across level of DIP; DIP = effect for level of DIP averaged across both levels of corn.

[a,b]Values for specific effect measured without common superscripts differ (*P*<.03) between levels of corn.

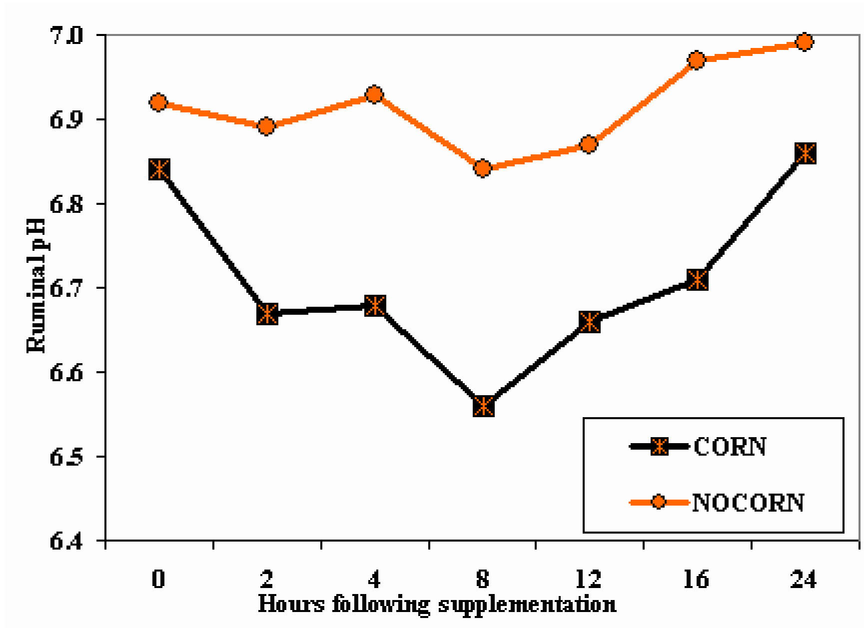

Figure 1. **Ruminal pH of steers fed prairie hay with supplements containing 0 or .75% BW dry-rolled corn for 24 h post-supplementation. Means differ (*P*<.05) between level of corn in supplement at each time point.**

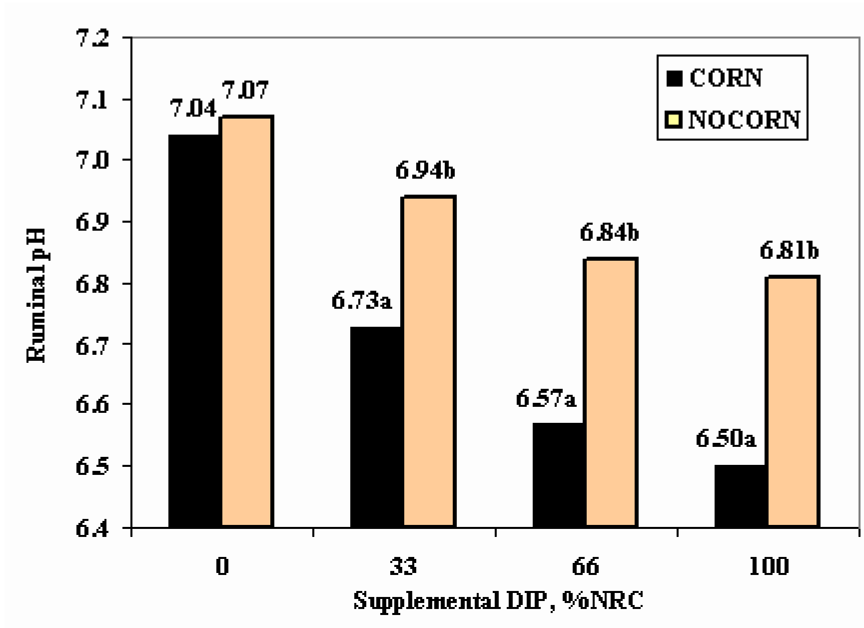

Figure 2. Average ruminal pH of steers fed prairie hay with supplements containing 0 or .75% BW dry-rolled corn and four increasing levels of DIP.

[a,b]Bars within level of DIP without common superscripts differ (*P*<.05)