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EFFECTS OF SUPPLEMENT SOURCE ON INTAKE, DIGESTION AND RUMINAL KINETICS OF STEERS FED PRAIRIE HAY

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Story in Brief

When forage quantity or quality limits animal performance, supplementation with either protein or energy may be required to increase or maintain level of animal production. Feeding supplements formulated with protein that breaks down in the rumen may alter animal response, particularly when the ratio between degradable protein and digestible nutrients is balanced. Ruminally cannulated steers (686 ± 49 lb) were fed low-quality prairie hay and monensin-containing treatments formulated from a mineral/vitamin mix, cottonseed meal/distillers grains, wheat midds/soybean hulls or milo/wheat midds to determine the effects on intake, digestibility, ruminal fermentation and kinetics. Steers were fed treatments daily and had ad libitum access to prairie hay in individual pens. Intake of forage was similar for steers fed mineral and either energy supplement while hay intake was greater for protein-supplemented cattle. Forage digestibility was not affected by treatment. Ruminal pH values were greatest for mineral, intermediate for protein and lowest for energy-supplemented cattle. Energy supplements increased propionate and decreased acetate concentrations and acetate:propionate ratios while total VFA and butyrate were increased by all supplements over mineral-fed cattle. Feeding low-quality prairie hay with either fiber- or grain-based supplements containing adequate degradable protein maintained forage intake with no substitution of supplement for forage. Only minimal changes in ruminal parameters were observed. The results of this research indicate that either grain or fiber ingredients can be used in pelleted supplements depending on cost.

Key Words: Fiber, Starch, Protein, Digestion, Beef Cattle

Introduction

Many producers supplement cattle with feeds containing either energy or protein. Responses to protein supplementation of low-quality forages are well-documented (Guthrie et al., 1984a; McCollum and Horn, 1990) as are the responses from either grain or fiber-based energy supplementation (Horn and McCollum, 1987; Chase and Hibberd, 1985; Guthrie et al., 1984b). This research was undertaken to determine the effect of feeding supplements with enough degradable intake protein (DIP) in relation to total digestible nutrients (TDN) on forage utilization by beef steers.

Materials and Methods

Animals and Diets. Four ruminally cannulated steers (Angus and Angus x Hereford; 686 ± 49 lb) were weighed at the initiation and completion of each period and housed in individual indoor 10 x 13 ft pens with ad libitum access to fresh water. Treatments (Table 1) were formulated to meet mineral and vitamin requirements, provide monensin (200 mg/hd/d) and consisted of: 1) MINCR (mineral/vitamin mix fed with cracked corn as a carrier), 2) MP (mid-protein; cottonseed meal/byproducts), 3) HF (high-fiber; wheat midds/soybean hulls), or 4) HG (high-grain; sorghum grain/wheat midds). Supplements (HF, HG and MP) had similar levels of DIP while HF and HG were formulated to be similar in TDN. Treatments were fed prior to hay at 8:00 a.m. daily at 1% of BW for HF and HG, .5% BW for MP and 4 oz of MINCR fed with 1 lb of cracked corn as a carrier.

Prairie hay was fed at 5 lb over previous day□s consumption.

Sample Collection and Preparation. Chromic oxide and acid detergent insoluble ash (ADIA) were used as indigestible markers to quantify fecal output. Co-EDTA and ytterbium (Yb) labeled hay were used for determination of ruminal fluid (FPR) and particulate passage rates (PPR). Feeds were weighed daily and samples of hay and supplements were collected d 15 through d 20. During each period, fecal grab samples, as well as ruminal fluid and content samples, were collected for determination of marker concentration, pH and fermentation profiles. *In situ* dry matter disappearance (DMD) was determined using dacron bags with 5 g of ground prairie hay incubated in the rumen for 0, 2, 4, 8, 12, 46, 24, 36, 48 or 72 h.

Laboratory and Statistical Analysis. Dry matter, ash, crude protein (CP), starch, chromium, neutral and acid detergent fiber (NDF, ADF) and ADIA were determined in feeds and fecal samples. Concentrations of Yb, Co, VFA□s and NH_3N were determined from rumen samples. Effects of OM intake, apparent OMD, fluid volume, ruminal fluid turnover time, fluid flow rate (L/h), PPR and FPR were analyzed using the GLM procedure of SAS (1996). Effects of pH and ISDMD, as well as NH_3N and VFA concentrations, were determined as a split plot in the time using the MIXED procedure of SAS (1996). All appropriate interactions were tested.

Results and Discussion

Intake. Hay OMI (Table 2) was similar (*P*>.18) for HF, HG and MINCR-fed animals while MP increased (*P*<.05) hay intake vs MINCR or HF. Total OMI (Table 2) was similar (*P*>.30) for supplemented steers and greater (*P*<.01) than animals fed MINCR. These results showed no substitution effect on intake of forage when energy supplements were fed, while protein increased intake. The level of supplemental starch from the grain-based supplement was similar to that reported by Chase and Hibberd (1985). However, when DIP requirements of the total diet were met, the current study found no advantage to feeding energy supplements composed of fibrous by-products compared to one consisting of 50% grain.

Digestibility. All diets had low apparent OMD of forage and total diet (Table 2) and were not affected (*P*>.19) by supplement type. Total diet OMD was highest (*P*<.10) for HF or HG and lowest (*P*<.10) for MINCR or MP. Extent of *in situ* DMD was not affected (*P*>.92) by diet.

Ruminal pH. Ruminal pH showed a tendency (*P*<.11) for a diet x time interaction (Figure 1). Average ruminal pH (Table 3) was greatest (*P*<.01) for mineral-fed steers, lower (*P*<.01) for energy supplemented steers and did not differ (*P*>.90) due to energy source. The pH values generated in this trial are similar to several other studies (Chase and Hibberd, 1985; Martin and Hibberd, 1987; Chan et al., 1991), and are within the range adequate for effective fiber digestion. However, feeding pelleted fiber- or grain-based supplements decreased ruminal pH to a similar degree. Other possible factors contributing to the maintenance of ruminal pH include the effects of the ionophore monensin and(or) the buffering effect of fiber intake (NRC, 1996).

Ruminal NH_3N. Ruminal NH_3N concentrations (Figure 2) exhibited a diet x time interaction (*P*<.01). Average ruminal NH_3N concentrations (Table 3) were lowest (*P*<.10) for MINCR and not different (*P*>.10) between supplements. It appears from these results that similar DIP to TDN ratios for energy sources resulted in similar ruminal NH_3N levels.

Ruminal Kinetics. Rate of ISDMD was greater (*P*<.04) for supplemented steers than for those fed the mineral treatment, while no differences (*P*>.29) were found between supplement types. Only numeric differences (*P*>.42) in particulate passage rate (Table 3) were noted. Fluid passage rates (Table 3) were similar (*P*>.12) for HF and HG and similar (*P*>.10) for MINCR, MP or HG. Fluid flow rates (L/h; Table 3) and ruminal fluid volume (Table 3) were affected (*P*=.06) by treatment while ruminal fluid turnover time was not affected (*P*>.10) by treatment. Similar fluid and particulate passage rates may have played a role in maintaining similar ruminal pH, VFA, NH_3N and ISDMD.

Ruminal VFA. Energy supplements had similar (*P*>.10) acetate, propionate and acetate to propionate ratios (Table 4) while MINCR or MP treatments were similar (*P*>.10). Butyrate and total VFA concentrations were increased (*P*<.05) by supplementation while no differences (*P*>.10) were found for isobutyrate, valerate and isovalerate. As would be expected with similar levels of energy intake and fermentable substrate, VFA concentrations were physiologically similar between fiber and grain sources.

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Table 1. Nutrient composition (%DM) of forage and treatments, MINCR = Mineral/corn mix, MP = Mid-protein, HF = High Fiber, HG = High Grain.

Item	Prairie Hay	MINCR	MP[1]	HF[1]	HG[1]
DM	89.79	88.38	89.91	89.78	89.61

Ash	7.44	11.76	10.10	8.57	7.83
CP	5.49	7.89	26.91	16.24	18.56
DIP, g	--	18	301	334	345
NDF	72.60	20.01	37.64	46.96	44.21
ADF	39.97	4.02	20.12	21.10	9.31
Starch	.74	61.79	12.74	18.19	41.13

[1]Supplements formulated to provide 1 g DIP/kg BW.

Table 2. Average intake and digestibility of forage and total diet by steers fed prairie hay and one of four treatments, MINCR = Mineral/corn mix, MP = Mid-protein, HF = High Fiber, HG = High Grain.

	Diets			
Intake and digestion	MINCR	MP[1]	HF[1]	HG[1]
Hay OMI (lb)	8.67[a]	12.41[b]	9.58[a]	10.35[ab]
Supplement OMI (lb)	.99[b]	2.91[b]	6.29[a]	6.29[a]
Total OMI (lb)	9.66[a]	15.32[b]	15.87[b]	16.64[b]
Forage OM digestibility	41.23	35.85	40.53	37.13
Total diet OM digestibility	44.23[a]	42.40[a]	52.05[b]	49.73[b]
Total diet DIP:TDN ratio (%)	7.51	11.01	11.10	11.61

[1]Supplements formulated to provide 1 g DIP/kg BW.

[a,b]Values within rows without like superscripts differ (*P*<.05).

Table 3. Ruminal parameters for steers fed prairie hay and one of four treatments, MINCR = Mineral/corn mix, MP = Mid-protein, HF = High Fiber, HG = High Grain.

		Diets		
Ruminal parameter	MINCR	MP[1]	HF[1]	HG[1]
Average pH	6.81[a]	6.64[ab]	6.44[b]	6.42[b]
Ruminal NH_3N	.27[a]	1.31[b]	1.86[b]	1.25[b]
ISDMD, Kd (%/h)	1.92[a]	3.30[b]	3.35[b]	2.88[b]
Fluid passage rate, (%/h)	6.69[a]	7.05[a]	8.04[b]	7.33[ab]
Particle passage rate, (%/h)	2.72	2.71	3.97	3.88

Ruminal fluid volume, (L)	34.20[a]	45.58[b]	47.39[b]	40.47[ab]
Ruminal fluid turnover time, (h)	15.31	14.27	12.46	14.77
Fluid flow rate, (L/h)	2.29[a]	3.20[bc]	3.82[b]	2.97[ac]

[1]Supplements formulated to provide 1 g DIP/kg BW.

[a,b,c]Values within rows without like superscripts differ (P<.10).

Table 4. VFA concentrations for steers fed prairie hay and one of four treatments, MINCR = Mineral/corn mix, MP = Mid-protein, HF = High Fiber, HG = High Grain.

VFA		Diets		
mol/100 mol	MINCR	MP[1]	HF[1]	HG[1]
Acetate	71.34[a]	71.06[a]	67.62[b]	66.57[b]
Propionate	19.19[a]	18.73[a]	21.31[b]	22.60[b]
Butyrate	7.04[a]	7.81[b]	8.70[c]	8.26[bc]
Isobutyrate	0.00	0.02	0.03	0.04
Isovalerate	1.29	1.33	1.36	1.53
Valerate	1.14	1.05	0.99	1.01
Acetate:Propionate	3.82[a]	3.83[a]	3.30[b]	3.01[b]
Total VFA mmol/L	71.06[a]	74.47[ab]	84.25[b]	86.01[b]

[1]Supplements formulated to provide 1 g DIP/kg BW.

[a,b,c]Values within row without like superscripts differ (P < .10).

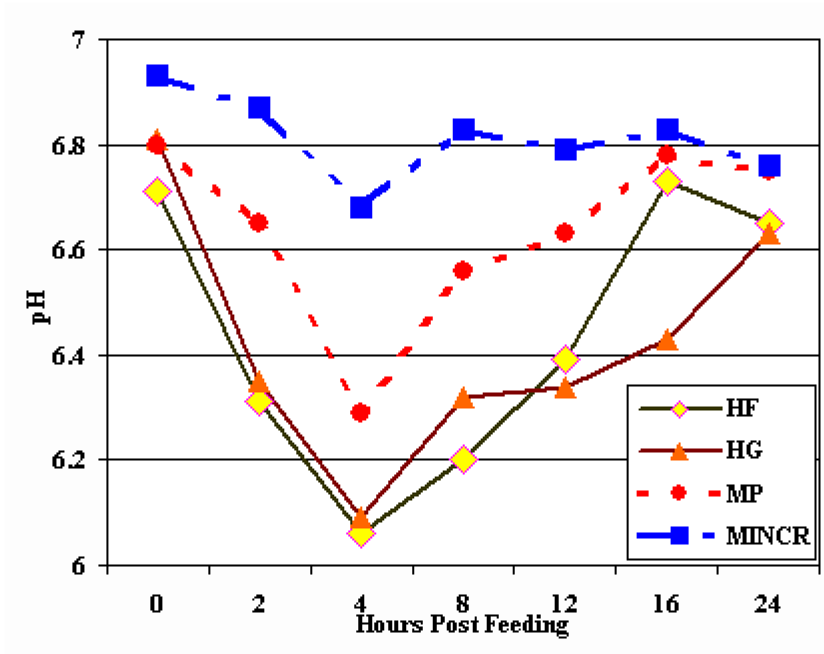

Figure 1. Effect of supplement on ruminal pH for steers consuming prairie hay and fed one of four treatments: MINCR = Mineral/corn mix, MP = Mid-protein, HF = High Fiber, HG = High Grain.

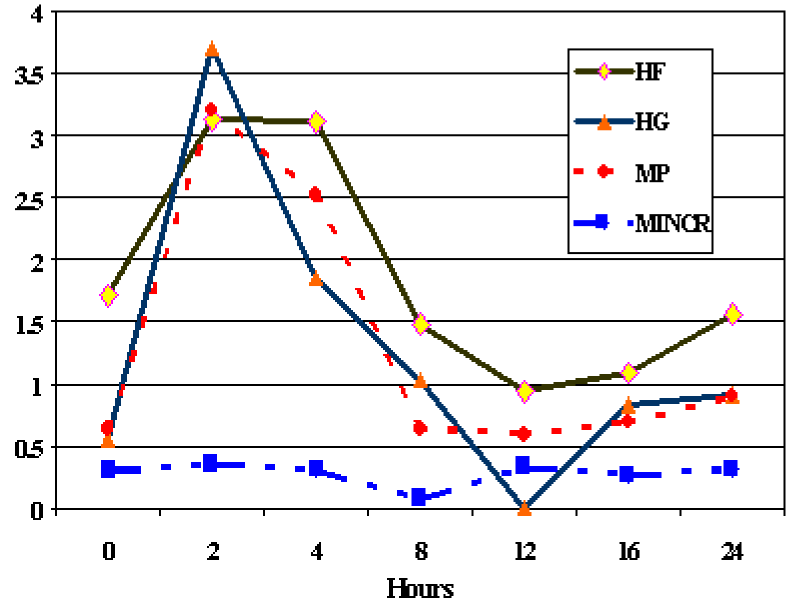

Figure 2. **Effect of supplement on ruminal ammonia N for steers consuming prairie hay and fed one of four treatments: MINCR = Mineral/corn mix, MP = Mid-protein, HF = High Fiber, HG = High Grain.**

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