EFFECTS OF CORN GLUTEN FEED ON FORAGE INTAKE, DIGESTIBILITY, AND RUMINAL PARAMETERS OF CATTLE FED NATIVE GRASS HAY

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Story in Brief

Thirty-two beef cows (1027 lb) were individually fed native grass hay and supplement for two 14 day periods in each of 2 years. Supplement treatments and amounts fed (lb/day) were negative control (NC), 0; or equal amounts of protein from soybean meal (SBM), 1.5; a blend of soybean meal and corn gluten feed (SBM/CGF), 2.2; or corn gluten feed (CGF), 3.5. Cows received supplement at 6:45am, and had ad libitum access to native grass hay from 7:00am to 11:30am and 3:30pm to 8:00pm. Replacing SBM with CGF decreased the molar proportion of acetate but increased propionate and butyrate proportions 4 hours after the supplement was fed. Cows fed SBM consumed more hay and water, had higher ADF and DM digestibilities and greater forage digestibility than the negative control cows. Voluntary forage intakes were similar for SBM and SBM/CGF treatments (1.75 and 1.73% of body weight, respectively), but forage intake was reduced to 1.62% when SBM was totally replaced by CGF. Forage, ADF, and total DM digestibilities were not significantly changed by type of supplement. Forage intake declined when CGF was fed as the sole source of supplemental protein as compared to the SBM control though energy intakes were similar due to the greater amount of supplement fed. Calculated ME (Mcal/day) intakes were 12, 17, 18, and 17 for NC, SBM, SBM/CGF, and CGF, respectively. Increased forage intake and ADF digestion with CGF indicate that CGF is an acceptable protein/energy supplement for beef cows consuming low quality forage.

(Key Words: Corn Gluten Feed, Forage Intake, Native Hay, Beef Cows, Forage Digestibility.)

Introduction

The positive associative effects of supplementing low quality roughage diets with protein are well documented, although feeding energy in the form of readily available carbohydrate usually decreases forage intake and fiber digestibility. The use of high fiber, low starch, energy sources may alleviate such negative effects of cereal grain based supplements.

Corn gluten feed (CGF), a by-product of the corn milling industry, is the portion of corn kernel that remains after removing the germ, starch, and gluten. CGF is commonly marketed at 21% crude protein and 8.5% crude fiber. The protein content and highly digestible fiber should make CGF useful as a protein/energy supplement because the *in vitro* neutral detergent fiber (NDF) disappearance of CGF is rapid and extensive while the protein of CGF is more extensively degraded in the rumen than SBM. Similar fiber and N digestibilities for lamb diets supplemented with wet CGF, dry CGF, and soybean meal (SBM) indicate that

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CGF could furnish the rumen with N for efficient microbial growth. This study was conducted to evaluate CGF as a protein/energy supplement for beef cows consuming low quality forage.

Materials and Methods

Thirty-two nonlactating Hereford and Hereford x Angus cows (1027 lb mean weight) were individually fed mature native grass hay plus supplement for two 14 day periods in each of 2 years for a total of 32 measurements on each of four treatments. In period 1 of each year, cows were randomly allotted within breed, body weight and condition, and pregnancy status to four treatment groups. In period 2, cows were reallotted by the above criteria plus previous treatment. Treatments were negative control (no supplement; NC); positive control, (soybean meal; SBM); soybean meal/corn gluten feed blend (SBM/CGF) in which one-half of the supplemental protein was replaced by CGF; and corn gluten feed (CGF). Amounts of feed and supplement compositions are presented in Table 1. Cows were housed individually with ad libitum access to native grass hay for 9 hour/day (7:00 to 11:30am; 3:30 to 8:00pm), and to water plus minerals for 15 hour/day (11:30am to 3:30pm; 8:00pm to 7:00am). Hay was not ground or chopped prior to feeding. The isonitrogenous supplements were fed as 3/16 inch diameter pellets once daily at 6:45am.

After 8 days of acclimation to the supplements, voluntary forage intake was measured directly for the following 6 days. Fecal output was estimated using ytterbium (Yb) as an indigestible marker. Three tenths of a pound of Yb-labeled cottonseed hulls containing 462 mg of Yb were fed once per day (6:45am) for 8 days prior to and during the 2 day fecal sampling period. To reduce the effects of diurnal variation, fecal samples were obtained six times during the 48 hour collection period at 8 hour intervals. Feces were totally collected for a 48 hour period from two animals per treatment to appraise marker accuracy. Water consumption was measured for 48 hour on days 13 and 14 of each period. Fecal grab samples were obtained at 8:00am on days 1, 2, and 3 after terminat-

Table 1. Supplement composition and amounts fed.

	SBM	SBM/CGF	CGF
Ingredients, %:			
Soybean meal	93.1	32.3	0.0
Corn gluten feed	0.0	62.6	96.38
Molasses	3.6	3.6	3.6
Dical	3.2	1.4	0.0
Vitamin A premix	0.07	0.05	0.04
Year I			
Amount fed, lb/d, 100% DM	1.5	2.4	3.57
Supplied per day:			
Crude protein, lb	.62	.62	.62
TDN, lb	1.12	1.78	2.55
Year II			
Amount fed, lb/d, 100% DM	1.56	2.05	3.12
Supplied per day:			
Crude protein, lb	.57	.57	.57
TDN, lb	1.17	1.52	2.31

ing Yb dosing in year II to estimate particulate passage rate based on the decline in Yb concentration of fecal DM.

In year II, rumen fluid samples were obtained via stomach tube at 4 and 24 hours after protein supplement was fed. To avoid excessive interruption of hay intake, the 4 hour sample was taken at 11:00am on day 8 whereas the 24 hour sample was obtained at 7:00am on day 14. Ruminal fluid pH was determined immediately before samples were acidified. One ml of rumen fluid was taken at 7:00am on day 14 during period 2 of year II and stored for subsequent enumeration of protozoa.

Fecal output, as measured by total collection for eight cows per period, was 115% (± 25) of fecal output estimates based on the Yb marker; hence, the fecal output estimates calculated from Yb dilution were used for subsequent calculations. Fecal output from forage alone was calculated as total fecal output minus feces derived from the supplement by assuming that digestibility of each supplement was 80% based on literature values for CGF and SBM. Forage digestibility for each cow in each period was calculated from measured intake of hay and fecal output calculated to be from forage. Digestibility of ADF was calculated from total ADF intake (Table 2) and total ADF output in feces without adjustment for indigestible ADF from the supplement. Particulate passage rate was estimated by regressing the natural logarithm of fecal Yb concentration against time after withdrawal of Yb from the diet.

Results and Discussion

Rumen fluid pH values were quite similar among treatments both at 4 and 24 hours after feeding supplements (Table 3). Failure of supplements to depress ruminal pH contrasts with results from some trials using high-starch supplements and is probably due to the slower rate of fermentation of a fibrous feedstuff. This suggests that higher fiber supplements can be fed at much higher levels than grains without

Table 2. Chemical analysis of forage and supplements (DM basis).

Item	Forage	Supplement		
		SBM	SBM/CGF	CGF
Year I				
Dry matter	94.40	90.13	90.87	89.92
Ash	4.30	.25	.50	1.10
Crude protein	4.82	42.91	25.10	18.78
Neutral detergent fiber	69.01	20.75	42.27	51.32
Acid detergent fiber	43.71	10.47	11.00	10.61
Cellulose	31.20	8.56	9.12	8.69
Lignin	8.20	1.70	1.39	1.32
Year II				
Dry matter	92.30	89.70	88.08	88.80
Ash	3.40	.11	.65	1.05
Crude protein	5.26	36.00	27.70	20.90
Neutral detergent fiber	76.02	22.74	40.02	49.52
Acid detergent fiber	45.45	11.38	10.37	10.40
Cellulose	33.93	9.56	8.24	8.50
Lignin	8.12	1.68	1.32	1.27

depressing ruminal pH to levels which reduce rate or extent of fiber digestion.

Ruminal ammonia levels 4 hours after the supplement was fed were lowest for unsupplemented cows and highest for cows receiving CGF (Table 3). This suggests that protein from CGF is extensively degraded in the rumen. Ammonia levels 4 hour after supplementation tended to be lower with SBM than CGF supplements. Ammonia levels with the blend of SBM and CGF were significantly lower than with CGF alone. Such a blend of SBM and CGF would not be expected to produce lower ammonia values than the average of each fed alone. Twenty-four hours after supplement feeding, ammonia levels remained higher ($P<.01$) for cows receiving protein than for cows in the NC treatment group. Ruminal ammonia levels at 24 hours were higher ($P<.01$) for SBM than CGF with SBM/CGF being intermediate. The 24 hour data suggests that SBM tends to maintain a higher rumen ammonia concentration than CGF.

Total VFA concentrations in ruminal fluid for cows fed SBM tended to be higher ($P<.17$) at 4 hour after supplement feeding than for unsupplemented NC cows (Table 3). The molar proportions of acetate, propionate, and butyrate were similar for the NC and SBM treatments. However, replacing SBM by CGF decreased ($P<.01$) the molar proportion of acetate and increased ($P<.01$) the proportions of propionate and butyrate. A similar response was observed with CGF supplements fed to gestating beef cows grazing dormant winter range (Fleck and Lusby,

Table 3. Ruminal pH, ammonia, VFA, and protozoa concentration, at four and twenty-four hours after feeding supplement.

	Treatment[d]				
	NC	SBM	SBM/CGF	CGF	SE
Cows sampled	16	16	16	16	
Rumen fluid pH:					
4 hours	6.84	6.92	6.82	6.80	.13
24 hours	7.12	7.05	7.08	6.97	.13
Rumen ammonia, mg/dl:					
4 hours	.49[a]	4.09[bc]	2.36[ab]	5.81[c]	1.62
24 hours	1.16[a]	4.23[d]	3.30[c]	2.31[b]	.65
VFA, 4 hours:					
Total µmoles/ml	123.00	134.28	126.33	127.90	14.72
Acetate, %	80.22[a]	79.66[ab]	78.64[b]	76.69[c]	.96
Propionate, %	11.67[a]	11.61[a]	12.37[ab]	12.98[b]	.70
Butyrate, %	8.11[a]	8.72[b]	8.99[bc]	10.32[c]	.74
VFA, 24 hours:					
Total µmoles/ml	97.25	96.06	92.86	95.52	12.57
Acetate, %	81.94	81.95	81.57	81.81	.89
Propionate, %	9.79	10.13	10.03	10.06	.57
Butyrate, %	8.27	7.92	8.39	8.12	.66
Protozoa:[e]					
Small	14.4	26.2	22.2	17.4	4.2
Large	8.0	14.5	9.6	5.7	2.4
Total	22.4	40.7	31.8	23.1	5.5

[abc]Means in same row with different superscripts differ $P<.05$.
[d]Least squares means.
[e]Least squares means of 8 cows per treatment are x 10^{-3}/ml.

1986). If increased ruminal concentrations reflect increased ruminal production of propionate and butyrate, CGF supplementation may increase efficiency of utilization of dietary energy and decrease loss of energy as methane from the rumen. At 24 hours after feeding supplements, total volatile fatty acid (VFA) concentrations and molar proportions of acetate, propionate, and butyrate were similar among all treatments.

The number of small and large protozoa in ruminal samples tended to decrease ($P<.15$) with substitution of CGF for SBM (Table 3). Protozoa and bacteria are usually inversely related suggesting an active competition between these microbes for energy and/or nitrogen. If the observed protozoal numbers reflect the total ruminal mass of protozoa, CGF substitution for SBM may reduce nutrient competition between these two groups of microbes and increase bacterial yield and ruminal protein output.

Intakes, digestibilities, and particulate passage rates are presented in Table 4. Compared with cows fed no supplemental protein, cows fed SBM consumed more ($P<.01$) hay and had higher digestibilities for forage ($P<.05$), ADF ($P<.05$), and total DM ($P<.01$). This demonstrated a need for dietary protein supplementation. Cows fed CGF tended ($P<.22$) to consume more hay than unsupplemented cows but less than SBM-fed cows. Feeding the blend of SBM/CGF resulted in hay intake similar to that of SBM-fed cows and greater than that of unsupplemented cows ($P<.01$). Forage dry matter digestibility was increased by feeding SBM/CGF ($P<.05$)

Table 4. Voluntary forage intake, water intake, forage digestibility, and ytterbium passage rate (DM basis).

	Treatment[c]				
	NC	SBM	SBM/CGF	CGF	SE
Cows/treatment	32	32	32	32	
Cow wt, lb	1025	1027	1025	1034	
Forage intake, % of body wt	1.56^a	1.75^b	1.73^b	1.62^a	.07
Water intake, % of body wt	4.35^a	5.83^b	5.20^b	5.48^b	.49
Digestibility:					
Forage DM, %	45.87^a	50.21^{ab}	52.81^b	48.90^{ab}	3.56
ADF, %	41.06^a	46.98^b	50.32^b	47.34^b	3.84
Total DM, %	46.68^a	52.78^b	55.96^b	53.53^b	3.34
Digestible DM intake:					
Forage, % of BW	$.69^a$	$.86^b$	$.89^b$	$.76^a$	.075
Total, % of BW	$.69^a$	$.98^b$	1.06^b	1.01^b	.075
Total ME, Mcal/kg[d]	$.12^a$	$.16^b$	$.18^b$	$.17^b$	.012
Indigestible intake:					
DM, % of body wt	.87	.93	.88	.92	.055
ADF, % of body wt	.42	.43	.41	.40	.027
Particulate passage rate, %/hour[e]	3.79	3.74	3.91	3.85	.6

[ab]Means in same row with different superscripts differ $P<.05$.
[c]Least squares means.
[d]ME Mcal/kg Metabolic Body Size = .82 (DDMI * 4.4 Mcal/kg) / cow weight$^{.75}$.
[e]Based on 16 animals per treatment.

and was slightly increased by feeding SBM or CGF as compared to no supplement. ADF digestibility was increased (P<.05) by feeding either SBM/CGF or CGF. Total diet dry matter digestibility was greater (P<.01) for supplemented than unsupplemented cows.

To determine if all of the intake response could be attributed to increased diet and forage digestibility, daily intakes of indigestible DM and ADF (Table 4) were calculated. Intakes of indigestible DM and ADF were not altered by protein supplementation suggesting that ruminal or gut fill of indigestible material probably limited intake of all diets and that intake increases were associated with increased diet digestibility. Water intake was higher (P<.01) for cows fed protein supplement. This is probably due to greater forage intakes and fluid excretion in feces and urine. Water intake was no different between supplemented groups. Rate of passage for Yb ranged from 3.74 to 3.91%/hour and were not affected by treatment.

The lower forage intake and digestibility observed when CGF was fed as the sole source of supplemental protein was partly offset by the increased supply of energy in CGF when fed at the same protein level as SBM. Using digestible DM as an estimate of dietary TDN and converting TDN to metabolizable energy based on NRC (1984) equations, metabolizable energy intakes (Mcal/day) were 12.3, 16.9, 18.4, and 17.5 for the NC, SBM, SBM/CGF, and CGF treatment groups, respectively. These relative differences in ME intakes mirror performance differences observed in performance trials. Heifers grazing summer range and fed these same supplements for 84 days gained 86, 123, 138, and 138 lb/head, respectively (Fleck and Lusby, 1987), while gestating beef cows grazing dormant winter range for an average of 116 days had weight changes of -77, -24, +2.8, and +1.0 lb/head, respectively (Fleck and Lusby, 1986).

The results of this trial suggest that as a source of supplemental protein, CGF can alter ruminal fermentation and increase forage intake and fiber digestion. In addition, corn gluten feed fed as a protein and energy supplement to beef cows consuming low quality forage increases the total energy intake by cattle. Adding SBM to CGF appears to improve the utilization of CGF which suggests that some combination of CGF and SBM may be a more useful supplement than CGF alone.

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