The effects of corn milling coproducts on growth performance and diet digestibility by beef cattle[1]

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ABSTRACT: Simmental × Angus weanling heifers (n = 96; 239 ± 2.3 kg) were used in four replications to evaluate three dietary treatments in Trial 1. Treatments were cracked corn-hay diets supplemented with one of three corn milling industry coproducts: dry corn gluten feed (DCGF), dried distillers grains (DDG), and a new modified corn fiber (MCF). In Trial 2, ruminally cannulated mature crossbred beef steers (n = 4; 606 ± 60 kg) were used in a 4 × 4 Latin square with 11-d periods to determine digestibility and ruminal metabolism of limit-fed cracked corn-alfalfa haylage diets supplemented with cornstarch (CON), DCGF, DDG, or MCF. During Periods 3 and 4, an in situ study was conducted to compare the rate and extent of CP degradation of DCGF, DDG, and MCF. In Trial 1, there were no differences ($P > .10$) in initial weights or DM intake. Average daily gain and feed efficiency (G/F) were improved ($P < .01$) for heifers fed DCGF or DDG vs heifers fed MCF. In Trial 2, no differences ($P > .10$) in digestibilities of any nutrients or in ruminal VFA concentrations were observed for steers fed coproducts. The CON supplementation decreased ($P < .05$) total dietary fiber (TDF) digestibility, improved ($P < .10$) digestibilities of DM and OM, increased ($P < .05$) total VFA concentrations and concentrations of propionate and valerate, and decreased ($P < .05$) concentrations of butyrate, isobutyrate, and isovalerate when compared with the coproducts. Dry corn gluten feed increased ($P < .05$) and DDG tended ($P < .10$) to increase percentages of the immediately soluble fraction of CP, and both had increased ($P < .05$) rates (K_d) and greater ($P < .05$) extent of ruminal CP degradation than MCF. These data suggest that DCGF and DDG may be utilized in limit-fed high-energy diets without sacrificing performance. Feeding of MCF resulted in poorer performance of heifers, suggesting a limited feeding value that results from high ADIN content and slow in situ protein digestion.

Key Words: Maize Byproducts, Beef Cattle, Feeding

 J. Anim. Sci. 2000. 78:1–6

Introduction

Recently, increased consumer demand for fructose sweetener and the use of ethanol as a fuel additive have resulted in increased wet and dry milling of corn (Schrage et al., 1991). This has resulted in the production of coproducts, such as corn gluten feed and a new ethanol coproduct, hereafter referred to as modified corn fiber (**MCF**), that may be used as feedstuffs for livestock.

Corn gluten feed has been used in high-energy diets for cattle because it contains large amounts of readily fermentable fiber and CP (Bowman and Paterson, 1988) that will provide additional energy without depressing fiber digestion (Hannah et al., 1990). Dried distillers grains (**DDG**) are a coproduct of the dry milling industry and contain dealcoholized fermentation residues that remain after cereal grains have been fermented by yeast (Weigel et al., 1997). Dried distillers grains are beneficial in some ruminant diets due to their high content of undegraded intake protein (**UIP**).

Modified corn fiber is produced by a secondary, bacterial- and yeast-driven, fermentation of the corn bran and may enable corn processors to more fully recover ethanol from the corn. This modified corn fiber may be an effective fiber and protein source in ruminant diets. It is high in CP (22%), possibly contributed to by yeast residues, moderate in total dietary fiber (36%), and may be an effective supplement if the fiber is highly digestible and the protein quality is acceptable for the ruminant. Therefore, the objective of this study was to compare the utilization of MCF in limit-fed high-energy diets to dry corn gluten feed (**DCGF**) and DDG and to

[1]This research was supported in part by a grant from the Illinois Corn Marketing Board, 2415 E. Washington St., Bloomington, IL 61704-4409.

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Received December 16, 1998.
Accepted June 8, 1999.

Table 1. Composition of diets fed to growing heifer calves (Trial 1)[a]

Ingredient	Treatment[b] DCGF	DDG	MCF
	kg DM/d		
Alfalfa hay	.54	.54	.54
Cracked corn	3.65	4.09	4.09
Dry corn gluten feed	1.25	—	—
Dried distillers grains	—	.82	—
Modified corn fiber	—	—	.82

[a]Heifers also received trace-mineralized salt, 114 g·heifer^{-1}·d^{-1}, composition (%): NaCl, 20 to 24; Ca, 14.5 to 16.5; P, > 8; Mg, > 1.1; S, > .71; K, > 2.24; Fe, > .25; Zn, > .25; Mn, > .25; Cu, > .03; Co, > .003; I, > .004; Se, > .0026 and vitamin A, > 529,100; vitamin D_3 > 88,183; vitamin E, > 441 IU/kg; and Rumensin 80 at 200 mg of active ingredient·heifer^{-1}·d^{-1}.
[b]DCGF = dry corn gluten feed diet, DDG = dried distillers grains diet, MCF = modified corn fiber diet. All diets were limit-fed.

Table 2. Composition of corn coproducts fed in Trials 1 and 2

Item	Corn coproduct[a] DCGF	DDG	MCF
DM, %	83.1	87.1	82.2
OM, % DM	93.8	91.9	69.9
CP, % DM	20.1	29.4	23.3
NDF, % DM	37.7	45.2	49.4
ADF, % DM	7.0	12.9	45.4
TDF, % DM[b]	32.3	35.5	35.6
ADIN, % N[c]	5.3	14.2	67.9
GE, Mcal/kg DM	4.55	4.78	4.71

[a]DCGF = dry corn gluten feed, DDG = dried distillers grains, MCF = modified corn fiber.
[b]Total dietary fiber.
[c]Acid detergent-insoluble N expressed as a percentage of N.

compare the ruminal protein degradation characteristics of these coproducts.

Materials and Methods

Trial 1. Simmental × Angus weanling heifers (n = 96; 239 ± 2.3 kg) at the Orr Research Center, Baylis, IL, were used in four replications to evaluate three treatments. This resulted in 12 pens with eight heifers per pen. The three treatments were cracked corn-hay diets supplemented with three corn coproducts: dry corn gluten feed, corn-derived dried distillers grains, or modified corn fiber (Table 1). The diets were supplemented with trace minerals and Rumensin 80 (Elanco Animal Health, Indianapolis, IN), and were limit-fed to allow the heifers to attain a predicted daily gain of .8 kg. The diets were fed to supply similar amounts of energy and protein and to ensure that all other nutrients met or exceeded National Research Council (1996) recommendations. Heifers were blocked by weight and randomly assigned to pens, and pens were randomly assigned to treatment. Full weights were taken on two consecutive days and averaged to obtain initial (d 0) and final weights for each heifer (d 84). Weights were taken every 28 d during the trial. Samples of the three corn coproducts were taken every 14 d, composited, and analyzed for DM, OM, Kjeldahl N (AOAC, 1984), NDF (Jeraci et al., 1988), ADF (Goering and Van Soest, 1970), ADIN (Goering and Van Soest, 1970), total dietary fiber (**TDF**) (Prosky et al., 1984), and GE (Table 2). Animal use procedures for Trial 1 were approved by the University of Illinois Laboratory Animal Care Advisory Committee.

Trial 2. Ruminally cannulated crossbred beef steers (n = 4; 606 ± 60 kg) were used in a 4 × 4 Latin square arrangement of treatments with 11 d in each period (d 1 to 7, adaptation; d 8 to 11, sampling) to evaluate four treatments.

The four treatments were based on a diet of limit-fed cracked corn-alfalfa haylage supplemented with one of four corn coproducts: cornstarch (**CON**), DCGF, DDG, or MCF at 20% of the diet DM. The CON diet served as the negative control. This inclusion level was chosen to maintain similar CP percentages among the DGCF, DDG, and MCF diets (16.5 to 18.5%). The diets (Table 3) were limit-fed at 2% of BW and were supplemented with urea, limestone, and potassium chloride; Rumensin 80 was also added to provide 196 mg of active ingredient·steer^{-1}·d^{-1}. Supplemental ingredients were individually weighted daily, combined, and incorporated

Table 3. Ingredient and chemical composition of diets fed to cannulated beef steers in Trial 2[a]

Ingredient	Treatment[b] CON	DCGF	DDG	MCF
	kg DM basis/d			
Alfalfa haylage	2.50	2.52	2.50	2.54
Cracked corn	6.46	6.53	6.49	6.58
Cornstarch	2.50	—	—	—
Dry corn gluten feed	—	2.52	—	—
Dried distillers grains	—	—	2.50	—
Modified corn fiber	—	—	—	2.54
Corn steep liquor	.62	.63	.63	.64
Urea, g[c]	124.8	126.1	125.2	127.0
Limestone, g[c]	87.4	88.3	87.6	88.9
Potassium chloride, g[c]	62.4	63.1	62.6	63.5
Rumensin 80, g[cd]	1.10	1.11	1.10	1.12
DM, %	74.4	73.5	74.4	73.4
Organic matter, % DM	88.8	87.6	87.2	82.9
Total dietary fiber, % DM	21.4	27.9	28.5	28.5
Crude protein, % DM	12.6	16.5	18.5	17.1

[a]Animals had ad libitum access to trace-mineralized salt, composition (%): NaCl, 20 to 24; Ca, 14.5 to 16.5; P, > 8; Mg, > 1.1; S, > .71; K, > 2.24; Fe, > .25; Zn, > .25; Mn, > .25; Cu, > .03; Co, > .003; I, > .004; Se, > .0026 and vitamin A, > 529,100; vitamin D_3, > 88,183; vitamin E, > 441 IU/kg.
[b]CON = cornstarch diet, DCGF = dry corn gluten feed diet, DDG = dried distillers grains diet, MCF = modified corn fiber diet. All diets were limit-fed.
[c]These ingredients were weighed daily at feeding, mixed, and added to the diet.
[d]Rumensin 80 contained 176 g of active ingredient/kg and was fed to obtain 196 mg of active ingredients·steer^{-1}·md^{-1}.

into their respective diets at the time of feeding. Corn steep liquor and urea were added to ensure that DIP was not limiting. Expected DIP levels were 1,236, 1,616, and 1,434 g/d for the CON, DCGF, and DDG treatments, respectively. The DIP provided in the MCF treatment was 1,236 g/d, excluding possible DIP contributed by the modified corn fiber present in the diet. Diets were balanced to meet or exceed all NRC (1996) recommendations. Steers had ad libitum access to trace-mineralized salt during the trial.

Steers were gradually adjusted to an 80% concentrate diet before beginning the study. Animal use procedures for Trial 2 were approved by the University of Illinois Laboratory Animal Care Advisory Committee. Steers were housed in a climate-controlled building with the temperature maintained between 18 and 25°C. Steers were able to stand and lie down freely on rubber mats to prevent feet and leg problems and were allowed to exercise in a paddock for one-half day following each period. Steers were washed, and feces and urine were removed at least twice daily.

A gelatin capsule containing 7.5 g of Cr as Cr_2O_3 was inserted into the rumen daily at 0800 and 2000 as a marker to use in estimating fecal output for calculation of total-tract digestibility. On d 8 through 11 of each period, fecal grab samples were collected and frozen immediately. Samples were collected every 4 h each day, and the sampling times were advanced 1 h each day to yield 23 samples that represent a 24-h period. Fecal samples for each animal in each period were composited, dried at 55°C, ground through a Wiley mill equipped with a 2-mm screen, and analyzed for Cr concentration according to Williams et al. (1962). Feed samples were taken before and during each collection period and composited by period. Feed and fecal samples were dried at 55°C and ground through a Wiley mill equipped with a 2-mm screen. Samples were analyzed for DM, OM, Kjeldahl N (AOAC, 1984), and TDF (Prosky et al., 1984). Total dietary fiber was analyzed instead of NDF and ADF to more accurately reflect fiber content and to remove interference from inorganic matter and Maillard browning products often present in corn coproducts due to heat treatment or drying during processing. Gross energy was determined for both feed and fecal samples using bomb calorimetry (AOAC, 1984). Digestible energy of the diets was estimated from the GE of the feed and feces and from the digestibility of the dietary DM.

Ruminal fluid samples were collected at 0, 2, 4, 6, 8, 12, 16, and 20 h after feeding on d 8 of each period. Ruminal fluid pH was determined immediately after collection using a Sentron Model 1001 (Medtronic Synectics, Minneapolis, MN). Subsequently, a 50-mL sample was acidified with 1 mL of 6 *N* HCl and frozen. At the conclusion of Trial 2, samples were allowed to thaw, and a 10-mL subsample was taken from each of the individual samples and composited for each animal by period for VFA analysis (Merchen et al., 1986).

At the conclusion of Periods 3 and 4, in situ disappearance of CP in DCGF, DDG, and MCF supplements were measured using the animal fed the CON diet during the respective period. Original CP percentages were calculated from Kjeldahl N (AOAC, 1984). Approximately 5 g of each sample was placed, in triplicate, into 5- × 10-cm polyester bags and tied closed with string. Duplicate empty bags were placed into the rumen for each time period to permit correction for microbial attachment to the sample bag. Bags were removed at 0, 3, 6, 9, 12, 18, and 24 h of incubation. Bags for the 0-h incubation were not suspended in the rumen but soaked in warm tap water for 20 min and rinsed to determine the immediately soluble fraction. All other bags were suspended in the rumen for their appropriate time of incubation, removed, and rinsed with tap water until the rinse water was clear. Bags were subsequently dried at 55°C, and subsamples were taken from each bag and analyzed for Kjeldahl N (AOAC, 1984). Rate of CP disappearance was computed as the slope of the natural logarithm of the percentage of CP remaining against time (24 h). Estimates of the extent of ruminal CP degradation were determined according to Mathers and Miller (1981). The equation utilized was

$$a + (1 - a)(K_d/K_r + K_d)$$

where K_r = rate constant for passage of undegraded CP from the rumen, assumed in this case to be .05/h, K_d = rate of disappearance of the potentially degradable CP (the amount of CP that was not immediately soluble in the rumen) from polyester bags (%/h), and a = proportion of CP disappearance at 0 h (assumed soluble and 100 % degradable).

Statistical Analysis

Effects of dietary treatment on heifer performance (Trial 1) were analyzed using the GLM procedure of SAS (1990) for a completely randomized design, with pen as the experimental unit. Orthogonal contrasts were used to compare DCGF vs MCF and DDG vs MCF (Trial 1). Data from the digestibility study were analyzed according to the GLM procedure of SAS (1990) for a 4 × 4 Latin square design. Digestion criteria (Trial 2) were analyzed using a model containing digestibilities of DM, OM, TDF, CP, and GE and ruminal VFA data as dependent variables and treatment, period, and animal as independent variables. Orthogonal contrasts were used to compare CON vs DCGF, DDG, and MCF; DCGF vs MCF; and DDG vs MCF. Ruminal pH was analyzed using the GLM procedure of SAS (1990) using a model containing treatment, period, animal, hour, and treatment × hour as independent variables and pH as the dependent variable. The same orthogonal contrasts were used as for the digestibility data. There was no treatment × hour interaction ($P > .99$), so the interaction was removed from the model statement and only the main effects were reported. Rate and extent

Table 4. Performance of heifers fed corn coproducts (Trial 1)[a]

Item	Treatment[b] DCGF	DDG	MCF	SEM
Initial wt., kg	238	238	240	1.08
Final wt (d 84), kg[cd]	314	320	299	2.65
Total wt gain (d 1 to 84), kg[cd]	76	82	59	2.57
Avg. daily gain (d 1 to 84), kg/d[cd]	.91	.97	.70	.031
Gain/feed[cd]	.167	.179	.125	.012

[a]Least squares means.
[b]DCGF = corn gluten feed diet, DDG = dried distillers grains diet, MCF = modified corn fiber diet. All diets were limit fed at 5.45 kg/d.
[c]DCGF vs MCF ($P < .01$).
[d]DDG vs MCF ($P < .001$).

of CP degradation were analyzed according to the GLM procedures of SAS (1990), with animal as the experimental unit. Orthogonal contrasts were used to compare DCGF vs MCF and DDG vs MCF.

Results and Discussion

Trial 1. Chemical composition of the corn coproducts is shown in Table 2. Modified corn fiber had a drastically higher concentration of ADF (45.4%) than did DCGF or DDG, and accounts for the higher concentration of ADIN (67.9%), expressed as a percentage of total N, than for DCGF or DDG (5.3 and 14.2%, respectively). Concentrations of TDF were similar among corn coproducts. Heifers consuming the DDG- and DCGF-supplemented diets had gains that exceeded the projected ADG of .8 kg/d (Table 4).

Heifers had similar beginning weights and overall DMI among the three treatments. Average daily gain was increased ($P < .001$) by 39% for heifers fed DDG and by 29% ($P < .01$) for heifers fed DCGF compared with those fed MCF. Feed efficiency was improved by 43% ($P < .001$) and by 34% ($P < .01$) for the DDG and DCGF treatments, respectively, vs the MCF treatment. Heifers fed the DCGF and DDG treatments had similar ADG and gain/feed responses when fed diets containing 23% DCGF and 15% DDG. In contrast, Berger and Firkins (1985) observed that steers fed diets containing 17.4% DDG grew more rapidly and were more efficient than those fed diets containing 34.9% DCGF. This may be due to a lower energy content of the DCGF diet and level of DCGF fed in that experiment. Berger and Willms (1992) and Hussein and Berger (1995) observed that limit-fed heifers consuming 25% WCGF had gains similar to those of heifers on limit-fed diets based on corn and corn silage. These data suggest that MCF has a lower feeding value than DDG or DCGF.

Trial 2. The ingredient and nutrient composition of the diets fed to the cannulated steers are shown in Table 3. The effects of corn coproducts on apparent total-tract digestibilities are shown in Table 5. Dry matter intake was similar among treatments because diets were limit-fed at 2% of BW. Steers fed the CON diet tended ($P < .10$) to have increased digestibilities of DM (DMD) and OM (OMD) compared with the other diets but had decreased ($P < .05$) TDF digestibility (TDFD) compared with the other treatments.

No differences ($P > .10$) in digestibilities of any nutrients were detected for DCGF vs MCF or DDG vs MCF. However, steers fed the MCF treatment had numerically lower DMD, OMD, and CPD than the steers fed DCGF or DDG treatments. The dried distillers grains diet had numerically higher TDFD than those fed the DCGF- or MCF-supplemented diets. Ham et al. (1994) also observed no differences in the digestibilities of OM, starch, NDF, and N when comparing DCGF and wet distillers grains (WDG). In agreement with these data, Hannah et al. (1990) concluded that feeding corn gluten feed had no negative effects on rate of forage digestion or dietary OM, NDF, and ADF digestibilities. Oliveros et al. (1987) stated that the steep liquor portion of corn gluten feed increases microbial activity in the rumen, and it may increase the supply of protein and energy to the ruminant.

The effects of corn coproducts on energy intakes and digestibilities are also shown in Table 5. The GE intake was similar among treatments. However, steers fed the CON diet tended ($P < .10$) to have increased digestible energy (DE) as a percentage of GE intake when compared to the other treatments. No differences ($P > .10$) were observed between DCGF and MCF or DDG and MCF, although MCF had numerically higher GE output in the feces than DCGF or DDG and subsequently had a lower numerical value for DE as a percentage of GE intake than DCGF or DDG. Digestible energy was calculated for each treatment; no differences ($P > .10$) were observed, although the MCF diet had numerically lower DE than the other treatments. Corn gluten feed not only offers a highly digestible fiber, but the steep liquor also enhances the energy value by moderating ruminal pH and subsequently increasing ruminal fiber digestion (Green and Stock, 1986).

There were no differences ($P > .30$) in ruminal pH (Table 6) when comparing MCF with DCGF or DDG. Steers fed the CON treatment had lower ($P < .05$) average ruminal pH when compared with the other treatments.

No differences ($P > .10$) were observed in VFA concentrations and molar percentages between DCGF or DDG, and MCF (Table 6). Supplementing cornstarch (CON) resulted in increases ($P < .05$) in total VFA concentrations and concentrations of propionate and valerate, and decreases ($P < .05$) in concentrations of butyrate, isobutyrate, and isovalerate. However, steers fed the CON diet had increased ($P < .05$) percentages of propionate and decreased ($P < .05$) percentages of acetate and butyrate when expressed as a percentage of total VFA. The difference in starch vs fiber content of the treat-

Table 5. Effects of corn coproducts on DMI and apparent total-tract digestibilities in steers (Trial 2)[a]

	Treatment[b]				
Item	CON	DCGF	DDG	MCF	SEM
Dry matter intake, kg/d	12.5	12.6	12.5	12.7	.7
Digestibilities, %					
DM[c]	70.8	62.0	62.6	59.6	1.9
OM[c]	70.1	61.0	61.0	54.9	2.2
TDF[d]	24.5	33.7	42.1	38.6	3.9
CP	51.1	43.9	40.8	39.2	4.0
GE intake, Mcal/d	49.8	51.3	51.6	52.1	2.6
GE output, Mcal/d[d]	17.1	21.9	21.7	25.1	2.0
DE, %[c]	65.2	57.0	57.3	51.9	4.8
DE, Mcal/kg	2.6	2.3	2.4	2.1	.2

[a]Least squares means.
[b]Coproduct supplemented: CON = cornstarch, DCGF = dry corn gluten feed, DDG = dried distillers grains, MCF = modified corn fiber.
[c]CON vs CGF, DDG, MCF ($P < .10$).
[d]CON vs CGF, DDG, MCF ($P < .05$).

ments accounts for the shift toward increased propionate production and decreased acetate production.

Rate and extent of in situ CP degradation of corn coproducts are shown in Table 7. Dry corn gluten feed had a greater ($P < .05$) fraction and DDG tended to have an increased ($P < .10$) fraction of CP that was immediately soluble (CP disappearance at 0 h) when compared with MCF.

Rates of disappearance of the potentially degradable substrate or the rate of disappearance of the amount of CP that is not immediately soluble in the rumen were calculated using the slope of the natural logarithm of the percentage of CP remaining against time for a duration of 20 h. The CP degradation rate of MCF (–.07%/h) was lower ($P < .05$) than for DCGF or DDG, suggesting that there was no disappearance of CP in MCF from the polyester bags other than the immediately soluble fraction. Extent of CP degradation was calculated according Mathers and Miller (1981) using an assumed ruminal passage rate of .05/h, and MCF had lower ($P < .05$) extent of CP degradation (27.6%) than DCGF and DDG (73.2 and 57.6%, respectively). The extent of CP degradation for MCF in relation to the immediately soluble fraction (27.6 vs 29.0%) suggests that the fraction of CP in MCF that is not immediately soluble is completely unavailable. This is substantiated by the high concentration of ADIN present in MCF.

Firkins et al. (1984) reported that DCGF had a higher rate of in situ N disappearance than DDG for 2 to 8 h of incubation. They further concluded that CP escaping the rumen and reaching the duodenum was higher for DDG than for DCGF, stating that DDG has a higher UIP than DCGF. Firkins et al. (1985) also stated that DDG had higher UIP than corn gluten feed, therefore increasing the amount of protein directly available to the ruminant.

Table 6. Effects of corn coproducts on ruminal pH and VFA concentrations in steers (Trial 2)[a]

	Treatment[a]				
Item	CON	DCGF	DDG	MCF	SEM
Ruminal pH[b]	5.96	6.19	6.24	6.28	.04
Total VFA, m*M*[b]	64.4	55.5	56.0	53.3	1.39
Acetate	31.5	32.9	32.6	31.8	.68
Propionate[b]	25.8	13.9	14.2	13.0	1.34
Butyrate[b]	4.6	6.3	6.8	6.4	.38
Isobutyrate[b]	.48	.60	.67	.59	.04
Valerate[b]	1.35	.65	.65	.56	.10
Isovalerate[b]	.67	1.15	1.10	.99	.06
VFA, % of total VFA					
Acetate[b]	48.9	59.4	58.3	59.5	1.07
Propionate[b]	39.9	24.8	25.3	24.6	1.75
Butyrate[b]	7.2	11.4	12.1	11.9	.67

[a]Coproduct supplemented: CON = cornstarch, DCGF = dry corn gluten feed, DDG = dried distillers grains, MCF = modified corn fiber.
[b]CON vs DCGF, DDG, MCF ($P < .05$).

Table 7. Rate and extent of in situ degradation of CP in corn coproducts (Trial 2)[a]

Item	Treatments[b]			
	DCGF	DDG	MCF	SEM
Initial CP, % DM	19.7	28.6	21.1	—
CP disappearance at 0 h, %[cde]	62.6	39.2	29.0	2.48
K_d, %/h[cdf]	1.98	2.17	−.07	.17
Extent of CP degradation, %[dfg]	73.2	57.6	27.6	4.74

[a]Least squares means.
[b]DCGF = dry corn gluten feed, DDG = dried distillers grains, MCF = modified corn fiber.
[c]Rate of degradation of the potentially degradable substrate.
[d]DCGF vs MCF ($P < .05$).
[e]DDG vs MCF ($P < .10$).
[f]DDG vs MCF ($P < .05$).
[g]Calculated using an assumed ruminal rate of passage (K_r) of .05/h.

Implications

Corn gluten feed and dried distillers grains seem to be effective energy and protein sources in high-grain diets limit-fed to heifers. Modified corn fiber does not seem to be an acceptable source of protein for ruminants. Its feeding value seems limited by the unavailability of its protein fraction as evidenced by its high acid detergent-insoluble nitrogen content and slow in situ protein digestion. Modified corn fiber could be more efficacious as a feedstuff if it were processed in a different manner.

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