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# Feeding Wet Corn Gluten Feed to Reduce Subacute Acidosis in Cattle[1]

**C. R. Krehbiel, R. A. Stock[2], D. W. Herold, D. H. Shain, G. A. Ham, and J. E. Carulla**

Department of Animal Science, University of Nebraska, Lincoln 68583-0908

**ABSTRACT:** Two experiments were conducted to evaluate the effects of feeding wet corn gluten feed (WCGF) on subacute acidosis in cattle. In Exp. 1, 60 individually fed yearling steers (270 ± 22 kg BW) were used in a 5 × 2 factorial arrangement of treatments. Steers were assigned to one of five dietary treatments: 1) dry-rolled corn (DRC), 2) 35% WCGF fed d 1 to 132, 3) 86.5% WCGF fed d 1 reduced to 35% WCGF by d 19 and increasing the proportion of DRC, 4) 86.5% WCGF fed d 1 to 132, or 5) 94.5% WCGF fed d 1 to 132. Final diets for Treatments 1 through 4 contained 92% concentrate and 8% alfalfa hay (DM basis). Treatment 5 was a 100% concentrate diet. All diets were fed with or without the addition of escape protein. During d 19 to 24, steers fed WCGF had less ($P$ < .05) DMI variation than steers fed the control diet. Steers fed 86.5 and 94.5% WCGF had lower ($P$ < .05) DMI and ADG than steers fed Treatments 1 through 3, although gain/feed was not different ($P$ > .10) In Exp. 2, three ruminally fistulated steers (615 ± 36 kg BW) were used in a repeated 3 × 3 Latin square design. On d 14 of each period, 7.9 kg (DM) of 100% DRC, 50% DRC:50% WCGF, or 100% WCGF was intraruminally dosed as an acidosis challenge. Area within the curve below ruminal pH 6.0 was greater ($P$ < .05) over a 24-h period for steers dosed with 100% DRC than for steers dosed with 50% DRC: 50% WCGF or 100% WCGF. In addition, more ($P$ < .05) ruminal VFA accumulated over 24 h for steers dosed with 100% DRC. These data suggest that feeding WCGF does not eliminate ruminal acidosis but may reduce the length of time cattle are exposed to the insult.

Key Words: Corn Gluten Feed, Cattle, Acidosis, Performance, Starch, Fiber

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## Introduction

Wet corn gluten feed (**WCGF**) has been shown to have 94 to 100% of the NE value of dry-rolled corn (**DRC**; Green et al., 1987; Ham et al., 1995). Although WCGF contains a high content of NDF (42%) and a limited amount of starch (22.5%) relative to DRC (Ham et al., 1994), the fiber fraction is both highly (87%) and rapidly (6.2%/h) digested in the rumen (DeHaan, 1983). In addition, the protein in WCGF is rapidly digested (9.5%/h) in the rumen and, therefore, the escape protein content of WCGF is low (26%; Firkens et al., 1984).

Subacute acidosis is a major problem for cattle during adaptation to high-grain finishing diets and has been characterized in the feedlot by reduced and erratic feed intakes (Fulton et al., 1979), which cause lower feed efficiencies and gains (Stock et al., 1990). Feeding high-energy, low-starch fiber sources in feedlot diets may be a method of reducing metabolic disorders related to ruminal acidosis. One objective of this research was to determine whether feeding WCGF would reduce subacute acidosis as measured by DMI variation, animal performance, and ruminal metabolism. Because of the rapid ruminal degradation and low escape value of the protein in WCGF, an additional objective of this research was to determine whether cattle consuming WCGF would respond to the addition of escape protein.

## Materials and Methods

*Experiment 1.* A 132-d finishing trial used 60 individually fed yearling Hereford steers (BW = 270 ± 22 kg) in a randomized complete block design with a 5 × 2 factorial arrangement of treatments. Steers were blocked by weight and randomly assigned within block to one of five dietary treatments: 1) DRC control, 2) 35% WCGF fed d 1 through 132, 3) 86.5% WCGF fed d 1 reduced to 35% by d 19 and increasing the proportion of DRC, 4) 86.5% WCGF fed d 1 through 132, or 5) 94.5% WCGF fed d 1 through 132. Wet corn

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[2]To whom correspondence should be addressed.

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Table 1. Composition of dry supplements fed in Experiment 1[a]

| | DRC[b] | | 35% WCGF[b] | | 86.5% WCGF | | 94.5% WCGF | |
|---|---|---|---|---|---|---|---|---|
| Item | WO/EP[b] | W/EP[b] | WO/EP | W/EP | WO/EP | W/EP | WO/EP | W/EP |
| Fine ground corn | 48.30 | 3.29 | 64.61 | 19.72 | 55.47 | 10.29 | 47.96 | 2.76 |
| Fat | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 | 2.00 |
| Corn gluten meal | — | 28.89 | — | 28.89 | — | 28.89 | — | 28.89 |
| Blood meal | — | 16.18 | — | 16.18 | — | 16.18 | — | 16.18 |
| Limestone | 24.24 | 24.06 | 26.13 | 25.95 | 35.27 | 35.38 | 42.78 | 42.91 |
| Potassium chloride | 4.13 | 4.25 | — | — | — | — | — | — |
| Salt | 3.82 | 3.82 | 5.46 | 5.46 | 5.46 | 5.46 | 5.46 | 5.46 |
| Urea | 15.82 | 15.82 | — | — | — | — | — | — |
| Trace mineral premix[c] | .91 | .91 | .91 | .91 | .91 | .91 | .91 | .91 |
| Vitamin premix[d] | .18 | .18 | .18 | .18 | .18 | .18 | .18 | .18 |
| Thiamine premix[e] | — | — | .11 | .11 | .11 | .11 | .11 | .11 |
| Rumensin premix[f] | .38 | .38 | .38 | .38 | .38 | .38 | .38 | .38 |
| Tylan premix[g] | .23 | .23 | .23 | .23 | .23 | .23 | .23 | .23 |

[a]Supplements fed at 5.5% of diet DM.
[b]DRC = dry-rolled corn; WCGF = wet corn gluten feed; WO/EP = without escape protein; W/EP = with escape protein.
[c]Contained 10% Mg, 6% Zn, 4.5% Fe, 2% Mn, .5% Cu, .3% I, and .05% Co.
[d]Contained 15,000 IU of vitamin A, 3,000 IU of vitamin D, and 3.7 IU of vitamin E/g of premix.
[e]18 g of thiamine/kg of premix.
[f]132 g of monensin/kg of premix.
[g]88 g of tylosin/kg of premix.

gluten feed was supplied by Minnesota Corn Processors (Columbus, NE). Final diets for Treatments 1 through 4 contained 92% concentrate and 8% alfalfa hay (DM basis). Treatment 5 was a 100% concentrate diet. All diets were fed with or without the addition of escape protein (2.5% on a DM basis; Table 1).

Steers had ad libitum access to feed throughout the experiment. Steers receiving Treatments 1 and 2 were adapted to the final diets in 18 d using four grain adaptation diets containing (DM basis) 45 (d 1 through 3), 35 (d 4 through 6), 25 (d 7 through 12), and 15% (d 13 through 18) alfalfa hay. Cattle were fed their final 8% alfalfa hay diets an additional 6 d, at which time they were considered to be on feed. On d 1, cattle receiving treatments 3 and 4 were fed an 8% alfalfa hay diet and cattle receiving Treatment 5 were fed an all-concentrate diet. All final diets were formulated to meet ruminally degradable N requirements (6.7%), resulting in final diets containing (DM basis) 12.4% CP without the addition of escape protein and 14% CP with the addition of escape protein. The composition of the supplements fed is shown in Table 1. Diets were formulated to contain (DM basis) .70% Ca, .30% P, .70% K, 25 g/ton of monensin (Elanco Animal Health, Indianapolis, IN), and 10 g/ton of tylosin (Elanco Animal Health). Orts were weighed every 3 d for the first 28 d of the experiment and then every 7 d to calculate DMI. Orts were dried in a forced-air oven at 60°C for 48 h. All steers were implanted with Revalor (Hoeschst-Roussel Agri-Vet Company, Somerville, NJ), once at the beginning of the experiment and again on d 84.

Variation in DMI during the grain adaptation period was analyzed separately for each grain adaptation diet and for the first 6 d of the final diet. Intake variation during each step of the adaptation period was calculated by two methods based on residual intake estimates. In the first method, residual intake (for each steer) was calculated as actual daily DMI minus the average DMI for all days within the concentrate period for that steer. In the second method, residual intake was calculated as actual daily DMI (for each steer) minus the average DMI for all steers within treatment for each day. Intake variation was calculated on intake residuals within an animal across all days in the grain adaptation period (animal intake variation; **AIV**), or on intake residuals within the day among all animals within the treatment (day intake variation; **DIV**).

Initial and 28-d weights were the average of three weights taken on consecutive days before feeding. Hot carcass weight, adjusted for 62% dressing percentage, was used to estimate final live weight. Carcass measurements included hot carcass weight, 12th rib fat thickness, yield grade, quality grade, and liver score. Livers were scored by the system developed by Elanco Products Company (1974). Twelfth rib fat thickness, yield grade, and quality grade were collected after a 48-h chill.

Analysis of variance for a randomized complete block design was performed using the GLM procedure of SAS (1989). Steer was used as the experimental unit; the main effects were WCGF treatment, escape protein, and the WCGF × escape protein interaction. Least squares means were separated using the Least Significant Difference method when a significant ($P < .10$) treatment $F$-test was detected. Data were pooled across escape protein when the WCGF × escape protein interaction was not significant ($P > .10$).

Table 2. Composition of diets (% on a DM basis) fed in Experiment 2

| Item | DRC[a] | 50% DRC:50% WCGF[a] | WCGF |
|---|---|---|---|
| Dry-rolled corn | 57.83 | 29.30 | — |
| Wet corn gluten feed | — | 29.30 | 58.84 |
| Corn silage | 20.00 | 20.00 | 20.00 |
| Alfalfa hay | 20.00 | 20.00 | 20.00 |
| Dry supplement | | | |
| Urea | 1.51 | .66 | — |
| Limestone[b] | .30 | .38 | .80 |
| Sodium chloride | .30 | .30 | .30 |
| Fat | .01 | .01 | .01 |
| Vitamin premix[c] | .01 | .01 | .01 |
| Trace mineral premix[d] | .02 | .02 | .02 |
| Rumensin premix[e] | .02 | .02 | .02 |
| Tylan premix[f] | .01 | .01 | .01 |
| Nutrient composition, %[g] | | | |
| CP | 14.12 | 14.12 | 14.60 |
| Ca | .45 | .50 | .69 |
| P | .26 | .42 | .57 |
| K | .73 | 1.08 | 1.43 |

[a]DRC = dry-rolled corn; WCGF = wet corn gluten feed.
[b]Limestone was increased to maintain a Ca:P of 1.2:1.
[c]15,000 IU of vitamin A, 3,000 IU of vitamin D, and 3.7 IU of vitamin E/g of premix.
[d]10% Mg, 6% Zn, 4.5% Fe, 2% Mn, .5% Cu, .3% I, and .05% Co.
[e]132 g of monensin/kg of premix.
[f]88 g of tylosin/kg of premix.
[g]Based on tabular values.

*Experiment 2.* An acidosis challenge experiment used three ruminally fistulated steers (615 ± 36 kg BW) in a repeated 3 × 3 Latin square design balanced for residual effects (Cochran and Cox, 1957). Two additional ruminally fistulated steers were used as donors of ruminal contents. Surgical procedures and postsurgical care had been previously reviewed and accepted by the University of Nebraska Institutional Animal Care and Use Committee. At the beginning of the experiment, test steers were randomly allotted and adapted to a 70% concentrate diet (Table 2). Steers were fed in 12 equal portions daily at 1.20% of BW (7.4 kg DMI, DM basis) by an automatic feeding system. The donor steers were fed once daily a diet consisting of (DM basis) 33% DRC, 33% alfalfa hay, 33% corn silage, and 1% dry supplement. All steers had ad libitum access to fresh water.

Each period lasted 14 d. On the 1st d of a period, 10 L of ruminal contents from each of the test steers was replaced with the same volume of pooled ruminal contents from the donor steers. Days 1 to 11 were a dietary adaptation period. Composition of dietary treatments is shown in Table 2. On d 12, feed was withheld from the test steers and 7.9 kg (DM) of 100% DRC, 50% DRC:50% WCGF, or 100% WCCF was intraruminally dosed to each steer. A preliminary experiment revealed that 7.9 kg (DM) of DRC was needed to reduce ruminal pH to 5.6 or below. The DRC-dosed grain was sieved through a 5-cm screen to remove any whole grain kernels. This acidosis challenge was conducted to simulate situations in the feedlot in which cattle overconsume large quantities of a high-concentrate diet. The acidosis challenge diets were formulated to contain a minimum of 13% CP, .3% Ca, .2% P, and .2% K. Ruminal fluid was collected at 0, 3, 6, 9, 12, 15, 18, 21, and 24 h after dosing. Ruminal pH was measured immediately with a combination electrode, and the sample was frozen (−20°C) for later analyses. On d 14, the next period was started by removing 10 L of ruminal contents and reinoculating with pooled ruminal contents from donor steers to re-establish ruminal microorganisms.

Ruminal fluid was deproteinized with one-fourth volume of 20% metaphosphoric acid (Erwin et al., 1961) and with 25 m*M* 2-ethylbutyrate as an internal standard for VFA analysis. Ruminal VFA were separated and quantified using a GLC (Hewlett-Packard, Avondale, PA) equipped with a packed (10% SP1200/1% $H_3PO_4$ on chromosorb W/AW; Supelco, Belfonte, PA) glass column and a flame ionization detector. Ruminal fluid was also deproteinized with one-tenth volume 6 *N* $HClO_4$ for L(+) and D(−)-lactate analysis and measured enzymatically (Gutmann and Wahlefeld, 1974; Engel and Jones, 1978; Brandt et al., 1980).

Area below pH 6.0 was calculated to quantity total decrease in ruminal pH over the 24-h sampling period. The calculation was the average of the measurements (0 and 3 h, 3 and 6 h, 6 and 9 h, etc) multiplied by the hours separating the measurements (i.e., 3). The positive values (negative values reflect pH greater than 6.0) were summed. We selected pH 6.0 as our reference of measurement because this pH represents when fermentation may be altered (Owens and

Table 3. Effect of feeding wet corn gluten feed in grain-adaptation diets on daily DMI variation ($kg^2$)[a]

| Item | Control | 35%[b] WCGF | 86.5-35%[b] WCGF | 86.5%[b] WCGF | 94.5%[b] WCGF | SEM |
|---|---|---|---|---|---|---|
| Step 1 (d 1 to 3) | .89 | 2.33 | 1.10 | .99 | .83 | .46 |
| Step 2 (d 4 to 6) | 1.23[c] | 1.04[d] | 2.84[d] | 2.04[cd] | 1.13[c] | .37 |
| Step 3 (d 7 to 12) | 2.09[c] | .90[de] | 3.04[f] | 1.02[de] | .61[e] | .24 |
| Step 4 (d 13 to 18) | 1.44[c] | 1.56[c] | 3.46[d] | .87[c] | .79[c] | .29 |
| Step 5 (d 19 to 24) | 4.11[c] | 1.58[d] | 3.61[e] | 1.04[d] | .85[d] | .29 |
| Overall (d 1 to 24) | 1.60[cd] | 1.29[c] | 2.44[d] | 1.04[c] | .77[c] | .31 |

[a]Residual intake calculated as actual DMI minus the average DMI for all animals within treatment for each day. Intake variation calculated on intake residuals.
[b]35% WCGF = 35% wet corn gluten feed fed d 1 through 132; 86.5-35% WCGF = 86.5% wet corn gluten feed fed d 1 reduced to 35% wet corn gluten feed by d 19 while increasing dry-rolled corn; 86.5% WCGF = 86.5% wet corn gluten feed fed d 1 through 132; 94.5% WCGF = 94.5% wet corn gluten feed fed d 1 through 132.
[c,d,e,f]Means within a row with unlike superscripts differ ($P < .05$).

Goetsch, 1988). A larger value indicates more time spent below pH 6.0 and consequently a greater amount of acid production and(or) accumulation. In addition, area below the curve was calculated for ruminal VFA and lactate to quantify their total accumulation over the 24 h-period in which the ruminal environment was monitored. the calculation was a sum of the measurements multiplied by the hours separating the measurements.

Data were analyzed as a repeated Latin square using the GLM procedure of SAS (1989). Ruminal metabolism data were analyzed as a split plot in time in which the main effects of square, steer within square, period, and treatment were tested with the between-subject residual error term and the effect of time and its interactions were tested with the within-subject residual error term. Area below the curve data were analyzed as a repeated Latin square with main effects of square, steer within square, period, and treatment. Least squares means for all data were separated by the protected Least Significant Difference method when a significant ($P < .10$) treatment *F*-test was detected.

## Results

*Experiment 1.* No WCGF × escape protein interaction ($P > .10$) was detected for intake variation during the grain adaptation period; therefore, data were pooled across escape protein levels. Wet corn gluten feed and escape protein had no effect ($P > .10$) on AIV during the grain adaptation period (d 1 through 24; data not shown). However, from d 7 through 12 and d 13 through 18, steers fed 86.5% WCGF d 1 reduced to 35% WCGF by d 19, and increasing the proportion of DRC, had greater DIV ($P < .05$) than steers receiving the other treatments (Table 3). In addition, on d 7 through 12, DIV was greater ($P < .05$) for steers fed DRC than for steers fed 35, 86.5, and 94.5% WCGF.

Table 4. Effects of feeding wet corn gluten feed (WCGF) on feedlot performance and carcass characteristics in Experiment 1

| Item | Control | 35% WCGF | 86.5-35% WCGF | 86.5% WCGF | 94.5% WCGF | SEM |
|---|---|---|---|---|---|---|
| 28-d feedlot performance | | | | | | |
| DMI, kg/d | 9.05[a] | 8.84[a] | 8.37[a] | 7.55[b] | 6.87[c] | .24 |
| ADG, kg | 1.43[a] | 1.67[ab] | 1.78[b] | 1.59[ab] | 1.50[a] | .09 |
| Gain/feed | .158[a] | .188[b] | .212[b] | .211[b] | .217[b] | .010 |
| 132-d feedlot performance | | | | | | |
| DMI, kg/d | 10.03[a] | 9.84[a] | 10.06[b] | 8.82[b] | 8.26[b] | .21 |
| ADG, kg | 1.57[a] | 1.59[a] | 1.64[b] | 1.39[b] | 1.34[a] | .06 |
| Gain/feed | .156 | .162 | .163 | .157 | .163 | .005 |
| Initial weight, kg | 284 | 282 | 283 | 283 | 280 | 7 |
| Final weight, kg[d] | 490[a] | 492[a] | 505[a] | 466[ab] | 457[b] | 9 |
| Hot carcass weight, kg | 302[a] | 305[a] | 313[a] | 289[ab] | 283[b] | 6 |
| Fat thickness, cm | 1.04[a] | .69[b] | .97[a] | .69[b] | .61[b] | .10 |
| Yield grade | 2.58[a] | 2.37[a] | 2.63[a] | 2.17[ab] | 1.58[b] | .22 |
| Quality grade[e] | 18.0[a] | 17.1[ab] | 18.2[a] | 17.2[ab] | 16.2[b] | .4 |

[a,b,c]Means within row with unlike superscripts differ ($P < .05$).
[d]Estimated from hot carcass weight adjusted for 62% dressing percentage.
[e]19 = low Choice, 18 = high Select, 17 = average Select, 16 = low Select.

On d 19 through 24, DIV was lower ($P < .05$) for steers fed WCGF (Treatments 2 through 5) than for steers fed DRC. When DIV was determined for the entire grain adaptation period (d 1 through 24), DIV was greater ($P < .05$) for steers fed 86.5% WCGF d 1 reduced to 35% WCGF by d 19 while increasing DRC than for steers fed 35, 86.5, and 94.5% WCGF; the DRC control steers were intermediate. On d 4 through 6, steers fed escape protein had lower ($P < .05$) DIV than steers not fed escape protein (2.09 vs 1.22 $kg^2$, respectively). However, on d 13 through 24, steers receiving escape protein had greater ($P < .05$) DIV than steers not receiving escape protein (1.36 vs 2.51 $kg^2$, respectively). When calculated for the entire 24-d grain adaptation period, escape protein addition had no effect ($P > .10$) on DIV (1.60 vs 1.29 $kg^2$ with and without escape protein, respectively) (data not shown).

No WCGF × escape protein interaction was found ($P > .10$) for the 28- or 132-d finishing performance data; therefore, data were pooled across escape protein. Steers fed 86.5 and 94.5% WCGF throughout the 28-d feeding period had lower ($P < .05$) DMI than steers fed DRC, 35% WCGF, or 86.5% WCGF fed d 1 reduced to 35% WCGF by d 19 (Table 4). Steers fed 86.5% WCGF d 1 reduced to 35% WCGF by d 19 gained faster ($P < .05$) than steers fed DRC or 94.5% WCGF. On d 28, steers fed WCGF in Treatments 2 through 5 were more efficient ($P < .05$) than steers fed DRC.

Steers fed 86.5 and 94.5% WCGF throughout the 132-d feeding period had lower ($P < .05$) DMI and ADG than steers fed DRC, 35% WCGF, or 86.5% WCGF reduced to 35% WCGF by d 19, although gain/feed was not affected ($P > .10$) by treatment (Table 4). Numerically, steers fed 86.5% WCGF d 1 reduced to 35% WCGF by d 19 had the highest ADG. Steers consuming 94.5% WCGF had the lowest ($P < .05$) hot carcass weight, 12th rib fat depth, yield grade, and quality grade (Table 4). The only treatment in which liver abscesses were observed was in steers consuming DRC (data not shown).

Table 5. Effects of feeding escape protein on feedlot performance and carcass characteristics in Experiment 1

| Item | Control | Escape protein | SEM |
|---|---|---|---|
| 28-d feedlot performance | | | |
| DMI, kg/d[a] | 7.92 | 8.35 | .15 |
| ADG, kg | 1.54 | 1.65 | .06 |
| Gain/feed | .195 | .200 | .006 |
| 132-d feedlot performance | | | |
| DMI, kg/d | 9.26 | 9.54 | .13 |
| ADG, kg | 1.47 | 1.54 | .04 |
| Gain/feed | .159 | .162 | .004 |
| Initial weight, kg | 283 | 282 | 4 |
| Final weight, kg[b] | 477 | 487 | 6 |
| Hot carcass weight, kg | 295 | 302 | 4 |
| Fat thickness, cm[c] | .28 | .34 | .03 |
| Yield grade | 2.26 | 2.27 | .14 |
| Quality grade[d] | 17.6 | 17.1 | .24 |

[a]Escape protein effect ($P < .05$).
[b]Estimated from hot carcass weight adjusted for 62% dressing percentage.
[c]Escape protein effect ($P < .10$).
[d]Scale; 19 = low Choice, 18 = high Select, 17 = Select, etc.

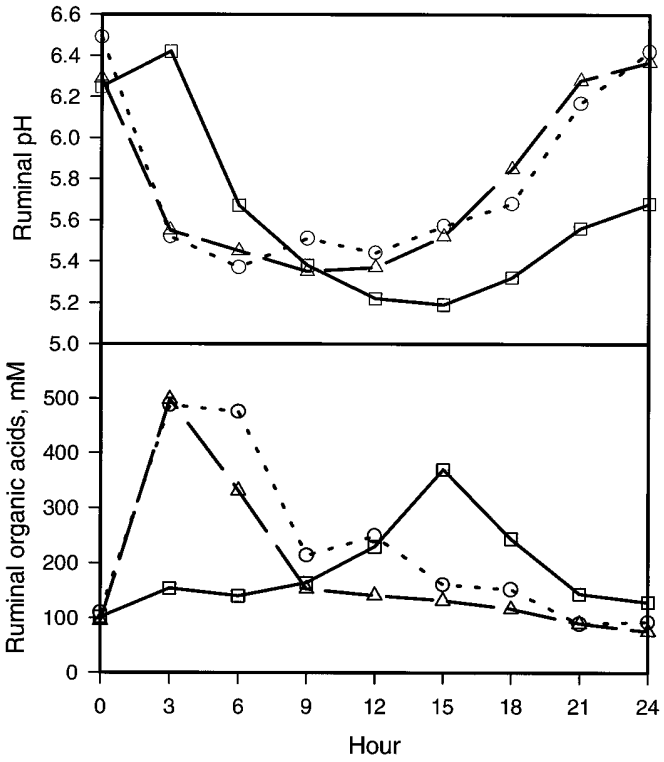


Figure 1. Effect of 100% dry-rolled corn (DRC; —□—), 50% DRC:50% wet corn gluten feed (WCGF; —△—), or 100% WCGF (-- o --) on ruminal pH and total organic acid concentration in Exp. 2. Ruminal pH; time × treatment interaction ($P < .01$), SEM = .09. Total organic acid; time effect ($P < .01$), SEM = 88.

On d 28, steers fed escape protein consumed more feed ($P < .05$), but ADG and gain/feed were not different ($P > .10$; Table 5). Over the entire 132-d feeding period, DMI, ADG, and gain/feed were not different for steers fed escape protein compared with steers not fed escape protein (Table 5). Twelfth rib fat thickness tended to be greater ($P < .10$) for steers fed escape protein. However, no difference ($P > .10$) was observed in hot carcass weight, yield grade, or quality grade for steers fed escape protein vs steers not fed escape protein.

*Experiment 2.* Ruminal pH responded with a time × treatment interaction ($P < .01$; Figure 1). Steers dosed with 50% DRC:50% WCGF or 100% WCGF had lower ruminal pH at h 3 and 6 than steers dosed with 100% DRC, although pH reached a plateau and returned to initial values by 24 h for steers dosed with the former treatments. In contrast, ruminal pH in

Table 6. Effect of 100% dry-rolled corn (DRC), 50% DRC:50% wet corn gluten feed (WCGF), or 100% WCGF on total decrease in ruminal pH and accumulation of ruminal metabolites over a 24-hour sampling period in Experiment 2

| Item | 100% DRC | 50% DRC: 50%WCGF | 100% WCGF | SEM |
|---|---|---|---|---|
| pH below 6.0, pH·h | 11.4[a] | 8.4[b] | 8.3[b] | .7 |
| Acetate, m*M*·h | 1,695 | 1,457 | 1,658 | 102 |
| Propionate, m*M*·h | 1,000[a] | 780[b] | 666[b] | 68 |
| Isobutyrate, m*M*·h | 44 | 18 | 22 | 18 |
| Butyrate, m*M*·h | 392 | 401 | 370 | 46 |
| Isovalerate, m*M*·h | 70 | 66 | 57 | 7 |
| Valerate, m*M*·h | 68 | 37 | 46 | 12 |
| Total VFA, m*M*·h | 3,270[a] | 2,759[b] | 2,819[b] | 131 |
| L(+)lactate, m*M*·h | 728 | 1,268 | 1,890 | 464 |
| D(–)lactate, m*M*·h | 686 | 616 | 1,083 | 329 |
| Total organic acid, m*M*·h | 4,684 | 4,643 | 5,792 | 695 |

[a,b]Means within row with unlike superscripts differ ($P < .05$).

steers dosed with 100% DRC declined from 3 to 15 h and did not return to initial values by 24 h. No significant ($P > .10$) treatment effect or time × treatment interaction was observed for total organic acid concentration (Figure 1). Ruminal concentrations of total lactate (L[+]lactate plus D[–]lactate) tended ($P = .10$) to respond with a time × treatment interaction (Figure 2). Lactate concentrations rose dramatically from 0 to 3 h in steers dosed with 50% DRC:50% WCGF or 100% WCGF but returned to initial values by 9 h in the 50% DRC:50% WCGF-dosed steers and by 15 h in the 100% WCGF-dosed steers. In contrast, in steers dosed with 100% DRC, ruminal lactate concentration began to rise by 9 h, peaked by 15 h, and returned to initial values by 21 h. Concentrations of ruminal VFA were greater ($P < .05$) 3 h after dosing and remained elevated longer ($P < .01$) in steers dosed with 100% DRC than in steers dosed with 50% DRC:50% WCGF or 100% WCGF (Figure 2).

Ruminal concentrations of acetate, butyrate, isobutyrate, and isovalerate were not affected ($P > .10$) by treatment. Ruminal concentrations of propionate were greater ($P < .01$) for cattle dosed with 100% DRC than for cattle dosed with 50% DRC:50% WCGF or 100% WCGF. Ruminal valerate responded with a time × treatment interaction ($P < .05$). At h 12, ruminal valerate concentrations increased for steers dosed with 100% DRC but remained constant in steers dosed with 50% DRC:50% WCGF or 100% WCGF (data not shown).

When pH was below 6.0, total decrease in ruminal pH over the 24-h sampling period was greater ($P < .05$) in steers dosed with 100% DRC than in steers receiving the other treatments (Table 6). This corresponded to a greater ($P < .05$) accumulation of total ruminal VFA over the 24-h sampling period in steers dosed with 100% DRC compared with steers dosed with 50% DRC:50% WCGF or 100% WCGF. Accumulation of acetate, isobutyrate, butyrate, isovalerate, and valerate over the 24-h period was not affected ($P > .10$) by treatment. However, total accumulation of propionate over the 24-h period was greater for cattle

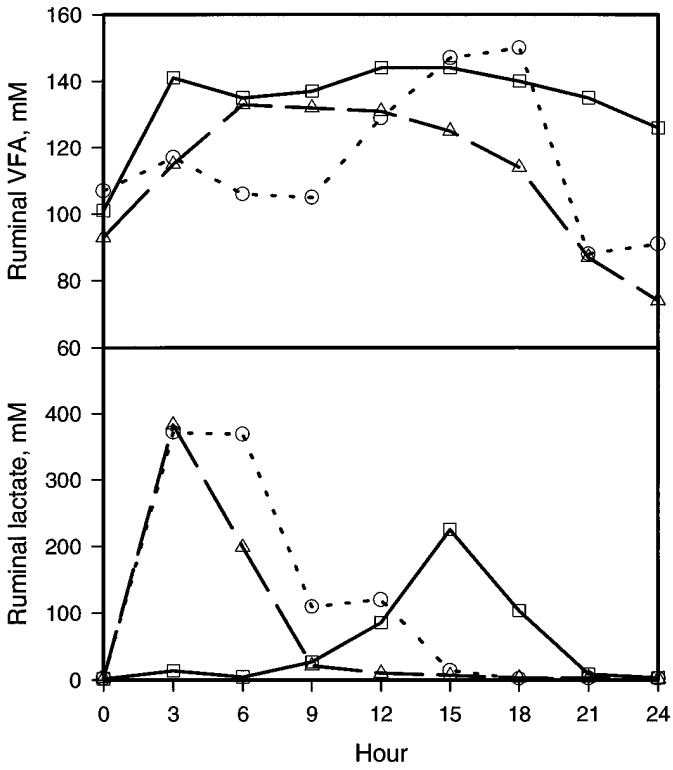


Figure 2. Effect of 100% dry-rolled corn (DRC; —□—), 50% DRC:50% wet corn gluten feed (WCGF; —△—), or 100% WCGF (-- o --) on ruminal concentrations of total lactate and total VFA. Lactate; time × treatment interaction ($P = .10$), SEM = .89. VFA; time effect ($P < .01$), treatment effect ($P < .05$), SEM = 13.

dosed with 100% DRC. Total accumulation of L(+)lactate and D(–)lactate over the 24-h period after dosing was numerically greater in steers dosed with 100% WCGF, but these differences were not significant ($P > .10$). These differences resulted in a numerically higher accumulation of total organic acids in steers dosed with 100% WCGF compared with steers dosed with 50% DRC:50% WCGF or 100% DRC.

## Discussion

*Experiment 1.* Intake patterns are important indicators of subacute acidosis (Fulton et al., 1979; Britton and Stock, 1987). Fulton et al. (1979) showed that daily fluctuations in feed intake and ruminal pH were greater in cattle fed wheat-based than in those fed DRC-based diets and intake during the day changed more drastically for the wheat-fed cattle. The authors stated that the alterations in intake seemed to be consistent with the ruminal fermentation differences observed between the two diets, which indicated that cattle being adjusted to wheat were experiencing more subacute acidosis. In Exp. 1, DIV was lower ($P < .05$) for cattle started d 1 on 35, 86.5, or 94.5% WCGF and maintained on that level of WCGF throughout the experiment. The lower DIV observed in steers consuming 35, 86.5, or 94.5% WCGF diets on d 24 may indicate that these cattle were experiencing less subacute acidosis. However, relieving subacute acidosis has usually been associated with an increase in intake (Fulton et al., 1979), not a decrease in intake, as seen in Exp. 1 for steers consuming 86.5 and 94.5% WCGF. This discrepancy may be explained in part by the moisture content of the feed. Ham et al. (1995) added water to a 70% dry corn gluten feed diet and showed a reduction in DMI and ADG, but no effect on feed efficiency compared with cattle fed DRC. Hanke et al. (1985) reported reduced intakes and similar feed efficiencies when water was added to a corn-corn silage finishing diet. Differences in rate of passage and its effect on intake have not been determined in these diets.

In Exp.1, DIV was greater in steers fed the DRC final diet for the first 6 d (d 19 through 24), than in cattle receiving the other treatments. In addition, steers fed DRC had a lower gain/feed than steers fed WCGF (Treatments 2 to 5) on d 28. This suggests that steers being adapted to high-grain diets using DRC were experiencing more subacute acidosis than steers receiving the other treatments. Over the entire 24-d grain adaptation period, cattle switched from 86.5% WCGF d 1 to 35% WCGF by d 19 had the greatest ($P < .05$) DIV (Table 3). However, the increased dietary energy content when 86.5% WCGF was fed d 1 in treatment 3 followed by a reduction in WCGF and increase in DRC resulted in 24.5% greater ADG and 34.2% greater gain/feed than control cattle on d 28. Therefore, the increased DIV observed in Treatment 3 was not associated with a decrease in ADG and gain/feed as was shown in the DRC fed steers. The increased DIV observed when steers were switched from 86.5% WCGF to 35% WCGF by d 19 and increasing DRC could be due to palatability effects, adaptation to the diet, or to an increase in subacute acidosis with increasing DRC.

In Exp. 1, feeding WCGF over the entire 132-d feeding period did not affect feed efficiency ($P > .10$); however, ADG and DMI were reduced ($P < .05$) when 86.5 and 94.5% WCGF were fed. Similarly, Ham et al. (1995) showed that replacing DRC with up to 86.5% WCGF (DM basis) did not affect feed efficiency. Maximum gain and DMI were achieved when WCGF replaced 40% of the DRC (35% of diet DM), indicating a positive associative affect occurred for gain and intake between feeding highly digestible fiber (WCGF) and highly fermentable starch (DRC). In Exp. 1, feeding 35% WCGF throughout the entire feeding period resulted in a 3.8% improvement in gain/feed compared with the DRC control. This is similar to the results of Ham et al. (1995), in which replacing 35% DRC (DM basis) with WCGF resulted in a 3.3% improvement in feed efficiency. Interestingly, in Exp. 1, feeding 86.5% WCGF d 1 reduced to 35% by d 19 while increasing DRC resulted in a 4.5% increase in both ADG and gain/feed compared with the DRC control. Although DIV may be increased with the addition of DRC, it seems that starting cattle on 86.5% WCGF reducing to 35% by d 19 while increasing DRC may be an alternative method for adapting cattle to high-concentrate diets.

On d 28 and 132, there was no significant effect of feeding escape protein on ADG and gain/feed. This is similar to other data in which no response to escape protein supplements in finishing diets were observed (Loerch and Berger, 1981; Plegge et al., 1983; Sindt et al., 1993). Sindt et al. (1993) suggested that large-framed calves (finished directly after weaning) fed DRC- or dry-rolled grain sorghum-based diets do not require escape protein after the first 80 d that the calves are on feed. In contrast, Trenkle (1992) reported an increased metabolizable protein requirement when large-framed yearling steers were implanted with Synovex-S and Finaplix-S and fed a cracked corn-based finishing diet. Daily gain, similar to that achieved in Exp. 1, was directly related to metabolizable protein intake. One difference between our data and the data of Trenkle (1992) is breed of cattle. Our data indicate that DRC or WCGF diets fed to yearling Hereford cattle, implanted with Revalor, do not require escape protein supplementation.

*Experiment 2.* It has been hypothesized that in high-grain diets, substituting grain with a highly

digestible fiber may reduce the potential for subacute acidosis (Farlin, 1981; Firkins et al., 1985; Larson et al., 1993) without dramatically reducing the energy density of the diet. Larson et al. (1993) fed 5.2, 12.6, and 40% wet distillers byproducts and improved feed efficiency by 5, 9, and 17% respectively, compared with cattle fed DRC. Cattle fed wet distillers byproducts consumed less starch and more corn fiber than cattle fed DRC, suggesting that increased feed efficiency may have been due in part to a reduction in subacute acidosis. From data in Exp. 2, it seems that ruminal metabolism of WCGF is different from that of DRC. Ruminal pH dropped sharply 3 h after dosing with 50% DRC:50% WCGF and 100% WCGF, which corresponded to an increase in ruminal organic acid concentration (Figure 1). The increase in organic acid concentration 3 h after dosing with 50% DRC:50% WCGF and 100% WCGF seems to be due to the rapid production of ruminal lactate when WCGF was dosed (Figure 2) or to high lactate concentrations in WCGF. Steep liquor, a component of WCGF, may contain significant amounts of lactic acid and probably explains the higher ruminal lactate levels during the initial 6 h. Because ruminal concentrations of total organic acids and lactate returned to near initial values by 9 and 15 h when 50% DRC:50% WCGF and 100% WCGF were intraruminally dosed, respectively, the insult of acidosis produced by these substrates seems to be short-term relative to DRC. For cattle dosed with 100% DRC, pH declined more gradually and stayed lower for a longer period of time (Figure 1). In addition, total decrease in ruminal pH and total accumulation of ruminal VFA within the 24-h period after dosing were greater for cattle challenged with 100% DRC vs 50% DRC:50% WCGF and 100% WCGF. However, because of the similarity in accumulation of total organic acids over the 24-h period after dosing 100% DRC, 50% DRC:50% WCGF, and 100% WCGF, these data suggest that feeding WCGF does not eliminate the incidence of ruminal acidosis. However, the amount of time cattle are exposed to an acidosis insult may be less for cattle overconsuming WCGF than for cattle overconsuming DRC.

## Implications

Although feeding cattle wet corn gluten feed does not eliminate acidosis, starting cattle on high levels of wet corn gluten feed and then decreasing it while increasing dry-rolled corn may be an alternative method for adapting cattle to high-concentrate diets. This dietary adaptation method can minimize the use of roughage in the diet while feeding a high-concentrate diet without increasing the severity of ruminal acidosis. Escape protein supplementation to dry-rolled corn or wet corn gluten feed diets fed to yearling Hereford cattle implanted with Revalor seems to have minimal effects on cattle gain and efficiency.

## Literature Cited


Brandt, R. B., S. A. Siegel, M. G. Waters, and M. H. Bloch. 1980. Spectrophotometric assay for D(–)-lactate in plasma. Anal. Biochem.88:475.

Britton, R. A., and R. A. Stock. 1987. Acidosis, rate of starch digestion and intake. In: F. N. Owens (ed.). Symp. Proc.: Feed Intake by Beef Cattle. Publ. MP 121. p 125. Oklahoma State Univ., Stillwater.

Cochran, W. G., and G. M. Cox. 1957. Completely randomized, randomized block, and Latin square designs. In: R. A. Bradley, J. S. Hunter, D. G. Kendall, and G. S. Watson (Ed.) Experimental Designs. Wiley & Sons, New York.

DeHaan, K. A. 1983. Improving the utilization of fiber and energy through the use of corn gluten feed and alkali compounds. Ph.D. Dissertation. Univ. of Nebraska, Lincoln.

Eagle, P., and J. B. Jones. 1978. Causes and elimination of erratic blanks in enzymatic metabolite assays involving the use of NADA+ in alkaline hydrazine buffer and improved conditions for the assay of L-glutamine, L-lactate and other metabolites. Anal. Biochem. 88:475.

Elanco Products Company. 1974. Tylan premix for beef cattle. Technical B Manual. pp 4–5. Indianapolis, IN.

Erwin, E. S., G. J. Marco, and E. M. Emery. 1961. Volatile fatty acid analyses of blood and rumen fluid by gas chromatography. J. Dairy Sci. 44:1768.

Farlin, S. D. 1981. Wet distillers grain for finishing cattle. Anim. Nutr. Health. 36:35.

Firkins, J. L., L. L. Berger, and G. C. Fahey, Jr. 1985. Evaluation of wet and dry distillers grains and wet and dry gluten feeds for ruminants. J. Anim. Sci. 60:847.

Firkins, J. L., L. L. Berger, G. C. Fahey, Jr, and N. R. Merchen. 1984. Ruminal nitrogen degradability and escape of wet and dry distillers grains and wet and dry corn gluten feeds. J. Dairy Sci. 67:1936.

Fulton, W. R., T. J. Klopfenstein, and R. A. Britton. 1979. Adaptation to high concentrate diets by beef cattle. I. Adaptation to corn and wheat diets. J. Anim. Sci. 49:775.

Green, D. A., R. A. Stock, F. K. Goedeken, and T. J. Klopfenstein. 1987. Energy value of corn wet-milling by-product feeds for finishing ruminants. J. Anim. Sci. 65:1655.

Gutmann, I., and W. Q. Wahlefeld. 1974. L(+)-lactate determination with lactate dehydrogenase and NAD. In: H. V. Bergmeyer (Ed.) Methods of Enzymatic Analysis. Vol 3. Academic Press, New York.

Ham, G. A., R. A. Stock, T. J. Klopfenstein, and R. P. Huffman. 1995. Determining the net energy value of wet and dry corn gluten feed in beef growing and finishing diets. J. Anim. Sci. 73: 353.

Ham, G. A., R. A. Stock, T. J. Klopfenstein, E. M. Larson, D. H. Shain, and R. P. Huffman. 1994. Wet corn distillers byproducts compared with dried corn distillers grains with solubles as a source of protein and energy for ruminants. J. Anim. Sci. 72: 3246.

Hanke, H. E., R. J. Vathauer, S. D. Plegge, T. M. Peters, A. DiCostanzo, and J. C. Meiske. 1985. Addition of water to corn silage–corn grain finishing diets. Minnesota Cattle Feeders' Rep. B-348:24.

Larson, E. M., R. A. Stock, T. J. Klopfenstein, M. H. Sindt, and R. P. Huffman. 1993. Feeding value of wet distillers byproducts for finishing ruminants. J. Anim. Sci. 71:2228.

Loerch, S. C., and L. L. Berger. 1981. Feedlot performance of steers and lambs fed blood meal, meat and bone meal, dehydrated alfalfa and soybean meal as supplemental protein sources. J. Anim. Sci. 53:1198.

Owens, F. N., and A. L. Goetsch. 1988. Ruminal fermentation. In D. C. Church (Ed.) The Ruminant Animal: Digestive Physiology and Nutrition. p 145. Prentice-Hall, Englewood Cliffs, NJ.

Plegge, S. D., L. L. Berger, and G. C. Fahey, Jr. 1983. Performance of growing and finishing steers fed roasted soybean meal. J. Anim. Sci. 57:1374.

SAS. 1989. SAS User's Guide: Statistics (5th Ed.). SAS Inst. Inc., Cary, NC.

Sindt, M. H., R. A. Stock, T. J. Klopfenstein, and D. H. Shain. 1993. Effect of protein source and grain type on finishing calf performance and ruminal metabolism. J. Anim. Sci. 71:1047.

Stock, R. A., M. H. Sindt, J. C. Parrott, and F. K. Goedeken. 1990. Effects of grain type, roughage level, and monensin level on finishing cattle performance. J. Anim. Sci. 68:3441.

Trenkle, A. 1992. Protein requirements of steers implanted with Synovex S and Finaplix S. Iowa State Beef-Sheep Res. Rep. AS-620:102.