Effect of Crude Glycerin Concentration on Forage Digestion Parameters in Beef Calves

Robert G. Bondurant, Jana L. Harding, Melissa L. Jolly-Breithaupt, Jim C. MacDonald,
Andrea R. McCain, and Samodha C. Fernando

Summary

Seven ruminally and duodenally cannulated steers were used to evaluate effects of increasing concentrations of crude glycerin on digestion in high forage diets. As glycerin inclusion increased, DM, OM, and NDF intake decreased. Neither DM nor OM digestibility were affected by glycerin inclusion. While dietary NDF digestibility decreased as glycerin increased, glycerin inclusion had no effect on rate or extent of in situ NDF digestibility estimates. As glycerin inclusion increased, propionate and butyrate VFA proportions increased while acetate decreased. Decreases in acetate to propionate ratio with increasing concentrations of crude glycerin may improve F:G in forage-based diets.

Introduction

Due to expansion of the alternative fuels industry, new feedstuffs, such as crude glycerin (GLY) have become available to producers. The production of biodiesel yields GLY as a byproduct resulting from the formation of methyl esters of fatty acids from triglycerides. Data on GLY in forage-based beef cattle diets are limited. Thus, the purpose of this experiment was to evaluate increasing inclusion of GLY in a forage-based diet to evaluate its effect on total tract digestibility, rate and extent of fiber digestibility, and rumen fermentation parameters.

Procedure

This experiment utilized 7 ruminally and duodenally cannulated steers (initial BW = 800 lb) in a row by column transformation with four periods, four dietary treatments, and seven steers. Each period consisted of 9 days for adaptation and 5 days for collection. Dietary treatments (Table 1) included 0, 4, 8, and 12% diet DM inclusion of GLY. Basal diets consisted of 50% wheat straw (WS), soybean hulls (SH), 4% supplement, and soybean meal, to maintain a consistent CP concentration. Dietary GLY replaced SH in treatment diets. Diets were mixed twice weekly and stored in a cooler (32° F) throughout the experiment.

Steers were ruminally dosed with 5 g of TiO_2 twice daily at 0800 and 1600 hours from d 3 to 13. During the 5 d collection period, fecal, rumen, and duodenal samples were collected 1 h prior to feeding and at 2, 5, and 8 h post feeding. Starting on d 10 of each period, in situ bags containing ground WS or SH were incubated in the rumen for 0, 6, 12, 16, 24, 48, and 96 h to determine NDF digestion rates. Rate of NDF digestion was calculated from the log of potentially digestible fiber remaining at each time point after correcting for indigestible fiber estimated at 96 h of incubation. The rates for each time point were averaged to estimate an overall rate of the feed.

Hourly duodenal samples were freeze-dried, ground and composited by steer into a daily composite. Within each day, fecal samples were composited by steer into a daily composite, then freeze-dried. Daily composites were ground, and a steer within period fecal composite sample was made and analyzed for NDF, OM, and percent Ti. Dietary ingredients and feed refusals were analyzed for DM, OM, and NDF. Percent DM was determined using a forced air oven set at 60° C for 48 hours.

Digestibility and *in situ* extent of NDF digestion data were analyzed using the GLIMMIX procedure of SAS (SAS Institute, Inc., Cary, N.C.). *In situ* data for rate of NDF digestibility were analyzed using the MIXED procedure of SAS. Orthogonal contrasts were used to test linear and quadratic effects of GLY inclusion. Ruminal VFA data were analyzed using the MIXED procedure of SAS with time within day as the repeated measure and AR (1) as the covariance structure.

Results

Both DMI and OM intake decreased quadratically ($P = 0.04$) as GLY increased in the diet, with lowest intakes occurring at 4% GLY inclusion (Table 2). As GLY inclusion increased from 0 to 12% diet DM, NDF intake linearly decreased ($P <$

Table 1. Composition of treatment diets (% of diet DM) fed to ruminally and duodenally fistulated steers

	Dietary Treatments			
	0	4	8	12
Ingredient, %				
Wheat Straw	50.0	50.0	50.0	50.0
Soybean Hulls	38.3	33.5	28.8	24.0
Soybean Meal	7.8	8.5	9.2	10.0
Crude Glycerin	0.0	4.0	8.0	12.0
Supplement[a]	4.0	4.0	4.0	4.0
Analyzed composition, % DM				
CP	18.7	18.7	18.3	17.7
OM	90.6	90.7	90.9	91.0
NDF	70.5	68.4	65.4	62.6

[a]Supplements formulated to provide minimum of 12.5% CP, 0.70% Ca, 0.40% P, and 0.40% Na for each treatment diet.

Table 2. Effect of increasing dietary crude glycerin concentration on intake, digestibility, and rate of fiber digestion.

	Glycerin Inclusion, % Diet DM					*P*-value	
	0	4	8	12	SE	Linear	Quadratic
Intake, lb/d							
DM	19.0[a]	17.7[b]	18.3[ab]	18.8[ab]	1.1	0.79	0.04
OM	17.1[a]	16.1[b]	16.6[ab]	17.1[a]	1.0	0.96	0.04
NDF	13.5[a]	12.2[b]	12.0[b]	11.8[b]	0.8	< 0.01	0.06
Duodenal flow, lb/d							
NDF	6.25	5.76	6.00	5.35	0.52	0.10	0.82
Ruminal digestibility, %							
NDF	53.63	51.17	50.17	53.72	3.22	0.98	0.33
Fecal output, lb/d							
OM	6.59	5.87	6.38	6.72	0.52	0.83	0.24
NDF	5.06	4.55	4.88	5.38	0.45	0.58	0.20
Total apparent digestion, %							
OM	61.62	62.90	60.98	60.35	2.72	0.75	0.73
NDF	62.61	61.90	58.16	53.82	3.24	0.08	0.58
Wheat Straw Rate[c]	4.67	4.61	4.48	4.53	0.20	0.64	0.78
Extent at 24 hour, %	31.79	35.80	34.39	34.65	2.03	0.25	0.26
Extent at 48 hour, %	49.45	47.67	49.06	47.69	1.00	0.14	0.80
Extent at 96 hour, %	55.45	55.74	57.56	55.79	1.36	0.82	0.34
Soy Hulls Rate[c]	4.33	4.78	4.59	4.59	0.19	0.34	0.27
Extent at 24 hour, %	72.57	81.97	74.99	76.11	3.00	0.38	0.16
Extent at 48 hour, %	96.09	96.01	96.54	95.32	0.63	0.31	0.30
Extent at 96 hour, %	97.25	97.24	97.92	97.73	0.18	0.07	0.59

[ab]Means within rows having different superscripts differ at $P \leq 0.05$.
[c]Percent NDF digestion per h

0.01) (13.5 to 11.8 lb, respectively) because GLY displaced SH in the diet and intake decreased. Increasing glycerin inclusion tended to linearly decrease ($P = 0.10$) NDF duodenal flow and had no effect on ruminal NDF digestibility ($P \geq 0.33$). Glycerin inclusion had no effect on OM or NDF fecal output ($P \geq 0.20$). As GLY inclusion increased from 0 to 12%, total tract OM digestibility was not different ($P \geq 0.73$) while total tract NDF digestibility tended to decrease linearly ($P = 0.08$) from 62.6 % to 53.8%, respectively. However, the inclusion of GLY had no effect on in situ rate of NDF digestibility ($P \geq 0.27$) for WS or SH. Because the GLY is replacing SH which has a higher NDF digestibility than WS, the proportion of digestible dietary NDF decreases. Thus, the decrease in total tract NDF digestibility may not be a result of changes in fermentation but rather a function of the decrease in a more digestible source of NDF as GLY displaced SH.

Molar acetate proportion (Figure 1) decreased ($P < 0.01$) while molar propionate proportions (Figure 2) increased ($P < 0.01$) as dietary GLY concentration increased and as time post-feeding progressed from-1 to 8 h. Butyrate concentration increased ($P < 0.01$) at 2, 5, and 8 h post feeding for 8 and 12% GLY, while proportions were unchanged for 0 and 4% GLY (Figure 3). Subsequently, acetate to propionate ratio decreased ($P < 0.01$) as GLY inclusion increased from 0 to 12% and time from feeding increased from-1 to 8 h (Figure 4).

The inclusion of GLY in forage-based diets appears to have an effect on fiber digestion due to a decrease in total tract NDF digestibility. However, when evaluating the decrease in dietary NDF digestibility as GLY replaces SH, coupled with no decrease in *in situ* NDF digestibility, the inclusion of GLY in forage-based diets does not appear to impact NDF digestibility. Incorporating GLY in forage-based diets decreases acetate to propionate ratio, which may improve F:G.

Robert G. Bondurant, research technician

Jana L. Harding, research technician

Melissa L. Jolly-Breithaupt, research technician

Jim C. MacDonald, associate professor

Andrea R. McCain, research technician

Samodha C. Fernando, assistant professor, University of Nebraska–Lincoln (UNL) Department of Animal Science, Lincoln, Neb.

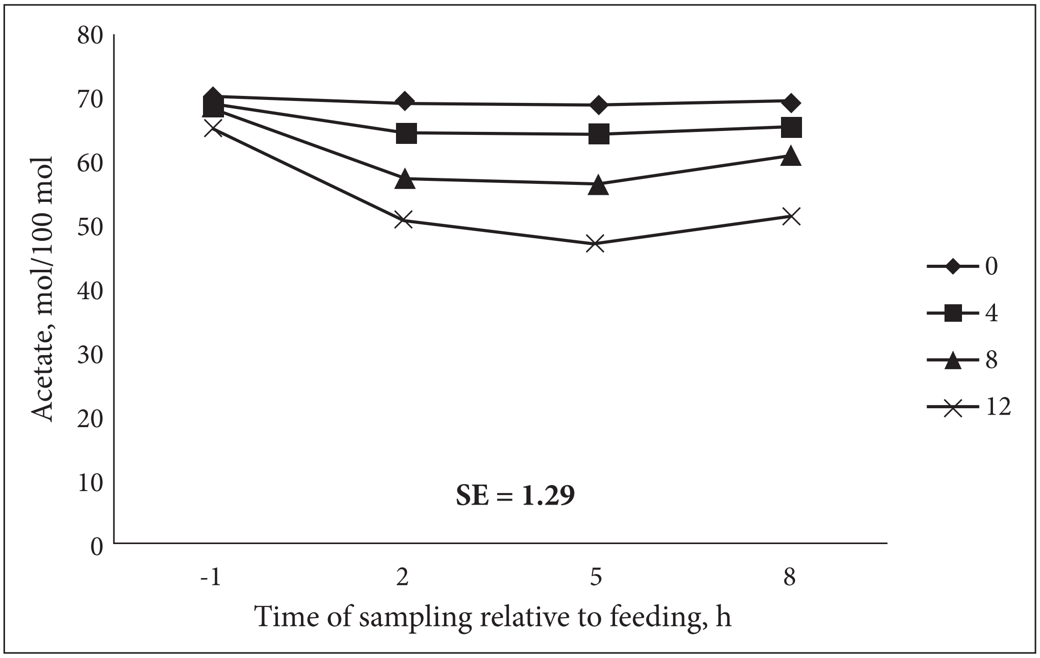

Figure 1. Ruminal acetate VFA proportions from samples collected at-1, 2, 4, and 8 h post feeding. Treatment diets consisted of 0, 4, 8, or 12% dietary crude glycerin (GLY). There was a treatment x time interaction ($P < 0.01$) for acetate VFA proportions as GLY inclusion increased. At 1 h pre-feeding, 0 and 4% GLY were similar ($P = 0.28$), while 0 and 8% GLY tended to be different ($P = 0.09$), and all were significantly different from 12% GLY ($P \leq 0.01$). Acetate VFA proportions were significantly different for all GLY concentrations at 2, 5, and 8 h post feeding ($P \leq 0.01$).

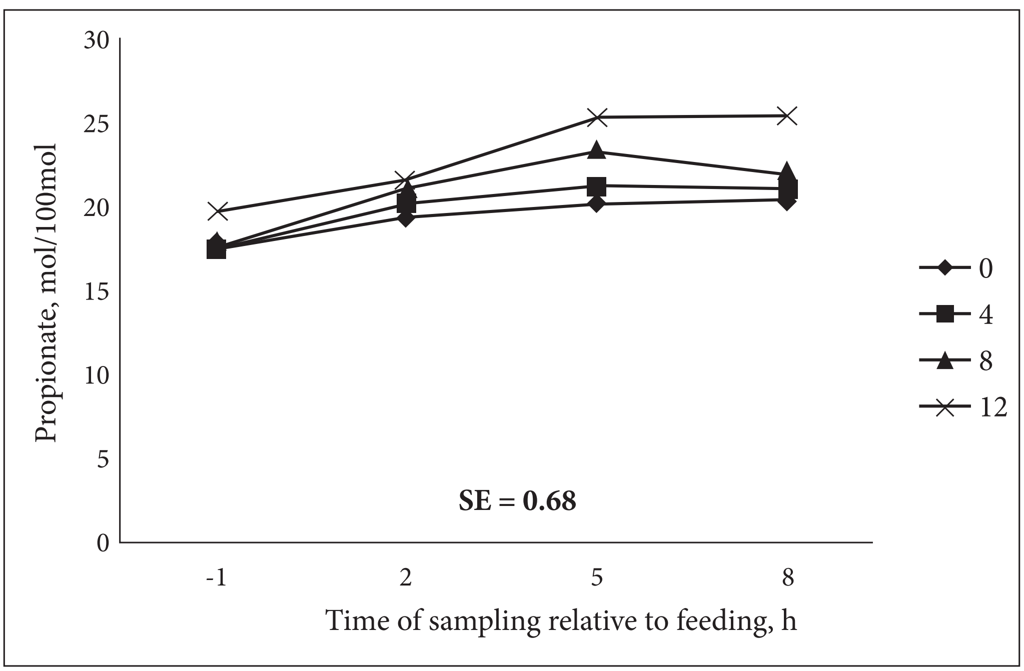

Figure 2. Ruminal propionate VFA proportions from samples collected at-1, 2, 4, and 8 h post feeding. Treatment diets consisted of 0, 4, 8, or 12% dietary crude glycerin (GLY). There was a treatment x time interaction ($P < 0.01$) for propionate VFA proportions as GLY inclusion increased. At 1 h pre-feeding, propionate VFA proportions for 0, 4 and 8% GLY were similar ($P \geq 0.52$) while all were significantly different from 12% GLY ($P \leq 0.01$). At 2 h post feeding, 0% GLY was similar to 4% GLY ($P = 0.22$) but different from 8 and 12% GLY ($P \leq 0.01$), while 4% GLY was similar to 8% GLY ($P = 0.19$) but different from 12% GLY ($P = 0.03$) and 8 and 12% GLY were similar ($P = 0.42$). At 5 h post feeding, 0% GLY was similar to 4% GLY ($P = 0.14$) but different from 8 and 12% GLY ($P \leq 0.01$), while 4, 8 and 12% GLY were significantly different ($P \leq 0.01$) from one another. At 8 h post feeding, 0% GLY was similar to 4% GLY ($P = 0.24$), but different from 8 and 12% GLY ($P \leq 0.02$), while 4% GLY was similar to 8% GLY ($P = 0.22$) but 4 and 8% GLY were different from 12% GLY ($P < 0.01$).

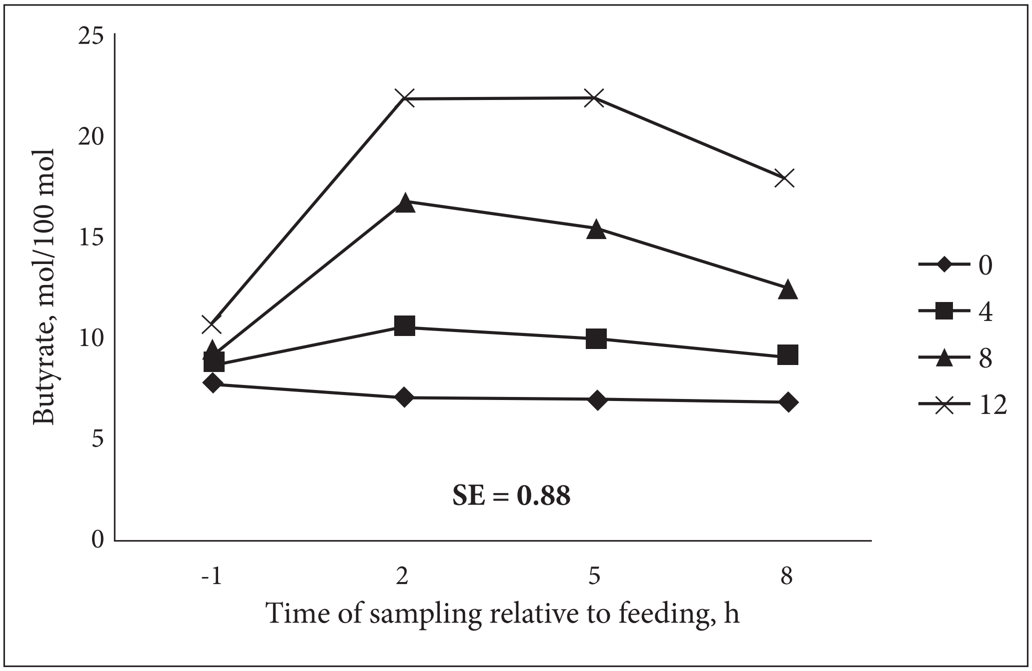

Figure 3. Ruminal butyrate VFA proportions from samples collected at-1, 2, 4, and 8 h post feeding. Treatment diets consisted of 0, 4, 8, or 12% dietary crude glycerin (GLY). There was a treatment x time interaction ($P < 0.01$) for butyrate VFA proportions as GLY inclusion increased. At 1 h pre-feeding, ruminal butyrate VFA proportions were similar between 0 and 4% GLY ($P = 0.19$), 4 and 8% GLY ($P = 0.58$), while 8% GLY tended to be different from 0% GLY ($P = 0.06$) and 12% GLY ($P = 0.10$). Butyrate VFA proportions quadratically increased ($P \leq 0.01$) as GLY concentration increased and time post feeding increased to 2, 5, and 8 h.

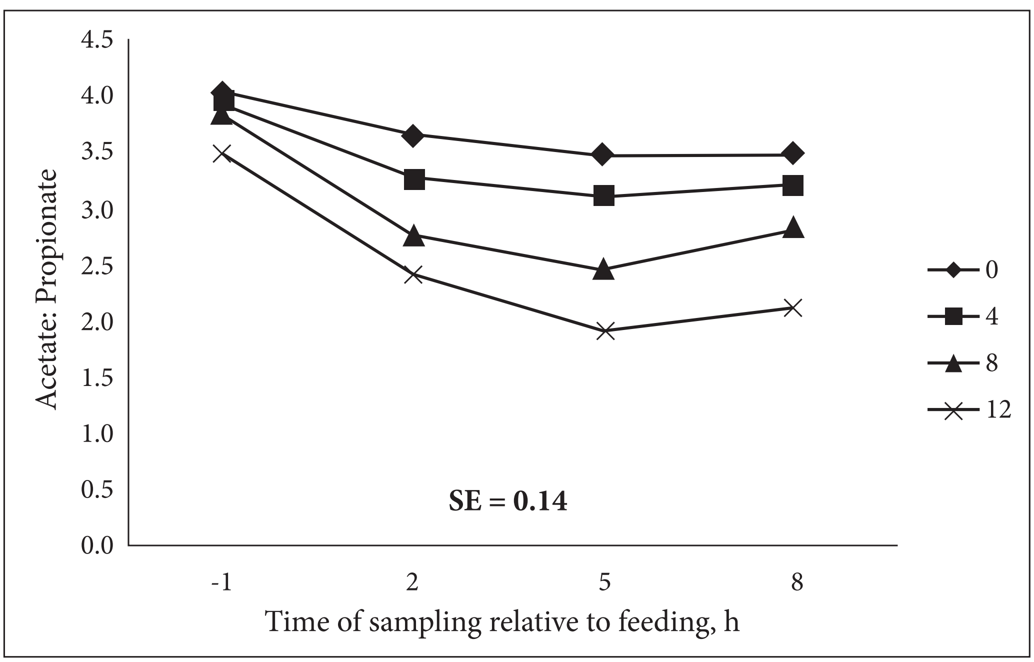

Figure 4. Ruminal acetate to propionate ratio from samples collected at-1, 2, 4, and 8 h post feeding. Treatment diets consisted of 0, 4, 8, or 12% dietary crude glycerin (GLY). There was a treatment x time interaction ($P < 0.01$) for acetate to propionate ratio as GLY inclusion increased. At 1 h pre-feeding, acetate to propionate ratio for 0, 4 and 8% GLY was similar ($P \geq 0.14$) while all were significantly different from 12% GLY ($P \leq 0.01$). Acetate to propionate ratio quadratically decreased ($P < 0.01$) as GLY concentration increased and time post feeding increased to 2, 5, and 8 h.