K-STATE Research and Extension

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KANSAS STATE UNIVERSITY CATTLEMEN'S DAY

# Digestibility of Dry Matter is Better and Manure Output is Lower in Growing Cattle Limit-Fed a High-Energy Diet During the Growing Phase Compared to a Traditional Roughage-Based Diet Fed for *Ad Libitum* Intake

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## Abstract

Eight ruminally cannulated crossbred Angus heifers [body weight (BW) = 450 ± 24 lb] were used in a cross-over design with two consecutive 15-day periods at the Kansas State University Beef Stocker Unit. Experimental unit was animal within period. Two dietary treatments were fed: (1) 45 Mcal of net energy for gain ($NE_g$) per 100 lb of dry matter (DM) fed for *ad libitum* DM intake (45AL), or (2) 60 Mcal $NE_g$ per 100 lb of DM limit-fed at 85% of 45AL diet intake on a DM basis (60LF85%). Both diets contained 40% of DM as Sweet Bran (Cargill Animal Nutrition, Blair, NE). Apparent total-tract diet digestibilities of DM and organic matter were 5.2% and 6.4% greater ($P < 0.01$) than roughage-based diets fed *ad libitum*, respectively, but fiber digestibility was not affected by diet ($P \geq 0.59$). Heifers fed 60LF85% had 35% lower ($P < 0.01$) apparent fecal output than heifers fed 45AL. There was a diet × hour interaction, such that ruminal pH was greater ($P < 0.01$) from 10:00 p.m. to 10:00 a.m. for heifers fed 60LF85% compared to heifers fed 45AL. There was a diet × hour interaction for ammonia concentration ($P < 0.01$), with heifers fed 45AL having a greater concentration of ammonia 2 hours after feeding and again from 8 to 18 hours after feeding compared to 60LF85% heifers. Acetate:propionate ratio was lower ($P < 0.01$) in heifers fed 60LF85% than heifers fed 45AL. Better diet digestibility and reduced production of manure was observed in heifers limit-fed a high-energy diet than heifers fed a traditional roughage-based diet.

## Introduction

Recent research conducted at the K-State Beef Stocker Unit suggests limit feeding a high-energy diet based on corn and Sweet Bran to growing cattle improves diet digestibility of dry matter without affecting fiber digestibility compared to a roughage-based diet. The objective of this experiment was to evaluate the impact on intake and diges-

[1] Corn Belt Livestock Services, Papillion, NE.

tion of a high-energy diet limit-fed at 85% of the *ad libitum* daily consumption of a roughage-based diet on a dry matter basis compared to a traditional roughage-based growing diet in growing cattle.

## Experimental Procedures

Eight ruminally cannulated crossbred Angus heifers [body weight (BW) = 450 ± 24 lb] were used in a cross-over design with two consecutive 15-day periods. Experimental unit was animal within period.

Eight, soil-surfaced 20 × 40 ft pens were constructed in a large outdoor holding facility. Each pen had access to a manually filled water tank, and cattle were fed once daily at 10:00 a.m. Each 15-day period included 10 days for diet adaption, 4 days for fecal sampling, and 1 day for ruminal sampling. All cattle were offered the 45AL treatment diet for 7 days prior to starting the study to acclimate and determine *ad libitum* DM intakes. Feed refusal for 45AL was targeted at 4 lb/day during diet adaption and sampling. Cattle receiving the 60LF85% diet were restricted to 85% of their own reference 45AL DM intake determined prior to study initiation.

Indwelling rumen pH boli (smaXtec, Graz, Austria) inserted through the ruminal cannula continuously monitored pH throughout the study in 10-minute intervals. On days 4 to 14, chromic oxide ($Cr_2O_3$) marker was top dressed and hand mixed into each total mixed ration to calculate apparent total-tract diet digestibility of DM, organic matter, fiber, and starch. Feed samples were collected on days 10–14. Feed refusals were collected on days 11–14 for each animal. Fecal samples were collected from the rectum of each animal on days 11–14 at 8-hour intervals after feeding. Fecal sampling time advanced by 2 hours each day, so each 2-hour interval after feeding was represented. Immediately following collection, all samples were frozen at -4°F. Following study completion all samples were thawed, mixed, subsampled, and refrozen by animal within period.

On day 15 of each period, four locations in the rumen were sampled prior to feeding, and at 2, 4, 6, 8, 12, 18, and 24 hours after feeding to determine ruminal volatile fatty acid profile and ammonia concentration. A small amount of ruminal fluid was strained through eight layers of cheesecloth. One cc of strained ruminal fluid was transferred into four, 2-cc microcentrifuge tubes each containing 250 μL of 25% (wt/vol) *m*-phosphoric acid, then frozen at -4°F. Following collection of samples prior to feeding, cobalt edetate (Co-EDTA) dissolved into 200 cc of distilled water was dosed through the ruminal cannula. At 2, 4, 6, 8, 12, 18, and 24 hours after feeding, 15 cc of ruminal fluid was transferred into scintillation vials to measure cobalt concentration and estimate liquid passage rate and ruminal liquid volume. Following collection all ruminal fluid samples were frozen at -4°F pending analysis.

## Results and Discussion

Composition of study diets are presented in Table 1, and results for intake and digestibility are presented in Table 2. By design, intake of DM, organic matter, and fiber was lower ($P < 0.01$) for 60LF85% heifers compared to 45AL heifers. Conversely, also by design, intake of starch was greater ($P < 0.01$) for 60LF85% heifers than 45AL heifers. By restricting intake of a high-energy diet, apparent total-tract diet digestibilities of DM and organic matter were 5.2% and 6.4% greater ($P < 0.01$) than roughage-based diets

fed *ad libitum*, respectively, but fiber digestibility was not affected ($P \geq 0.59$) by diet. Starch digestibility was also unaffected ($P > 0.32$) by diet. The 60LF85% heifers had a slower liquid dilution rate ($P < 0.01$) than 45AL heifers, but ruminal liquid volume was greater ($P < 0.01$) in 60LF85% heifers than 45AL heifers.

Ruminal pH data are presented in Figure 1 and concentration of ammonia over time is presented in Figure 2. Although ruminal pH in 60LF85% heifers rapidly declined after feeding, results showed no effect of diet on ruminal pH over the course of the experiment ($P < 0.93$; Figure 1), but there was an interaction of diet across time detected for ruminal pH. Ruminal pH was greater ($P < 0.01$) from 10:00 p.m. to 10:00 a.m. just before feeding for heifers fed 60LF85%. Ammonia concentration was greater in 45AL heifers than 60LF85% heifers ($P = 0.03$; Figure 2). There was a diet × hour interaction for ammonia concentration ($P < 0.01$; Figure 2), with 45AL cattle having a greater concentration of ammonia 2 hours after feeding and again from 8 to 18 hours after feeding compared to 60LF85% cattle. The heifers fed 45AL had greater concentrations of total ruminal volatile fatty acids than did cattle eating 60LF85%, and thus was largely a result of greater concentrations of acetate ($P < 0.01$). Butyrate was also greater ($P < 0.01$) for heifers fed 45AL than heifers fed 60LF85%. Propionate, isovalerate, and valerate were not affected ($P > 0.10$) by diet. There was a diet × hour interaction for straight-chain volatile fatty acids including propionate, butyrate, and valerate ($P < 0.01$), which resembles meal-eating behavior. Volatile fatty acids concentration peaked twice for heifers fed 45AL at 2 hours and 12 hours after feeding, while heifers fed 60LF85% peaked only once 4 to 6 hours after feeding. There was a diet × hour interaction ($P < 0.01$) for branched chain volatile fatty acids, including isobutyrate and isovalerate, with a greater decrease in concentration 2 hours after feeding in 60LF85% heifers than 45AL heifers. Acetate:propionate ratio was lower ($P < 0.01$) in heifers fed 60LF85% than heifers fed 45AL. Molar proportions of acetate were greater ($P < 0.01$) for 45AL heifers, whereas proportions of propionate, isobutyrate, isovalerate, and valerate were greater ($P < 0.01$) for 60LF85% heifers. These results suggest that apparent diet digestibility was better and apparent fecal output was reduced by 35% when heifers were limit-fed a high energy diet compared to a roughage-based diet fed *ad libitum*.

## Implications

Apparent diet digestibility was 5.2% better and fecal output was 35% lower in growing cattle limit-fed a high-energy diet based on corn and Sweet Bran compared to cattle full-fed a traditional roughage-based diet, which could help reduce manure removal costs and improve producer sustainability.

## Acknowledgments

National Cattlemen's Beef Association
Kansas Corn Commission

**Table 1. Composition and nutrient analysis of study diets**

| | Diet[1] | |
|---|---|---|
| **Ingredient, % of dry matter** | **45AL** | **60LF85%** |
| Corn[2] | 8.6 | 38.8 |
| Wet corn gluten feed[3] | 40.0 | 40.0 |
| Long-stem alfalfa | 22.5 | 6.5 |
| Chopped prairie hay | 22.5 | 6.5 |
| Supplement[4] | 6.4 | 8.2 |
| Nutrient, % of dry matter | | |
| Dry matter, % of as fed | 73.1 | 72.7 |
| Organic matter | 91.3 | 94.5 |
| Crude protein | 17.0 | 15.5 |
| Starch | 11.9 | 33.0 |
| Neutral detergent fiber | 36.4 | 24.6 |
| Acid detergent fiber | 18.3 | 9.9 |
| Calcium | 0.8 | 0.6 |
| Phosphorus | 0.6 | 0.7 |

[1] 45AL = 45 megacalories of net energy for gain per 100 lb of dry matter offered for *ad libitum* dry matter intake. 60LF85% = 60 megacalories of net energy for gain per 100 lb of dry matter limit-fed at 85% of 45AL diet intake on a dry matter basis.
[2] Dry-rolled yellow #2 corn.
[3] Sweet Bran, Cargill Animal Nutrition, Blair, NE.
[4] Supplement pellet (Cargill Animal Nutrition, Minneapolis, MN) was formulated to contain (dry matter basis) 9.2% crude protein, 1.53% crude fat, 17.0% crude fiber, 7.4% calcium, 0.22% phosphorus, 4.62% salt, 0.50% potassium, 331 mg/kg monensin, and 60.1 mg/kg diflubenzuron.

**Table 2. Effect of a limit-fed high-energy or traditional roughage-based diet in the growing phase on diet digestibility and ruminal characteristics**

| | Diet[1] | | | |
|---|---|---|---|---|
| **Item** | **45AL** | **60LF85%** | **SEM[2]** | ***P*-value** |
| Number of observations | 8 | 8 | | |
| Intake, lb/day | | | | |
| Dry matter | 17.77 | 13.73 | 0.82 | < 0.01 |
| Organic matter | 16.23 | 12.96 | 0.77 | < 0.01 |
| Neutral detergent fiber | 6.44 | 3.40 | 0.24 | < 0.01 |
| Acid detergent fiber | 3.24 | 1.37 | 0.11 | < 0.01 |
| Starch | 2.09 | 4.52 | 0.18 | < 0.01 |
| Ruminal[3] | | | | |
| Ammonia, m*M* | 5.22 | 3.89 | 0.49 | 0.03 |
| Acetate:propionate ratio | 2.80 | 1.98 | 0.15 | < 0.01 |
| Total volatile fatty acid, m*M* | 109.37 | 82.81 | 5.02 | < 0.01 |
| Acetate, m*M* | 66.90 | 44.18 | 2.48 | < 0.01 |
| Propionate, m*M* | 23.77 | 24.63 | 2.20 | 0.63 |
| Butyrate, m*M* | 13.78 | 9.05 | 0.53 | < 0.01 |
| Valerate, m*M* | 2.24 | 2.62 | 0.38 | 0.42 |
| Isobutyrate, m*M* | 0.89 | 0.67 | 0.04 | < 0.01 |
| Isovalerate, m*M* | 1.66 | 1.65 | 0.24 | 0.98 |
| Ruminal volatile fatty acid, molar % of total[3] | | | | |
| Acetate | 61.3 | 54.0 | 0.73 | < 0.01 |
| Propionate | 21.8 | 29.0 | 1.15 | < 0.01 |
| Butyrate | 12.49 | 11.11 | 0.54 | 0.02 |
| Valerate | 1.99 | 2.95 | 0.31 | 0.02 |
| Isobutyrate | 0.79 | 0.87 | 0.06 | 0.02 |
| Isovalerate | 1.51 | 2.12 | 0.32 | 0.06 |
| Liquid passage rate,[4] %/hour | 11.3 | 5.7 | 1.04 | < 0.01 |
| Ruminal liquid volume, gal | 8.6 | 12.7 | 1.02 | < 0.01 |
| Apparent total tract digestibility, % | | | | |
| Dry matter | 74.8 | 78.7 | 0.77 | 0.01 |
| Organic matter | 77.1 | 82.0 | 0.62 | < 0.01 |
| Neutral detergent fiber | 73.4 | 73.5 | 1.45 | 0.94 |
| Acid detergent fiber | 67.6 | 66.4 | 1.54 | 0.59 |
| Starch | 94.4 | 96.2 | 1.16 | 0.32 |
| Fecal dry matter output, lb/day | 4.52 | 2.92 | 0.24 | < 0.01 |

[1]45AL = 45 megacalories of net energy for gain per 100 lb of dry matter fed for *ad libitum* intake daily. 60LF85% = 60 megacalories of net energy for gain per 100 lb of dry matter limit-fed at 85% of 45AL diet intake.
[2]Largest standard error of the mean is reported.
[3]Average of values collected at 0, 2, 4, 6, 8, 12, 18, and 24 hours after feeding.
[4]Calculated from samples collected at 0, 2, 4, 6, 8, 12, and 18 hours after dosing of cobalt edetate (Co-EDTA) at time of feeding.

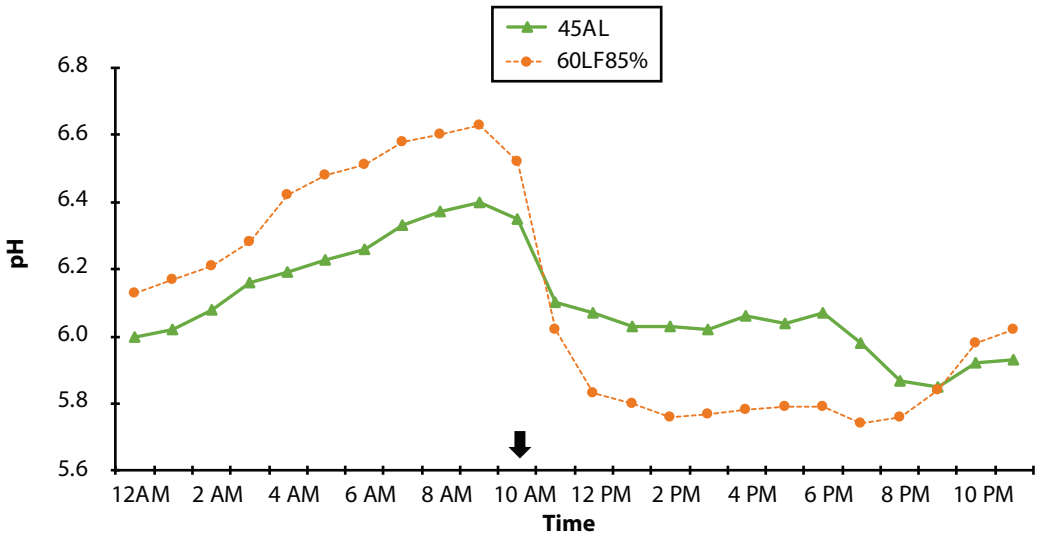


**Figure 1. Effect of a limit-fed high-energy or traditional roughage-based diet in the growing phase on hourly pH . 45AL (▲) = 45 megacalories of net energy for gain per 100 lb of dry matter offered for *ad libitum* intake, n = 7; 60LF85% (●) = 60 megacalories of net energy for gain per 100 lb of dry matter limit-fed at 85% of 45AL intake, n = 8. The arrow represents time of feeding (10:00 a.m.). Diet effect: $P = 0.93$. Hour effect: $P < 0.0001$. Diet × hour effect: $P < 0.0001$. Standard error of the mean = 0.11.**

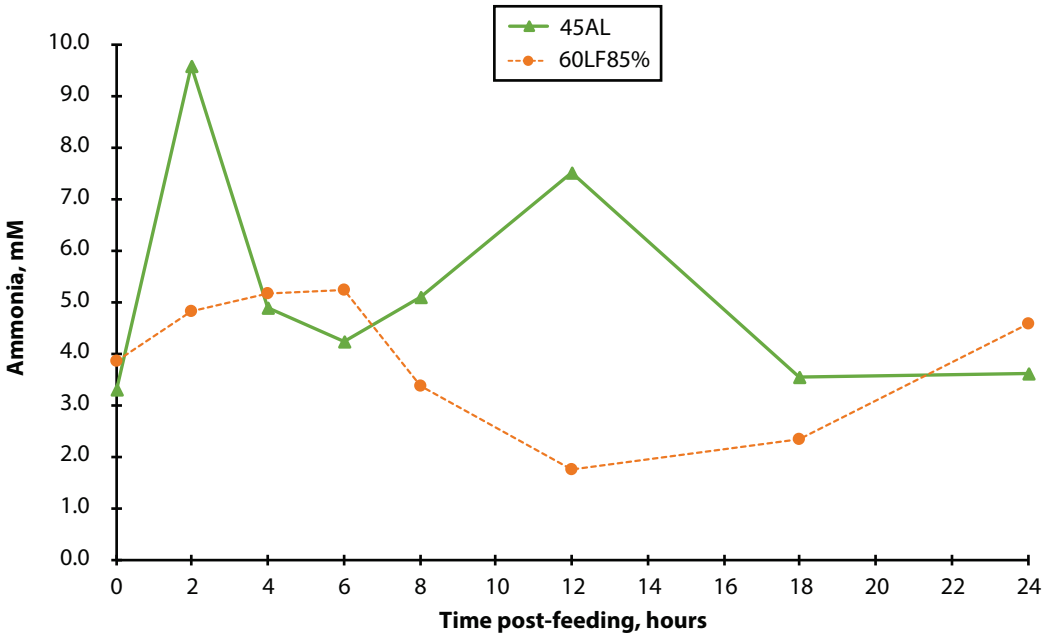


**Figure 2. Effect of a limit-fed high-energy or a traditional roughage-based diet in the growing phase on ruminal ammonia concentration over 24 hours. 45AL (▲) = 45 megacalories of net energy for gain per 100 lb of dry matter offered for *ad libitum* intake, n = 7; 60LF85% (●) = 60 megacalories of net energy for gain per 100 lb of dry matter limit-fed at 85% of 45AL intake, n = 8. Diet effect: $P = 0.03$. Hour effect: $P < 0.0001$. Diet × hour effect: $P < 0.0001$. Standard error of the mean = 0.73.**