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Abstract

Three hundred seventy crossbred heifers [initial body weight (BW) = 496 ± 44 lb] were used in a complete randomized block design receiving and growing study at the Kansas State University Beef Stocker Unit. Two dietary treatments included: (1) 45 Mcal of net energy for gain (NE_g) per 100 lb of dry matter (DM) fed for *ad libitum* intake (45AL), or (2) 60 Mcal NE_g per 100 lb of DM limit-fed at 2.2% of BW daily on a DM basis (60LF2.2). Both diets contained 40% of DM as Sweet Bran (Cargill Animal Nutrition, Blair, NE). Feed efficiency in the growing phase was greater ($P < 0.01$) by 35% for 60LF2.2 heifers compared to 45AL heifers. Average daily gain was lower for 60LF2.2 heifers than 45AL heifers ($P < 0.01$). Rumination time was greater ($P < 0.01$) for 45AL heifers compared to 60LF2.2 heifers, whereas activity was greater ($P < 0.01$) for 60LF2.2 heifers than 45AL heifers. These results suggest growing cattle fed a high-energy diet at a restricted intake level of 2.2% of BW daily on a DM basis have better feed efficiency and greater activity levels compared to growing cattle full-fed traditional roughage-based diets.

Introduction

Recent research suggests limit feeding a high-energy diet to growing cattle improves feed efficiency and reduces time spent ruminating during the growing phase prior to feedlot entry compared to roughage-based diets fed for *ad libitum* intakes on a dry matter (DM) basis. Intake restrictions were often applied based on a percentage of full-fed (*ad libitum*) intake. The objective of this experiment was to compare performance impacts of a high-energy diet limit-fed at 2.2% of body weight to a traditional roughage-based diet fed *ad libitum* during the growing phase.

Experimental Procedures

Three hundred seventy crossbred heifers [initial body weight (BW) = 496 ± 44 lb] were received at the Kansas State University Beef Stocker Unit on four separate days

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

in mid-March 2020. The experimental design was a randomized complete block, and the experimental unit was pen. Heifers were blocked by truckload and were assigned to pens based on day-1 BW. There were 16 soil-surfaced pens, with four pens per block. Twenty to twenty-five heifers were allocated to each experimental pen. Experimental diets were formulated to contain 40% of DM as Sweet Bran (Cargill Animal Nutrition, Blair, NE), and heifers were assigned to one of two dietary treatments: 45 Mcal of net energy for gain (NE_g) per 100 lb of DM fed for *ad libitum* intake (45AL) or 60 Mcal of NE_g per 100 lb of DM limit-fed at 2.2% of BW daily on a DM basis (60LF2.2). Animals were fed once daily at 7:00 a.m. using a Roto-Mix feed wagon (Model 414-14B, Dodge City, KS). Bunks were visually observed, and feed refused was estimated at 6:30 a.m. the following morning. Treatment 45AL feed refusal was targeted at 20 lb. A scale (Rice Lake Weighing Systems, Rice Lake, WI) was used to record weekly pen BW, adjust feed offerings, and to calculate pen performance. During the final 14 days of the study, all cattle were offered a gastrointestinal tract fill equilibration diet, which was formulated to contain 53 Mcal NE_g per 100 lb of DM, limit-fed at 2.5% of BW daily on a DM basis. Individual BW were measured on arrival, at revaccination (day 14), and at the conclusion of the study. Feed samples were collected weekly and frozen at -4°F. At the conclusion of the study, feed samples were thawed, mixed, subsampled, refrozen, and taken to a commercial laboratory for nutrient analysis (SDK Labs, Hutchinson, KS).

On arrival (day -1) cattle were individually weighed, received a visual number ear tag, and any pre-assigned ear tags or markings were recorded. Additionally, all cattle were ear-notched to mark cattle persistently infected with bovine respiratory disease. Cattle had *ad libitum* access to long-stem prairie hay and water via automatic waterers (Lil' Spring 3000; Miraco Livestock Water Systems, Grinnell, IA) prior to allocation to experimental pens on day 0. Twenty-four hours after arrival (day 0), cattle were individually weighed and were assigned an electronic identification ear tag. Each heifer was also outfitted with a 3-axial accelerometer ear tag (Allflex Livestock Intelligence, Madison, WI) to measure rumination and activity in 2-hour increments throughout the day, summarized in minutes per day. Cattle received a 7-way clostridial vaccine (Caliber 7, Boehringer Ingelheim Animal Health, Duluth, GA); and Titanium 5 (Elanco Animal Health, Greenfield, IN), a modified-live vaccine for protecting against infectious bovine rhinotracheitis, bovine viral diarrhea types 1 and 2, and parainfluenza. Additionally, cattle received Nuplura PH (Elanco Animal Health, Greenfield, IN) for protection against *Mannheimia haemolytica*; and tulathromycin (Draxxin; Zoetis, Parsippany, NJ), a macrolide antibiotic. Cattle were revaccinated on day 14 using Titanium 5.

Results and Discussion

Composition of study diets are presented in Table 1, and growing phase growth performance is presented in Table 2. Average daily gain for 60LF2.2 heifers was, on average, 15% lower ($P < 0.01$) than 45AL heifers, and feed to gain ratio was 35% greater ($P < 0.01$) for 60LF2.2 heifers than for heifers receiving 45AL. More DM was consumed by 45AL heifers than 60LF2.2 heifers ($P < 0.01$), except during gastrointestinal tract fill equilibration, by design ($P = 0.23$). The 45AL heifers lost BW during the first 7 days of the equilibration period. Concentration of NE_g calculated based on animal performance was greater for 60LF2.2 heifers than 45AL heifers ($P < 0.01$), but calculated net energy (NE) was lower relative to diet formulation. Our results indicate cattle performed worse than would have been predicted by NE_g, which may be due to environmental factors, including pen conditions, heat stress, or cold stress. Calculated

45AL NE concentration was 18.2% lower than diet formulation, whereas calculated 60LF2.2 NE concentration was only 3.8% lower than diet formulation.

The 60LF2.2 heifers spent, on average, 154 fewer minutes per day ruminating than 45AL heifers ($P < 0.01$; Table 2). An effect of diet was detected for rumination ($P < 0.01$, Figure 1), which was expected due to differences in DM intake between diets. A diet × day interaction was detected for rumination ($P = 0.04$; Figure 1), when the time 60LF2.2 heifers spent ruminating increased on day 56, increased between day 56 and day 75, and increased again on day 77. A diet × hour interaction was detected for rumination ($P < 0.01$; Figure 2); 45AL heifers spent more time ruminating overnight than 60LF2.2 cattle (8:00 p.m. to 6:00 a.m.; $P < 0.05$), but no differences ($P > 0.10$) were observed between treatments at 10:00 a.m. when rumination time for both groups reached a nadir. An effect of diet was detected for daily activity ($P < 0.01$; Figure 1), but no diet × day interaction for daily activity was detected ($P = 0.93$). A diet × hour interaction was detected for activity ($P < 0.01$; Figure 2), when 60LF2.2 heifers were more active 1 hour before feeding at 6:00 a.m., and again 3 to 7 hours after feeding between 10:00 a.m. and 2:00 p.m. ($P < 0.01$). The 60LF2.2 heifers were more active than 45AL heifers in this experiment, most likely due to increased appetite from meal-eating behavior and treatment design differences.

Implications

We interpret our results to suggest that growing cattle limit-fed a high-energy diet based on Sweet Bran and corn to have better feed to gain ratio, greater activity, and shorter rumination times compared to cattle fed traditional roughage-based diets *ad libitum*, which could enable more efficient observation of morbid cattle.

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**	**60LF2.2**	**GFE[2]**
Corn[3]	8.6	38.8	23.8
Wet corn gluten feed[4]	40.0	40.0	40.7
Long-stem alfalfa	22.5	6.5	14.2
Chopped prairie hay	22.5	6.5	14.4
Supplement[5]	6.4	8.2	6.9
Nutrient, % of DM			
DM, % of as fed	74.7	74.2	74.5
Organic matter	85.3	93.7	92.9
Crude protein	15.8	15.1	16.3
Starch	10.0	29.3	19.1
Neutral detergent fiber	40.8	25.7	33.6
Acid detergent fiber	20.8	9.9	15.9
Calcium	1.2	1.1	1.0
Phosphorus	0.5	0.6	0.6

[1]45AL = 45 Mcal of net energy for gain (NE_g) per 100 lb of dry matter (DM) offered for *ad libitum* DM intake. 60LF2.2 = 60 Mcal of NE_g per 100 lb of DM limit-fed at 2.2% of body weight (BW) daily on a DM basis.
[2]GFE = Gastrointestinal tract fill equilibration diet. Fed during last 14 days of the study (depending on block), it contained 53 Mcal of NE_g per 100 lb of DM limit-fed at 2.5% of BW daily on a DM basis.
[3]Dry-rolled yellow #2 corn.
[4]Sweet Bran, Cargill Animal Nutrition, Blair, NE.
[5]Supplement pellet (Cargill Animal Nutrition, Minneapolis, MN) was formulated to contain (DM 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 limit-fed high-energy or traditional roughage-based diets in the growing phase on performance and behavior

	Diet[1]			
Item	45AL	60LF2.2	SE[2]	*P*-value
Number of pens	8	8		
Number of animals	186	184		
BW,[3] lb				
Day 0	500.9	503.8	2.65	0.43
Treatment end[4]	757.7	721.6	5.91	< 0.01
GIT equilibration, day 7[5]	751.3	739.9	3.75	0.05
GIT equilibration, day 14[5]	780.7	770.1	3.70	0.07
ADG,[6] lb/day				
Day 0 – treatment end[4]	2.93	2.49	0.07	< 0.01
GIT equilibration, day 0 – 7[5]	-0.90	2.58	0.40	< 0.01
GIT equilibration, day 7 – 14[5]	4.19	4.34	0.20	0.59
GIT equilibration, day 0 – 14[5]	1.65	3.53	0.22	< 0.01
DM intake, lb/day	21.50	13.29	0.73	< 0.01
Daily intake, % of BW daily	3.42	2.17	0.11	< 0.01
Gain to feed ratio, lb/lb	0.139	0.188	0.01	< 0.01
NE_m, Mcal/lb DM[7]	0.63	0.87	0.02	< 0.01
NE_g, Mcal/lb DM[7]	0.37	0.58	0.01	< 0.01
Rumination, minutes/day[8]	455.7	302.8	12.01	< 0.01
Activity, minutes/day[8]	346.2	369.5	3.12	< 0.01

[1]45AL = 45 Mcal of net energy for gain (NE_g) per 100 lb of dry matter (DM) offered for *ad libitum* DM intake. 60LF2.2 = 60 Mcal of NE_g per 100 lb of DM limit-fed at 2.2% of BW daily on a DM basis.
[2]Standard error; largest standard error of the means is reported.
[3]Body weight.
[4]Treatment-end date was day 84 for 2 blocks, and day 91 for 2 blocks.
[5] Gastrointestinal tract equilibration diet. Fed for 14 days, it was formulated to provide 53 Mcal of NE_g per 100 lb of DM limit-fed at 2.5% of BW daily on a DM basis.
[6]Average daily gain.
[7]Net energy calculations from day 0 through GIT fill equilibration phase: Galyean (2021) using NRC (1996) equations.
[8]Measured using 3-axial accelerometer ear tags (Allflex Livestock Intelligence, Madison, WI).

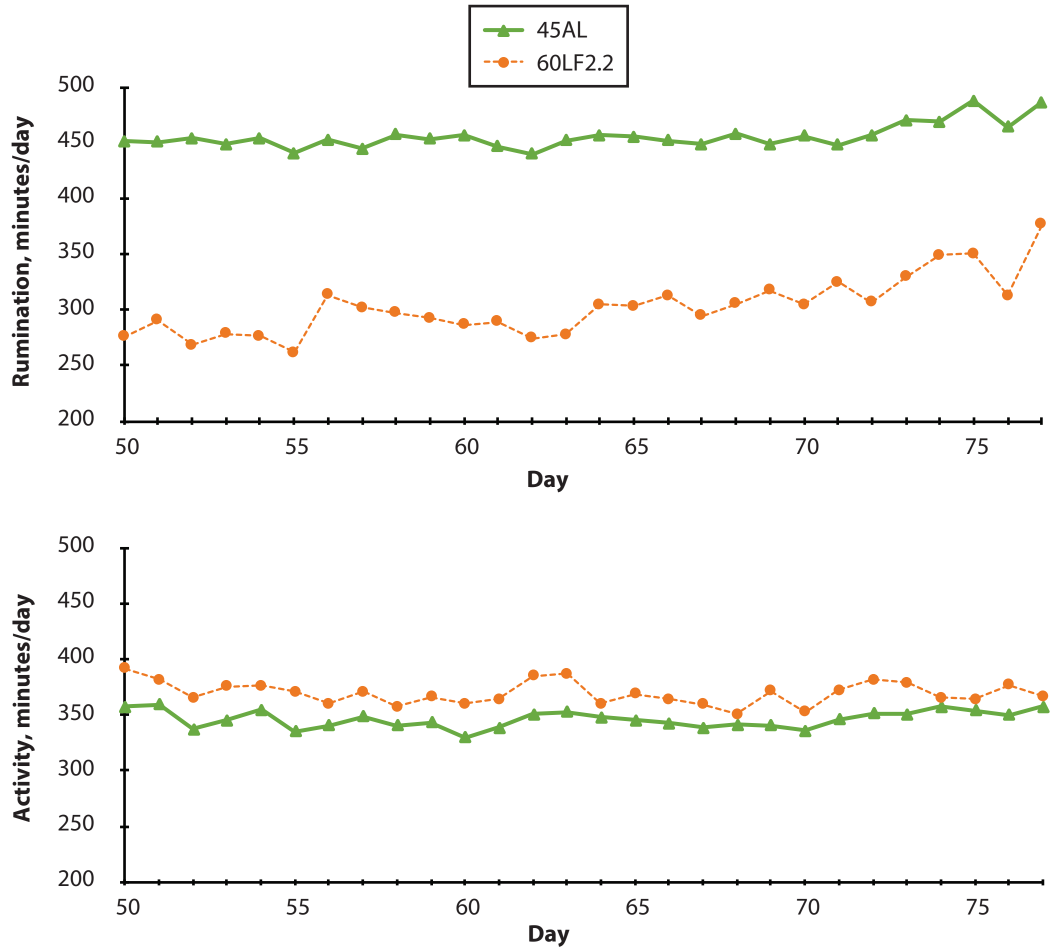

Figure 1. Effect of limit-fed high-energy or *ad libitum* roughage-based diets fed in the backgrounding phase on daily rumination and activity. Top graph: 45AL (▲) = 45 Mcal of net energy for gain (NE_g)per 100 lb of dry matter (DM) offered for *ad libitum* DMI, n = 186; 60LF2.2 (●) = 60 Mcal of NE_g per 100 lb of DM limit-fed at 2.2% of body weight (BW) daily on a DM basis, n = 184. Diet effect: $P < 0.0001$. Day effect: $P < 0.0001$. Diet × day effect: $P = 0.04$. Standard error of the mean (SEM) = 15.94. Bottom graph: 45AL (▲) = 45 Mcal of NE_g per 100 lb of DM offered for *ad libitum* DMI, n = 186; 60LF2.2 (●) = 60 Mcal of NE_g per 100 lb of DM limit-fed at 2.2% of BW daily on a DM basis, n = 184. Diet effect: $P < 0.001$. Day effect: $P = 0.01$. Diet × day effect: $P = 0.93$. SEM = 9.55.

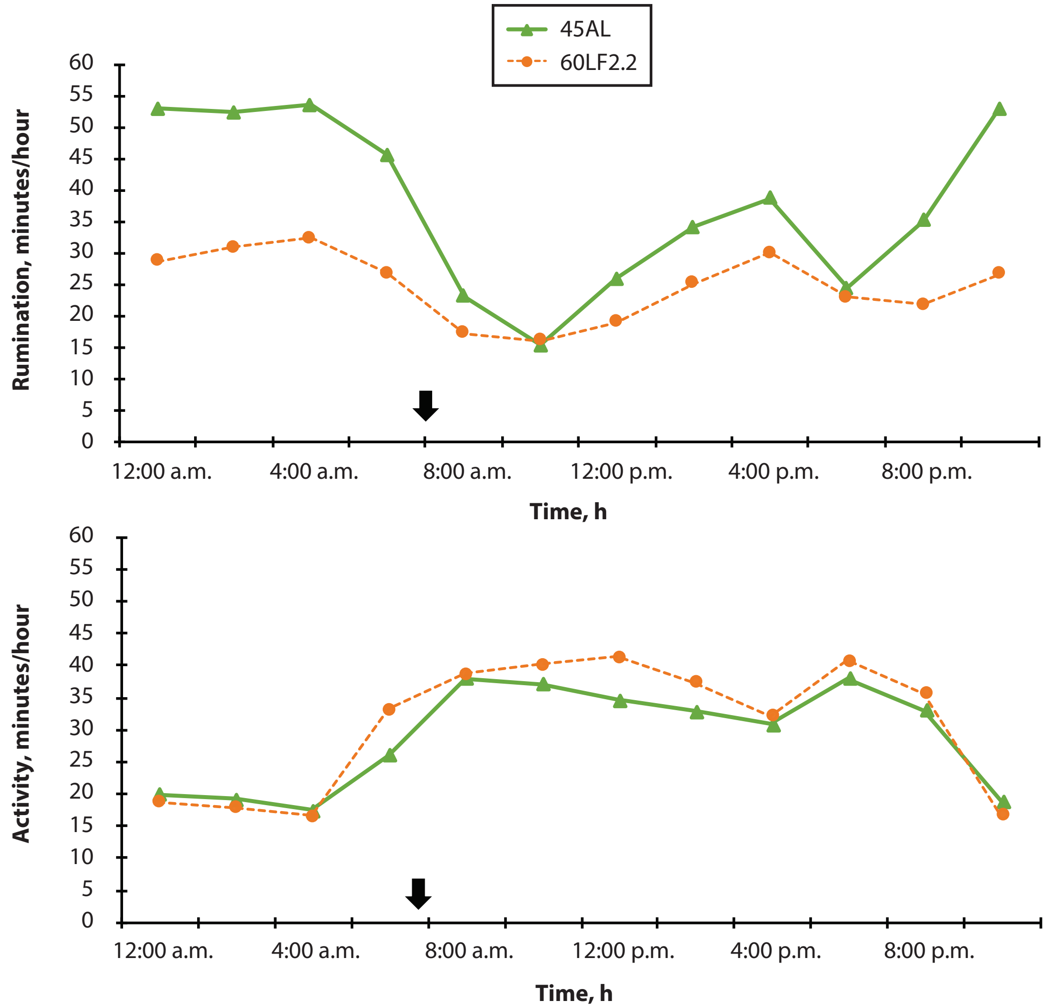

Figure 2. Effect of limit-fed high-energy or *ad libitum* roughage-based diets fed in the backgrounding phase on hourly rumination and activity. Top graph: 45AL (▲) = 45 Mcal of net energy for gain (NE_g) per 100 lb of dry matter (DM) offered for *ad libitum* intake, n = 186; 60LF2.2 (●) = 60 Mcal of NE_g per 100 lb of DM limit-fed at 2.2% of body weight (BW) daily on a DM basis, n = 184. The arrow represents time of feeding (7:00 a.m.). Diet effect: $P < 0.0001$. Hour effect: $P < 0.0001$. Diet × hour effect: $P < 0.0001$. Standard error of the mean (SEM) = 1.18. Bottom graph: 45AL (▲) = 45 Mcal of NE_g per 100 lb of DM offered for *ad libitum* DMI, n = 186; 60LF2.2 (●) = 60 Mcal of NE_g per 100 lb of DM limit-fed at 2.2% of BW daily on a DM basis, n = 184. The arrow represents time of feeding (7:00 a.m.). Diet effect: $P < 0.0001$. Hour effect: $P < 0.0001$. Diet × hour effect: $P < 0.0001$. SEM = 0.65.