Effect of diet on rumen temperature during grain adaptation and finishing in individually fed calves

T. K. Dye-Rose, L. O. Burciaga-Robles, C. R. Krehbiel, and C. J. Richards

STORY IN BRIEF

Continuous monitoring rumen temperature boluses were used to evaluate the effects of increasing concentrate levels, during final diet adaptation, on rumen temperature. Twenty-four Angus crossbred steers (initial BW = 686 ± 68 lb) were split into two groups, housed in individual stalls, and fed four different diets over a 104-d (period 1) or 90-d (period 2) grain adaptation and finishing period. Diets were dry-rolled, corn-based with decreasing levels of alfalfa hay. Alfalfa levels were: 1) 40% (7 d); 2) 28% (4 d); 3) 16% (5 d); and 4) 6% (analyzed for the first 5 d and during the total final diet period of 88 d or 74 d). Rumen temperature boluses programmed to transmit temperature once per minute were administered. Rumen temperature of cattle fed the 6% alfalfa diet was higher than cattle fed the other three diets. Mean temperature for the 16 through 40% alfalfa diets was 39.0°C and the 6% alfalfa diet was 39.2°C. There was no correlation of rumen temperature to dry matter intake or feed efficiency while consuming the finishing diet. When temperatures for each calf were averaged over the feeding period by hour of the day, a diurnal variation was evident. Highest hourly mean rumen temperature occurred from 2100 to 0200 and the lowest occurred between 0900 and 1100. The ability to remotely detect changes in rumen temperature in response to diet energy intake may aid in developing models to monitor animal health and behavior or may be used to determine rumen temperatures that could be used as benchmarks for treatment of metabolic disorders.

Key Words: feedlot cattle, rumen boluses, temperature monitoring

INTRODUCTION

Understanding rumen temperature changes that occur during the consumption of adaptation diets in feedlot cattle is important to better understand the potential use of rumen temperature boluses to detect morbidity. Differences in diet energy intake due to different intake levels or diets could result in differences in fermentation heat and consequently rumen temperature measures relative to temperature measures at other locations. If diet does affect rumen temperature, accounting for these factors could increase the accuracy of baseline temperature measures or identify animals not consuming feed. Evidence of diet affecting temperatures has been demonstrated by Mader et al. (2002), who reported tympanic temperatures were significantly different in cattle fed restricted vs. ad libitum diets. The objective of this study was to determine if remote monitored rumen temperature boluses detect changes in rumen temperature related to decreasing levels of alfalfa hay as calves are adapted to a finishing diet.

MATERIALS AND METHODS

Twenty-four Angus crossbred steers (initial BW = 686 ± 68 lb) were split into two groups and housed at the Nutrition Physiology Research Unit at Oklahoma State University. Steers had free choice access to water and were housed in individual pens with slotted floors and periodically in metabolism stanchions. Continuous, remote monitored rumen temperature boluses were

administered and rumen temperatures were recorded for 104 d (Period 1) or 90 d (Period 2). The four diets (Table 1) that were fed consisted of inclusion levels of alfalfa hay on a DM basis: 1) 40% (7 d), 2) 28% (4 d), 3) 16% (5 d), and 4) 6% (analyzed for the first 5 d and during the total final diet period of 88 d or 74 d). Feed was offered ad libitum with daily feeding times occurring at 0800 and 1600. Feed intake was calculated by determining the feed left in the feed bunk before the 0800 feeding. Diet samples were dried in a 140°F oven and DM was calculated according to Galyean (1997). Rumen temperature boluses transmitted temperature every minute to a remote data station located in the building. Rumen temperature readings above 100°F were used in the analysis. Temperatures below this were considered to be related to a water drinking event. All procedures were in accordance with Oklahoma State University Animal Care and Use Guidelines.

Table 1. Diets fed to determine if rumen temperature varied with consumption of diets with decreasing alfalfa hay

	Diet[a], % DM			
Ingredient	40%	28%	16%	6%
Cracked Corn	46.60	55.10	63.10	69.90
Corn Distillers Grains	9.00	11.50	14.00	15.70
Alfalfa Hay	40.00	28.00	16.00	6.00
Synergy 19-14[b]	1.00	2.00	3.50	5.00
Supplement	3.40	3.40	3.40	3.40
	Supplement, % DM			
Wheat Midds	33.07	33.07	33.07	33.07
Limestone 38%	37.35	37.35	37.35	35.91
Dical	7.35	7.35	7.35	7.35
Salt	9.71	9.71	9.71	9.71
Manganous Oxide	0.08	0.08	0.08	0.08
Availa Zinc 100	-	-	-	1.91
Zinc Sulfate	0.59	0.59	0.59	0.12
Potassium Chloride	7.65	7.65	7.65	7.65
Magnesium Oxide	3.24	3.24	3.24	3.24
Vitamin A-30,000	0.09	0.09	0.09	0.09
Vitamin E-50%	0.06	0.06	0.06	0.06
Rumensin 80	0.52	0.52	0.52	0.52
Tylan 40	0.28	0.28	0.28	0.28

[a]Diets differentiated by alfalfa hay inclusion. Diets fed for 7, 3, 4 and 88 or 74 d, respectively.
[b]Westway Feed Products; Guaranteed nutrient analysis: dry matter 40.0%, crude protein 19.0%, crude fat 14.0%, crude fiber 0.1%, phosphorus (P) 0.2%, potassium (K) 1.0%.

Rumen temperatures across diets were analyzed using repeated measures analysis of the MIXED procedure of SAS (SAS Inst., Inc., Cary, NC). The average days fed on the 40, 28, and 16% alfalfa diets was 5 d; therefore, the first three diet feeding periods and the first 5d of the 6% diet feeding were used to determine the short-term diet effect on rumen temperature. To determine if there was a difference during a longer feeding period, the entire 6% alfalfa diet feeding period was compared to the three higher alfalfa diets. To evaluate diurnal variation, rumen temperatures

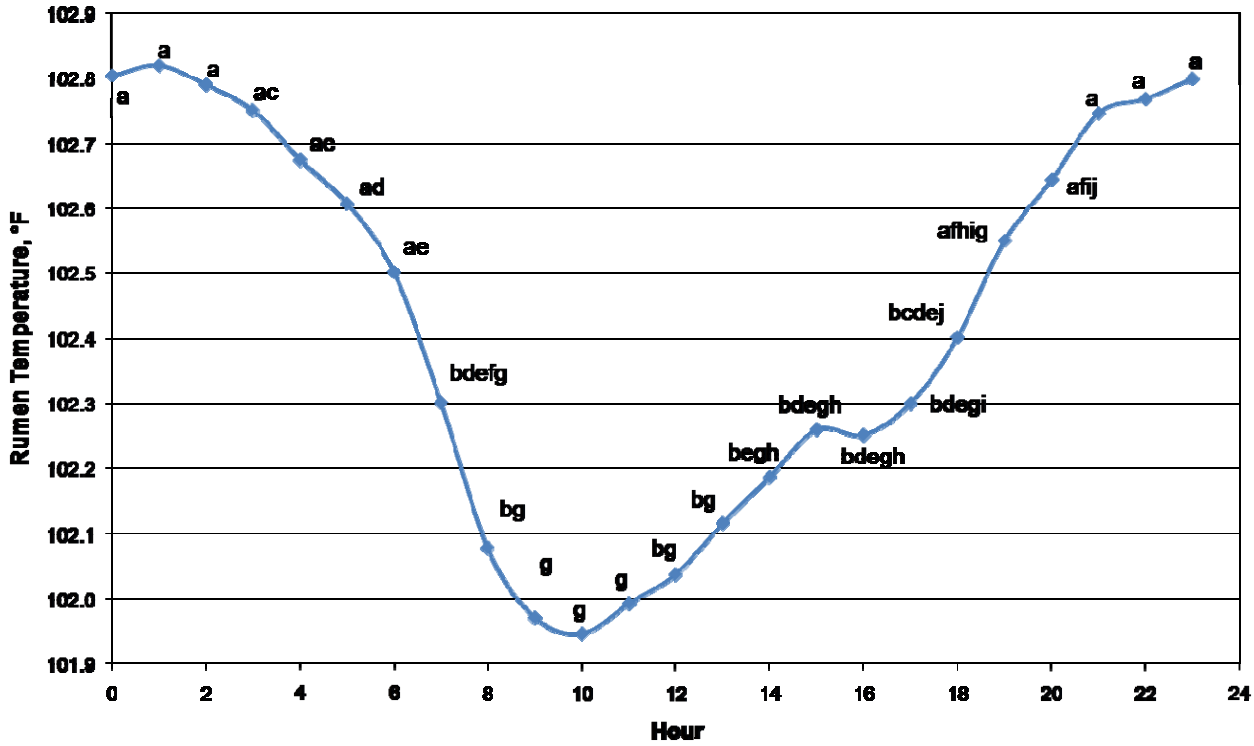
across all diets that were above 100°F were averaged by hour of the day within animal. Analysis was conducted using the MIXED procedure of SAS to determine differences in hourly temperatures. Rumen temperatures were compared to DM intake and feed efficiency while consuming the 6% diet using Pearson's Correlation Coefficient in SAS.

RESULTS AND DISCUSSION

There was no difference ($P > 0.88$) between mean rumen temperatures in 40%, 28% and 16% alfalfa hay diets. However, when the 6% alfalfa hay diet (fed for 5 d) was compared to the other three diets, there was a significant difference ($P \leq 0.04$). Rumen temperatures during the entire 6% alfalfa hay feeding period were also significantly higher ($P \leq 0.01$) than the previous three diets. Average rumen temperatures for 40%, 28%, 16% and 6% were 102.2°F, 102.2°F, 102.2°F and 102.6°F (SEM = 0.27), respectively. These results would suggest as concentrate in the finishing diet increased, rumen temperature increased. Mader et al. (2002) reported a significant decrease in tympanic temperature when animals were fed a restricted diet during induced heat stress. Lower tympanic temperatures during restricted feed intake might be attributed to a decrease in maintenance heat production, changes in organ size and changes in metabolic rate (Mader et al., 2002). Time on the 6% alfalfa hay diet did not affect the difference when compared to the three higher alfalfa diets. It is likely that changes in organ size or metabolic rate did not occur during the three highest alfalfa diets. The higher energy intake and number of days fed on the 6% alfalfa diet may have caused changes in organ size or metabolic rate and be at least partially responsible for temperature increases measured. However, as related to factors affecting temperature measurement for monitoring animal health, this research indicates that at least during the early period after calves arrive at a confined feeding facility, changes in diet forage levels does not dramatically impact average rumen temperature measures.

Rumen temperature was not correlated ($P > 0.47$) to free choice dry matter intake or feed efficiency in the current experiment. Mean and maximum rumen temperature after allowing a 5-d adaptation to the 6% diet were 102.4°F (± 0.54) and 103.4°F, respectively. Dry matter intake over the same period averaged 18.5 ± 3.3 lb, with a minimum of 13.2 lb and maximum of 25.3 lb. Mean, minimum and maximum gain to feed was 0.19 ± 0.09, -0.06 and 0.42, respectively.

Rumen temperatures averaged by hour within each day displayed diurnal variation (Figure 1). Rumen temperature was highest from 2100 to 0200 (102.7°F) and lowest from 0900 and 1100 (102.0°F; SEM = 0.20). Hahn (1999), analyzing tympanic temperatures in ad libitum-fed growing cattle, reported a monophasic trend to diurnal variation with the minimum temperature occurring in late morning, like the current study, and the maximum in late evening. In a study where animals were fed between 0800 and 1000, Mader et al. (2002) concluded average peak tympanic temperatures occurred at 1706 and 1824 during the summer for dark coat-colored and light coat-colored cattle, respectively. In heifers fed at 0800 daily, Mader and Kreikemeier (2006) reported tympanic temperatures in the summer were highest at 1700 and lowest at 0700, whereas high and low tympanic temperatures in the winter were not as evident. During summer months, Lefcourt and Adams (1996) reported daily patterns of body temperature in steers with minimum and maximum occurring at 0823 and 1836, respectively. The present study occurred from September to December in a partially temperature controlled facility, whereas those previously discussed were outdoors. During winter months, Lefcourt and Adams (1998) reported



curred
with

minimum and maximum body temperatures of feedlot steers occurred at 0800 and 1900, respectively. Hahn (1999) discussed that because of entrainment, diurnal cycle of body temperature tends to have a 3 to 4 h lag time behind ambient temperature, which could account for the variations in maximum and minimum times for body temperature in different experiments. Previous research (Hahn, 1999; Lefcourt and Adams, 1998; Mader, 2002; Mader and Kreikemeier, 2006; Davis et al., 2003) with tympanic temperatures agree with the present study using rumen temperatures that there is a diurnal variation in temperatures. Comparing different methods of temperature measurements and getting similar diurnal variation means heat of fermentation in the rumen is not the only cause of the rumen temperature change. It is imperative to consider an animal's environment, diet being consumed and time and frequency of feeding when comparing body temperatures such as rumen or tympanic.

LITERATURE CITED

Davis, M. S., T. L. Mader, S. M. Holt, and A. M. Parkhurst. 2003. Strategies to reduce feedlot cattle heat stress: Effects on tympanic temperature. J. Anim. Sci. 81:649:661.

Galyean, M. L. 1997. Pages 13-18 in Laboratory Procedures in Animal Nutrition Research. West Texas A & M University, Division of Agriculture and Texas A & M Research and Extension Center, Amarillo, TX.

Hahn, G. L. 1999. Dynamic responses of cattle to thermal heat loads. J. Anim. Sci. 77:10-20.

Lefcourt, A. M. and W. R. Adams. 1996. Radiotelemetry measurement of body temperatures of feedlot steers during summer. J. Anim. Sci. 74:2633-2640.

Lefcourt, A. M. and W. R. Adams. 1998. Radiotelemetric measurement of body temperature in feedlot steers during winter. J. Anim. Sci. 76:1830-1837.

Mader, T. L., S. M. Holt, G. L. Hahn, M. S. Davis, and D. E. Spiers. 2002. Feeding strategies for managing heat load in feedlot cattle. J. Anim. Sci. 80:2373-2382.

Mader, T. L. and W. M. Kreikemeier. 2006. Effects of growth-promoting agents and season on blood metabolites and body temperature in heifers. J. Anim. Sci. 84:1030-1037.

ACKNOWLEDGEMENTS

The authors would like to thank Jared Cullison for his assistance in conducting this research and caring for the animals.