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Tympanic Temperature of Steers Fed Different Levels of Metabolic Energy Intake During Summer and Winter

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Terry L. Mader[1]

Summary

Tympanic temperatures (TT) of steers were recorded during July (8 days) and January (6 days). In each experiment, steers were fed 11, 18, or 25 Mcal/day ME in a roughage-based diet, or 18, 25, or 32 Mcal/day ME in a concentrate-based diet. Tympanic temperatures were greater during summer than during winter. Also, steers fed a concentrate diet had greater TT than those fed a roughage diet. Linear equations were obtained to estimate TT of cattle for summer and winter seasons. During the winter, TT response to MEI was dependent on the type of diet. Results demonstrate that increases in the energy level of the diet result in increases in TT. However, the response appears to be dependent on season of year.

Introduction

Altering metabolizable energy intake (MEI) by diluting high concentrate diets with fiber is a diet change that aids in keeping cattle on feed in the winter, but could also lower total heat production in the summer. However, it is uncertain whether the greater heat increment per unit of digestible energy, often associated with fiber, may offset any advantages from dilution. A better understanding of the interactions among diet type, MEI, and environment is needed. The objectives of this study were to assess the effects of MEI and diet composition on body temperature changes during winter and summer seasons.

Procedure

The dataset used for this analysis was derived from two experiments conducted at the University of Nebraska–Lincoln Haskell Agricultural Laboratory at Concord, Neb. Experiment 1 was conducted during the summer, in which 96 steers with an average beginning weight of 950 lbs were randomly assigned to 12 pens of 8 steers per pen. Pens were subsequently randomly selected to receive one of six diets. Three diets were energy-based and three were roughage-based. The three diets in each category consisted of differing levels of metabolizable energy (ME) to be controlled by the amount of feed offered. The daily MEI levels for the roughage diet were 11, 18, or 25 Mcal, whereas daily MEI levels of the concentrate diets were 18, 25, or 32 Mcal. Diet composition was the same in both experiments (Table 1), and MEI levels were obtained by adjusting DMI. Experiment 2 was conducted during the winter utilizing cattle type, number, and weights comparable to those utilized in Exp. 1; the number of pens and pens/treatment were also the same.

In Exp. 1, 30 predominantly Angus and Angus crossbred steers (5 steers/diet treatment; 2 or 3 steers/pen) were fitted with a Stowaway XTI® data logger to record hourly tympanic temperature (TT). Data loggers were attached to a thermistor placed near the tympanic membrane and remained in the steers for 8 days during July 2006. In Exp. 2, 24 predominantly Angus and Angus crossbred steers (4 steers/diet treatment) were fitted with the same type of data loggers, which were placed in the ear utilizing the same procedure described in Exp 1. The devices remained in the steers for a 6-day period in January 2007.

Cattle were fed the respective diet and level for a minimum of 14 days prior to obtaining TT. Environmental variables (Table 2) were collected hourly from a weather station located in the feedlot and included air temperature (AT), wind speed (WS), relative humidity (RH), and solar radiation (SR).

Data were analyzed using incomplete factorial structure in a complete randomized design. Descriptive statistics analyses were obtained using JMP (SAS Inc., Cary, N.C.). PROC MIXED of SAS was utilized for the repeated measurement analysis and for the incomplete factorial analysis. This last analysis was performed within season, with MEI as the quantitative variable and three MEI levels and type of diet as the qualitative variables to obtain equations to predict TT by season.

Results

During summer, cattle received a mean net solar radiation of 326.2 Langleys/day more than during winter (Table 2). Wind speed was greater during winter (11.4 vs. 4.8 mph), while there was a trend for greater relative humidity during winter. The effect of type of diet and MEI levels on TT are presented in Table 3. Tympanic temperatures were greater during summer and dependent upon the level and type of diet fed to cattle ($P < 0.05$). During the summer, the greatest ($P < 0.05$) TTs were obtained in cattle consuming 25 Mcal ME of the roughage diet and in cattle consuming 25 and 32 Mcal ME of the concentrate diet. During the winter, for cattle consuming the roughage diet, the lowest ($P < 0.05$) TTs were reached in cattle consuming 11 Mcal ME, with the greatest ($P < 0.05$) TTs obtained in cattle receiving 25 Mcal of the concentrate diet. Mean TT was 0.5°F greater in summer than in winter (102.0 vs. 101.5°F, respectively, $P < 0.01$). Tympanic temperatures were consistently greater during the entire day in the summer ($P < 0.01$), regardless of diet type.

Cattle fed diets based on concentrates showed greater TT between 1000 hr and 1500 hr, as well as at 0700 hr, than those cattle fed diets based on

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Table 1. Composition of rations fed to steers during experimental period.

Ingredient	Diet type (DM basis) Roughage, %	Concentrate, %
Alfalfa	27.00	9.00
Corn silage	47.75	9.00
Rolled corn	22.00	77.25
Soybean meal	0.00	1.50
Liquid supplement	3.25	3.25
Energy content		
Mcal ME/lb	1.19	1.38
Mcal NEg/lb	0.49	0.63

Table 2. Environmental variables and indexes collected during experimental periods.

Experimental Period	AT	RH	THI	WS	SR	WCI
Summer						
Mean	76.7	75.7	73.3	4.8	537.2	—
SD	1.7	3.5	1.2	0.8	49.3	—
Range	12.7	25.3	9.6	5.7	396.9	—
Winter						
Mean	19.7	84.8	—	11.4	211.0	8.7
SD	4.8	4.0	—	2.4	15.5	6.4
Range	26.1	24.8	—	13.3	105.4	30.5

AT = Ambient air temperature (ºF); RH = Relative humidity (%); THI = Temperature-humidity index; WS = Wind speed (mph); SR = Solar radiation (Langleys); and WCI = Wind-chill index (ºF).

Table 3. Mean tympanic temperature (ºF) by diet treatment and season.

	Diet type, ME (Mcal) intake/day						
	Roughage			Concentrate			
	11	18	25	18	25	32	SE
Summer	101.8[a]	101.9[ab]	102.1[c]	102.0[bc]	102.2[d]	102.3[d]	.033
Winter	101.1[a]	101.5[d]	101.6[d]	101.3[b]	101.9[e]	101.4[c]	.031
Both seasons	101.5[a]	101.7[b]	101.9[d]	101.8[c]	102.1[e]	101.9[d]	.025

[abcde]Means in a row with different superscripts differ ($P < 0.05$).

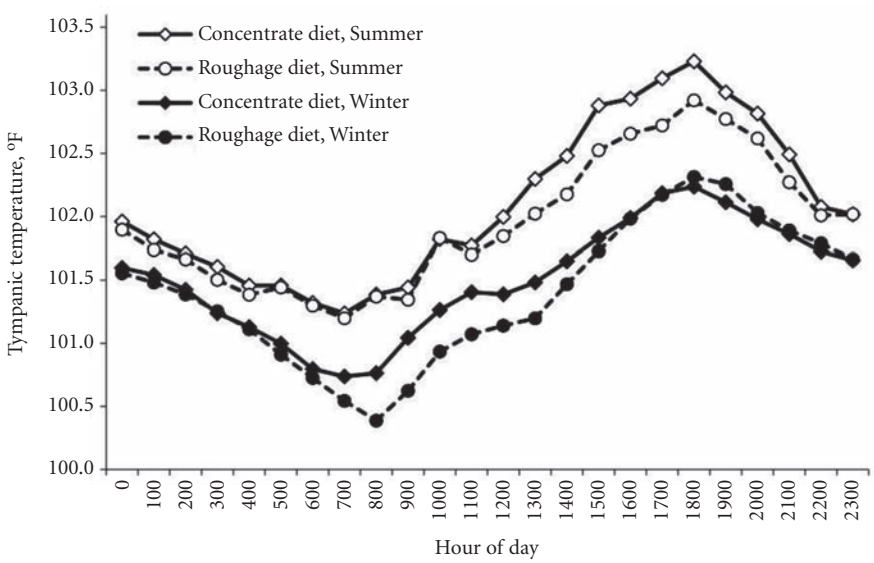

Figure 1. Average hourly tympanic temperature, by season, for steers fed concentrate vs. roughage diets.

roughages (Figure 1). Roughage diets allowed TT to reach the lowest levels in the winter, while concentrate diets allow TT to reach the highest levels in the summer. In contrast, TT of steers provided concentrate vs. those on roughage diets were similar during the coolest (0700 hr) part of the day during the summer and were also similar when TT peaked (1800 hr) in the winter.

There were no diet-by-ME intake level interactions during the summer season, with only main effects being significant ($P < 0.01$ for diet and MEI). Therefore, a common regression equation (similar slopes) for both types of diet was fit (Figure 2) with different intercepts for each diet. Thus, for both diets, cattle increased their TT 0.023ºF per each Mcal increase in daily MEI. During the winter, MEI had a quadratic effect ($P < 0.01$) on TT. In addition, there was an interaction for type of diet by MEI ($P < 0.01$). Thus, TT response to MEI is dependent on the type of diet fed to cattle (Figure 3). The predicted values of TT were: a) concentrate diet, TT = 95.08 + (0.535 * MEI) – (0.0106 * MEI^2); and b) roughage diet, TT = 99.87+ (0.145 * MEI) – (0.0030 * MEI^2).

For the most part, differences in TT among MEI levels would be expected due to differences in metabolic heat load, although the rate of change in TT per unit change in MEI was relatively small during the summer. However, these cattle were not experiencing significant heat stress during this time; thus, the cattle were able to efficiently dissipate metabolic heat. Under more adverse conditions, differences in TT among MEI levels increase with the build-up of metabolic heat, as reported in previous studies (*2001 Nebraska Beef Report*, pp. 69-77), in which managed or restricted feeding programs reduced TT up to 1.5ºF with limited effects on performance. The quadratic response of TT in the winter would possibly be due to altered or enhanced passage rate resulting from cold stress. Ingested feed residence time and

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overall digestibility are reduced under cold stress. Higher energy diets, which generally are composed of smaller particles, have the potential to exit the rumen and digestive tract much more quickly than higher fiber diets, although among diet types the higher concentrate diet generally produced greater overall metabolic heat. However, within the concentrate diet type, the MEI level for optimum metabolic heat production appears to be less than the highest MEI achievable.

In summary, results presented herein demonstrate an increase in energy level of the diet has a positive relationship with TT. However, the response depends upon season of year. Data suggest a linear response in TT for the summer and a quadratic response during the winter. In the summer, TT increases as MEI increases, while in the winter, peak TT would occur in steers consuming approximately 24 Mcal ME per day of a roughage diet and 25 Mcal ME per day of a concentrate diet.

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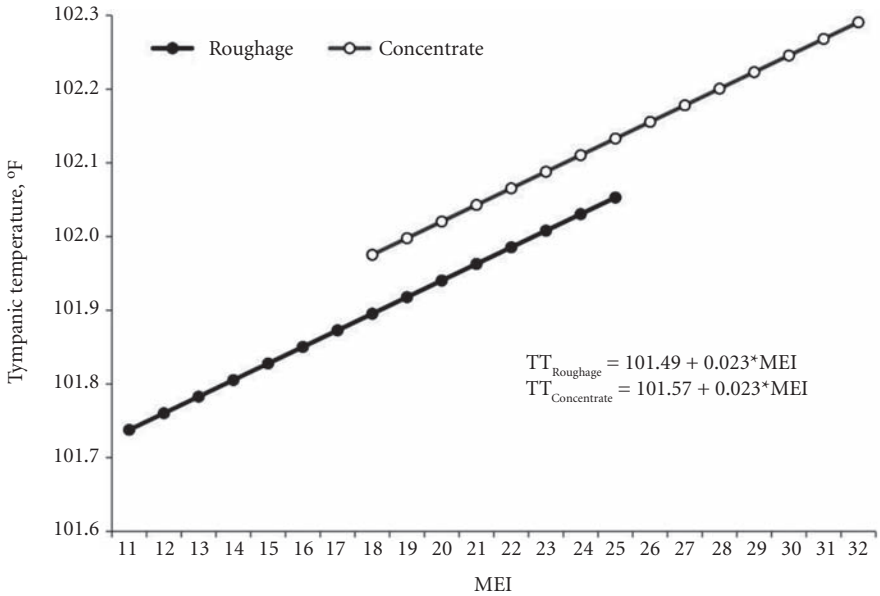

Figure 2. Predicted average daily tympanic temperature (TT) of steers during the summer.

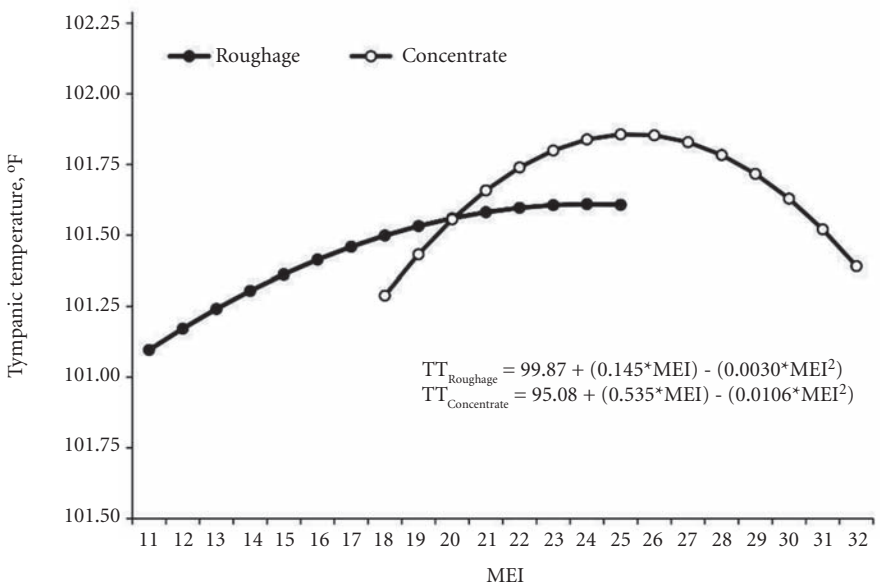

Figure 3. Predicted average daily tympanic temperature (TT) of steers during the winter.

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