RELATIONSHIP BETWEEN BODY CONDITION SCORE AND DAILY METABOLIZABLE ENERGY REQUIREMENT OF MATURE, NONPREGNANT, NONLACTATING HEREFORD COWS DURING WINTER

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Story in Brief

Thirty-five cows in 1982-83 and 36 cows in 1983-84 were utilized in a comparative slaughter trial to investigate the effects of carcass composition on winter metabolizable energy (ME) requirements for maintenance. Prior to initiation of the study, all cows were randomly assigned to one of three feeding regimes to either lose, maintain or gain weight and condition. By the start of the trials, live weight (LW) ranged from 606 to 1311 lb and condition score (CS) ranged from 2 to 8 units (1 = very thin, 9 = very fat). In December of each year, 12 cows representing the entire range of CS were slaughtered. Regression equations based on CS and LW were developed from the initial slaughter groups to predict the initial composition of the remaining cows. Remaining cows were individually fed differing amounts of a complete diet (1.13 mcal ME per pound dry matter) in drylot for an average of 115 days. Daily feed intakes were adjusted each week to maintain live weight throughout the winter. In March, all cows were slaughtered and carcass composition was determined. Data were analyzed by fitting the model, ME intake = k^{-1}(carcass energy change) + f(CS)$LW^{.75}$, where k = efficiency of ME use for carcass energy change, LW = kilograms live weight and f(CS) = function of condition score. The expression, .1028 + .0234(CS) - .0025$(CS)^2$, accounted for 41% of the variation in ME (mcal) for maintenance per kilogram $LW^{.75}$. These data suggest that cows in thin (CS = 3) condition and cows in fat (CS = 7) condition require 4.4 and 8.9% less ME per kilogram metabolic weight, respectively than cows in moderate (CS = 5) condition. Daily ME requirements for 950 lb cows with CS = 3, 5 or 7 were 14.2, 14.9 or 13.6 mcal, respectively.

(Key Words: Carcass Composition, Metabolizable Energy, Beef Cows.)

Introduction

In recent years, improving the efficiency of beef production has received increased emphasis. Tremendous improvement in understanding and predicting the performance of feedlot cattle has been achieved with the application of modern ration formulation programs such as the California Net Energy system.

Current National Research Council feeding standards compute energy requirements for beef cattle factorially. Energy expenditures for maintenance, tissue gain, and in the case of cows, pregnancy and lactation are summed and their total is considered to equal the requirement.

Cow size, as determined by cow weight, is the major factor determining energy expenditures for maintenance. The NE_m requirement for pen-

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ned cattle in nonstressful environments with minimal activity is estimated by the expression 77 kcal$\cdot W^{.75}$, where W is body weight in kilograms. Energy requirements for maintenance can be adjusted for differences in environmental temperature, humidity and wind velocity. Previous research has demonstrated variations in maintenance requirements due to breed, season of the year, previous plane of nutrition and body composition as related to feed intake and stage of production.

The objectives of this research were: 1) to evaluate the relationship between body condition score and winter maintenance energy expenditures in mature Hereford cows and 2) to develop equations based on weight and/or body condition score representing energy requirements for maintenance.

Materials and Methods

Thirty-five cows in 1982 and 36 cows in 1983 were randomly assigned to one of three feeding regimes to either lose, maintain or gain weight and condition. By November in year 1 and October in year 2, live weight (LW) ranged from 606 to 1311 lb and CS ranged from 2 to 8 units. In December of each year, 12 cows representing the entire range of CS were slaughtered. Regression equations were developed from the initial slaughter groups to predict the initial composition of the remaining cows. Remaining cows were individually fed a complete diet (Table 1) in drylot for an average of 114 days in year 1 and 115 days in year 2. Daily feed intakes were adjusted each week to maintain LW throughout the winter. In March, all cows were slaughtered and final composition was determined.

Daily weather data were obtained during each winter from the Oklahoma State University Agronomy Weather Station. Average daily temperature, rainfall and snow were computed for each week of the feeding trial. The effects of temperature and precipitation on metabolizable energy required for maintenance were examined.

Table 1. Composition of diet fed to cows.

Ingredient	Int. feed no.	Percentage[a]
Rolled corn	4-02-931	39.5
Alfalfa pellets	1-00-023	36.0
Cottonseed hulls	1-01-599	21.7
Cane molasses	4-04-696	2.5
Salt		.3
Dry matter, %		90.2
Crude protein		12.0
Metabolizable energy[b]		1.13

[a]Dry matter basis.
[b]Mcal/lb dry matter.

Results and Discussion

Throughout year 1 (Table 2), cows gained a mean of 3.7 lb LW and .2 units CS while cows in year 2 (Table 3) gained a mean of 9.7 lb LW and

Table 2. Data used to estimate maintenance requirements of cows fed during year one.

Item	Mean	Standard Deviation
Live weight, lb		
Initial	872.6	138.68
Final	876.3	143.90
Condition score, units		
Initial	5.0	1.33
Final	5.2	1.18
Carcass energy, mcal		
Initial[a]	378.7	177.1
Final	458.0	174.7
Carcass fat, lb		
Initial[a]	52.0	34.56
Final	64.1	35.07
Carcass protein, lb		
Initial[a]	59.9	8.27
Final	72.5	11.81
Daily energy intake, mcal	13.4	1.64

[a]Estimated using equations developed from initial kill data.

Table 3. Data used to estimate maintenance requirements of cows fed during year two.

Item	Mean	Standard Deviation
Live weight, lb		
Initial	859.6	159.79
Final	869.3	159.44
Condition score, units		
Initial	5.0	1.59
Final	5.1	1.47
Carcass energy, mcal		
Initial[a]	381.2	207.5
Final	423.8	198.0
Carcass fat, lb		
Initial[a]	52.5	39.69
Final	59.1	39.03
Carcass protein, lb		
Initial[a]	61.7	17.50
Final	67.4	13.33
Daily energy intake, mcal	14.5	1.77

[a]Estimated using equations developed from initial kill data.

.1 units CS. Cows in year 1 consumed from 10.24 to 16.77 mcal/day and gained a mean of 12.1 lb carcass fat, 12.6 lb carcass protein and 79 mcal carcass energy while cows in year 2 consumed from 10.14 to 17.76 mcal·day and gained a mean of 6.6 lb carcass fat, 5.7 lb carcass protein and 43 mcal carcass energy. Average daily ME intake was 13.4 mcal in year 1 and 14.5 mcal in year 2. The ME required for maintenance was estimated by solving the following multiple regression equation for zero energy retention, ME intake = k^{-1}·retained energy + f(CS)·$LW^{.75}$, where k = the efficiency of ME utilization for carcass energy change and f(CS) = function of CS and LW = kilograms live weight.

In year 1, daily maintenance energy requirement (zero energy retention) was best fit by the equation: ME (mcal) = (.0308 + .0474 CS - .0046 CS^2)$LW^{.75}$ (Table 4). Daily carcass energy change and the quad-

Table 4. Regression of metabolizable energy intake on energy retained and condition score.

Year	Equation[e]	Sy·x	R^2
1	ME intake[a] = .0308(±.0664)+.8056(±.5945)ECH[b] +.0474(±.0262)CS[c]-.0046(±.0024)CS^2	.0153	.29*
2	ME intake = .1324(±.0264)+.9728(±.5858)ECH +.0151(±.0114)CS-.0017(±.0012)CS^2	.0093	.34**
Both[d]	ME intake = .1028(±.0286)+.9181(±.4078)ECH +.0234(±.0116)CS-.0025(±.0011)CS^2	.0115	.41***

[a] Daily metabolizable energy intake, mcal per kg live weight $^{.75}$.
[b] Daily tissue energy change, mcal per kg live weight $^{.75}$.
[c] Condition score, units.
[d] Model includes year as a class variable.
[e] Regression coefficients ± standard error.
* P<.10.
** P<.05.
*** P<.0001.

ratic function of CS accounted for 29% of the variation in ME intake per kilogram $LW^{.75}$. In year 2, 34% of the variation in ME intake per kilogram $LW^{.75}$ was explained by daily carcass energy change and the quadratic function of CS (Table 4). Daily maintenance energy requirement was estimated by the expression: ME (mcal) = $(.1324 + .0151\ CS - .0017\ CS^2) \cdot LW^{.75}$.

Figure 1 shows the relationship between Mcal $ME \cdot (W^{.75})^{-1}$ required for maintenance and CS for years 1 and 2. Energy required for maintenance averaged 12% higher in year 2 than year 1. The winter of 1983-84 was more severe than the winter of 1982-83. Average daily temperature ranged from -1.4 to 10.7°C in year 1 and from -11.8 to 11.2°C in year 2. When data from both years were combined, the regression, ME intake per kilogram $LW^{.75} = \beta_0 + \beta_1(CS) + \beta_2(CS)^2$, was nonsignificant ($P<.18$) and only accounted for 11% of the observed variation in maintenance. When year was included as a class variable, the expression, $.1028 + .0234\ (CS) - .0025(CS)^2$ accounted for 41% of the variation in maintenance per kilogram $LW^{.75}$ (Table 4).

Equating the first derivative of the maintenance function of CS, .0234 - .005 CS, to zero and solving for CS indicates that maximum mcal $ME \cdot (LW^{.75})^{-1}$ occurs at CS = 4.68. Cows in thin condition (CS = 3) required 95.6% of the maximum mcal $ME \cdot (LW^{.75})^{-1}$ while cows in fat condition (CS = 7) required 91.1% of the maximum mcal $ME \cdot (W^{.75})^{-1}$.

The effects of environment on daily metabolizable energy required for maintenance were evaluated by fitting the model, ME intake = $k^{-1} \cdot$LW change each week + $[f(CS) + f(ENV)]\ LW^{.75}$, where k = the efficiency of LW change, f(CS) = the maintenance function of CS and f(ENV) = the function of average daily temperature and precipitation for each week. The interactions between environment and CS were also examined. The full model accounted for 41.2% of the variation in ME intake per kilogram $LW^{.75}$. Rainfall, snow, CS x rain and CS x snow were not significant ($P>.10$) sources of variation in ME intake per kilogram $LW^{.75}$ and were removed from the model. The reduced model (Table 5) explained

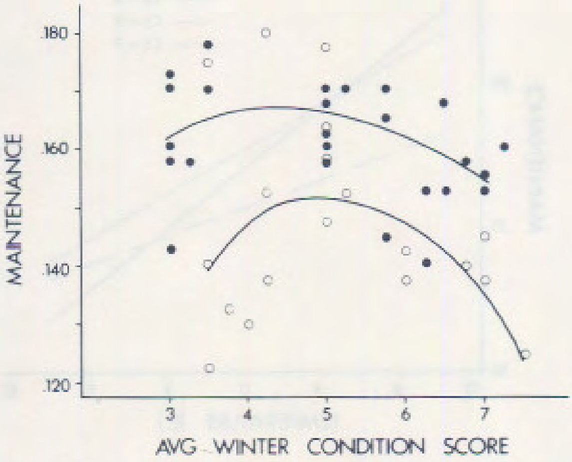

Figure 1. Relationship between metabolizable energy required for maintenance per kilogram body weight$^{.75}$ and average condition score during winter.

Table 5. Regression of daily metabolizable energy intake per kilogram live weight$^{.75}$ on live weight change per kilogram live weight$^{.75}$ and the maintenance function of condition score and on the function of environment.

Variable	Regression Coefficient	P^a	Standard Error
Intercept	.1151	.0001	.0199
Weight change[b]	.3127	.0001	.0581
Condition score, units	.0295	.0004	.0082
Condition score^2	-.0034	.0001	.0008
Temperature, °C	-.0076	.0001	.0008
CS x temperature[c]	.0007	.0001	.0002

[a]Probability of a greater T for the hypothesis, H_o: parameter = 0.
[b]Kilograms·(live weight$^{.75}$)$^{-1}$.
[c]Condition score x temperature interaction, units·°C.

39.7% of the variation in maintenance. The influence of temperature and the interaction between temperature and CS were highly significant (P<.0001) indicating that the effect of temperature on ME required for maintenance was dependent on CS. The interaction between average daily temperature for the week and CS is illustrated in Figure 2. For each °C decrease in average temperature, ME required per kilogram LW$^{.75}$ for maintenance was increased .0055, .0039 and .0025 mcal for cows with CS 3, 5 and 7 units, respectively. These data indicate that the effect of temperature on ME required for maintenance may be greater for thin cows than for cows in moderate or fat conditions.

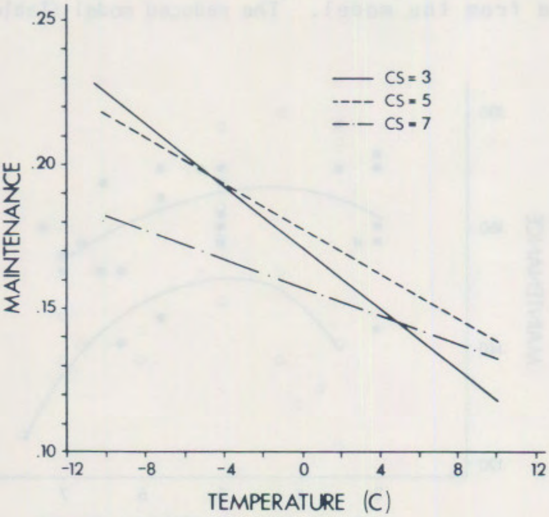

Figure 2. Relationship between metabolizable energy (mcal) required for maintenance per kilogram body weight$^{.75}$ and average weekly temperature for cows of condition score 3, 5 and 7 units.

Regression coefficients for CS (.0295±.0082) and CS^2 (-.0034±.0008) appeared similar to the regression coefficients reported earlier for CS (.0234±.0116) and CS^2 (.0025±.0011) when year was included in the model as a class variable. This indicates that most of the variation associated with year could be attributed to differences in environmental temperature.

Discussion

Data reported in this study suggest that cows in fatter body condition (CS = 7 units) and cows in thin condition (CS = 3 units) have lower ME requirements per kilogram body weight than cows with a moderate degree of fat (CS = 5 units). Maintaining the cow herd, especially during winter, is often regarded as the most important expense limiting the efficiency of beef production. Consequently, even a small savings in maintenance could improve net returns per cow.

Daily metabolizable energy requirements of nonpregnant, nonlactating cows for maintenance during winter are shown in Table 6. Frame score 3, condition score 3 Hereford cattle would weigh approximately 750 lbs and require 11.9 mcal ME for maintenance. The same cow at CS 5 would weigh 850 lbs and would require 13.7 mcal ME. At CS 7, this cow would weigh 1050 lbs and would require 14.4 mcal ME.

The utility of manipulating body fatness in an attempt to reduce maintenance costs is limited. Fat cows weigh more than thin cows of the same frame size. For cows of given breeding and type, fattening increases weight and additional energy is required to maintain this added weight. Perhaps in northern climates the insulatory benefits of additional fat may overcome the cost of maintaining additional weight. A 14.0% savings in feed costs, primarily due to lower LW, could be realized by maintaining cows in thin condition. The relationship between reproduction and cow weight and condition is well established. At present, it is not feasible to keep cows in thin condition and maintain satisfactory reproductive performance. If factors initiating estrus and maintaining pregnancy could be identified and managed to promote satisfactory reproduction under adverse conditions, maintaining cows in thin condition may become a viable option for cattlemen.

Table 6. Daily metabolizable energy required for maintenance by cows of various weights and condition scores.

	Body Condition Score				
Cow Weight (lb)	3	4	5	6	7
750	11.9	12.4	12.5	12.1	11.4
850	13.1	13.6	13.7	13.3	12.5
950	14.2	14.8	14.9	14.5	13.6
1050	15.3	15.9	16.0	15.6	14.4
1150	16.4	17.1	17.2	16.7	15.7

The results obtained from the current study are most useful as a tool to help budget feed requirements more precisely. Maintenance requirements per unit metabolic weight are not static and vary with environmental conditions, plane of nutrition, genotype, physiological status and carcass composition. Daily metabolizable energy (mcal) required by mature, nonpregnant, nonlactating Hereford cows during winter were best described by the expression, $[.1028 + .0234(CS) - .0025(CS)^2]LW^{.75}$ (LW = kg live weight).