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Summary

Net energy (NE) of diets containing 77.7% whole corn of either normal (53.8 lb/bushel, NC) or light (40.8 lb/bushel, LC) test weight was determined by total collection and indirect respiration calorimetry using six crossbred steers (avg wt 327 kg). Diet treatments were applied in a switchback design. The steers were initially adapted to ad libitum intake of either NC or LC diets for 32 days followed by 7 days total feces and urine collection. Gaseous exchange was subsequently measured for at least 48 hours. Intake was then reduced to an estimated 1.1 times maintenance for 6 days and collections were repeated. The steers were then switched between NC and LC diets and the entire process was repeated. As a percentage of gross energy consumed, fecal energy losses were 32% greater for the NC diet compared to LC ($P<.01$). Urinary energy losses were unaffected by diet ($P>.20$). Although energy lost as methane did not differ between diets at high intake, it was 27% greater for LC than NC at low intake (interaction $P<.05$). Adjusted to a common metabolizable energy (ME) intake, neither heat production nor retained energy differed between diets ($P>.20$). Partial efficiencies of ME used for maintenance (k_m) and gain (k_g), as well as ME required for maintenance, also were not different ($P>.20$). Diet NE for maintenance and gain was 13% greater for LC than NC. NE estimates calculated by difference for light and normal whole corn were 2.48, 1.65, 2.15 and 1.43 mcal/kg dry matter, respectively. These data demonstrate that corn of low test weight is not inherently lower in NE content than normal corn.

Key Words: Test Weight, Corn, Energy

Introduction

Late planting, cool growing seasons and early frost all contribute to the frequent occurrence of light test weight corn in the upper midwest. It has been assumed that useful feed energy content declines with test weight. This idea was supported by early Minnesota research conducted with sheep. However, feedlot performance and more recent research from Nebraska with cattle have indicated that this may not be the case.

The objective of this study was to determine the effect of light test weight, whole corn on energy partitioning and net energy estimates of finishing diets fed to cattle.

Materials and Methods

Six crossbred steers averaging 327 kg were tamed to lead and adapted to the metabolism facilities and collection procedures prior to the first collection period. The steers were paired by weight and allotted within pair to two groups which were alternately fed finishing diets containing whole corn of light (LC) or normal (NC) test weight in a switchback design. Corn analyses are presented in Table 1. Diet composition and analyses are presented in Table 2. Diet analysis differed with respect to

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Table 1. Chemical composition of light (LC) and normal (NC) test weight corn

Item	LC	NC
Dry matter, %	87.0	87.7
Crude protein, %	12.1	9.4
Ether extract, %	3.9	4.2
Test wt, lb/bushel	40.8	53.8

Table 2. Diet composition (dry matter basis)

Ingredient		
Whole corn		77.665
Ground corn cobs		9.000
Beet molasses		3.000
Soybean meal		8.469
Dicalcium phosphate		.330
Calcium carbonate		1.042
Potassium chloride		.144
Trace mineral salt		.250
Fat		.100
Analysis	LC	NC
Dry matter, %	86.8	87.4
Gross energy, kcal/g	4.33	4.31
Crude protein, %	13.9	11.9
Calcium, %[a]	.55	.55
Phosphorus, %[a]	.35	.35

[a]Calculated.

crude protein. However, crude protein levels were both considered in excess of requirements and were unlikely to bias the results. Corn supplies were acquired through normal commercial sources. Variety and maturity are unknown.

The steers were initially adapted to Ad libitum intake of either NC or LC diets for 32 days followed by 7 days of total feces and urine collection. Gaseous exchange was subsequently measured for at least 48 hours. Intake was then reduced to what was estimated to be 1.1 times the maintenance requirement. The steers were readapted for 6 days and collections were then repeated at this intake. Diet assignments of the steers were then switched and the entire process was repeated.

Weights of feed offerings and refusals, feces and urine were recorded during each collection period. With the exception of urine, samples were analyzed for dry matter (DM). Samples, including urine, were also analyzed for gross energy (GE) content by complete combustion.

Gaseous exchange (oxygen consumption and methane production) of the steers while fed each diet at high and low intakes was measured in one of four indirect, respiration calorimeters. Heat production (HP) was subsequently calculated as 5 kcal/liter of oxygen consumed. The calorimeters were designed to enclose only the animal's head but still allow free access to water and prescribed amounts of feed. Air flow through each calorimeter was measured by a dry gas meter and continuous samples of air were taken prior to entering and immediately after leaving the calorimeter.

Digestible energy (DE) was calculated as feed GE minus energy lost in the feces (FE). Metabolizable energy (ME) was calculated as DE minus urinary energy (UE) and energy lost in the form of methane (CH4E). Retained energy (RE)was equal to ME minus HP. The partial efficiencies of ME used for maintenance (k_m) and gain (k_g) represent the change in energy retained in the body per unit change in ME consumed (i.e., higher k_m and/or k_g imply more efficient metabolism). Diet k_g was derived from the linear regression of RE on ME. The ME requirement for maintenance (ME_m) represents ME intake necessary to result in no gain or loss of body energy by the animal and is determined from this regression. Diet k_m, on the other hand, was calculated by assuming fasting HP to be 77 kcal/kg body weight$^{.75}$ and dividing this by ME_m.

The data were statistically analyzed for the discrete effects of diet, intake level, diet x intake level and animal. HP and RE were additionally analyzed with the covariate ME intake replacing intake level.

Results and Discussion

Energy partitioning data are presented in Table 3. Twenty of 24 energy balances were successfully completed. The four uncompleted

Table 3. Partitioning of diet gross energy

Item	LC[a] Low intake	LC[a] High intake	NC[b] Low intake	NC[b] High intake	P Corn	P Intake	P Corn x intake
	—— kcal·body $wt^{-.75}$·day^{-1} ——						
Gross energy intake	199.2	403.1	191.0	379.5	.20	.01	.50
Fecal energy	33.4	90.4	40.6	115.3	.01	.01	.09
Urinary energy	8.3	9.4	8.9	8.6	.94	.65	.41
Methane energy	12.4	11.8	9.3	12.4	.26	.22	.09
Heat production	122.3	196.9	120.9	182.0	.21	.01	.27
Retained energy	22.8	89.9	9.3	59.2	.08	.01	.46
	—— Percentage of gross energy ——						
Fecal energy	16.7	22.5	21.9	30.0	.01	.01	.25
Urinary energy	4.2	2.4	4.6	2.3	.70	.01	.65
Methane energy	6.2	2.9	4.9	3.3	.33	.01	.05
Digestibility	83.3	77.5	78.1	70.0	.01	.01	.25
Metabolizability	72.9	71.7	68.3	64.1	.01	.10	.34

[a]LC = light test weight corn diet.
[b]NC = normal test weight corn diet

balances consisted of two NC and two LC fed steers.

Ad libitum GE intakes/$wt^{.75}$ (collection periods 1 and 3) for NC and LC diets were not different (P>.20). However, as a percentage of GE consumed, FE losses were 32% greater for the NC diet compared to LC (P<.01) resulting in average digestibilities of 74.0 and 80.4%, respectively (P<.01). Additionally, digestibility decreased 3.6 percentage points per 100 kcal increase in GE consumed (P<.01).

Urinary energy losses as a percentage of GE intake were unaffected by diet (P>.20) but decreased by almost half at the high intake compared to low ()<.01). At high intake, energy lost as methane was also not affected by diet. However, it was 27% greater for LC than NC at low intake (interaction P<.05). Metabolizability averaged 8.5% greater for the LC diet compared to NC (P<.01), primarily reflecting differences in FE. Level of intake effect on metabolizability, while significant (P<.10), was less than that on digestibility because increasing FE was partially offset by declining UE and CH4E.

The amount of heat produced by a growing animal is, to a large degree, a function of ME intake relative to ME required for maintenance. Although ad libitum GE intake did not differ between diets, metabolizability was greater for LC than NC, resulting in 19% greater ME intake for LC fed steers (287.3 vs 241.4 kcal·$wt^{-.75}$·day^{-1}; P<.01). Despite this, HP did not differ between diets (P>.20). Because energy retained in the body as new growth is equal to the difference between ME consumed and HP, high intake RE was 52% greater for LC fed steers (P<.08), a reflection of more ME being available above maintenance requirements. When adjusted to a common ME intake, neither HP nor RE differed between diets (P>.20).

Partial efficiency of ME used for growth (k_g) was determined from the linear regression of RE on ME intake. Lack of an interaction between diet and ME intake (P>.20) indicated that k_g did not differ between diets and the data from both were pooled (Figure 1). The pooled estimate of k_g was .48 and is in close agreement with other published estimates for similar diets.

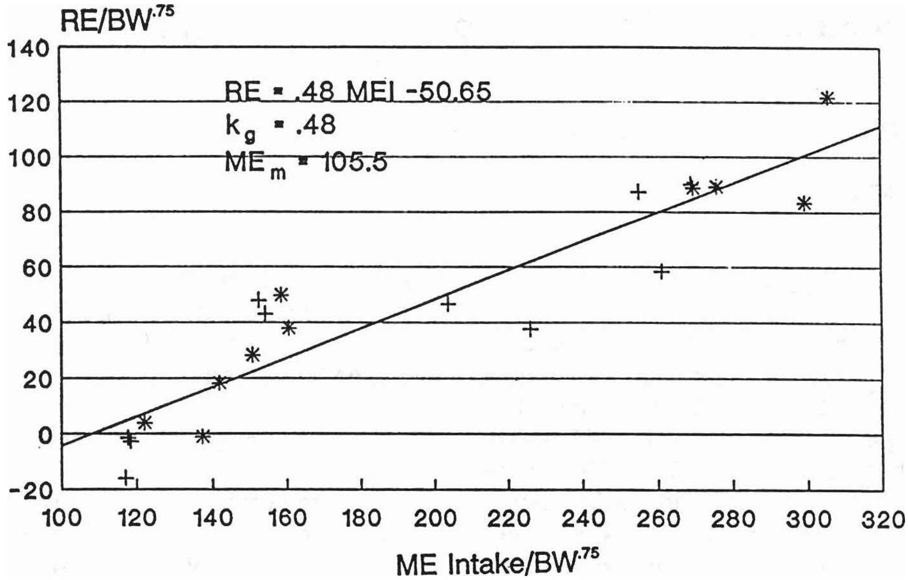

Figure 1. Regression of retained energy (RE) on metabolizable energy (ME) intake (+ = normal corn diet; * = light corn diet).

Extrapolation to zero RE yielded an ME_m estimate of 105.5 $kcal \cdot wt^{-.75} \cdot d^{-1}$.

Direct determination of k_m requires energy balance data for intakes below maintenance. In this study, all measurements were made near or above maintenance. Alternatively, one can estimate it by assuming fasting HP (RE at zero ME intake) equal to 77 $kcal \cdot wt^{-.75} \cdot d^{-1}$, the constant used in the current net energy system and divide this by ME_m. By the latter approach, k_m was equal to . 73.

Diet and corn energy estimates calculated from the high intake data are expected to be most applicable to diet formulation in production situations and are presented in Table 4. Regardless of the energy expression used, diet estimates were 13% greater for LC than NC. Differences in energy estimates reflect the greater FE loss of the NC diet. Energy estimates for light and normal whole corn were calculated by difference using published values for the noncorn components of the diet. Normal whole corn NE estimates for maintenance and gain were 2.15 and 1.43 mcal/kg dry matter, respectively. Net energy estimates for LC were 15% greater and more comparable to values one might expect for flaked or high moisture corn.

In conclusion, these data demonstrate that corn of low test weight is not inherently lower in NE content than normal corn.

Table 4. Diet and corn energy estimates (high intake)

	Diets		Corn	
Item	LC	NC	LC	NC
	Mcal/kg dry matter			
DE	3.35	2.99	3.51	3.05
ME	3.08	2.73	3.31	2.86
NE_m	2.25	1.99	2.48	2.15
NE_g	1.48	1.31	1.65	1.43