1993

Net Energy of Soybean Mill Run for Growing Cattle

C. P. Birkelo
South Dakota State University

D. Thomson
South Dakota State University

NET ENERGY OF SOYBEAN MILL RUN FOR GROWING CATTLE

C. P. Birkelo[1] and D. Thomson[2]
Department of Animal and Range Sciences

CATTLE 93-6

Summary

The objective of the experiment was to estimate the net energies for maintenance (NE_m) and gain (NE_g) of soybean mill run (SMR), a by-product typically containing about 90% soyhulls. Six steers with an average weight of 288 kg were alternately fed pelleted test diets at intakes varying from 3.6 to 9.4 kg per day in an energy balance experiment arranged in a crossover design. The test diets contained either 96.6% alfalfa (ALF) or 46.6% alfalfa and 50.0% soybean mill run (ALFSMR). Energy intake from feed and losses in feces and urine were determined from total collections. Energy lost as methane and heat were determined by indirect respiration calorimetry while the steers were fed and also while fasted. Dry matter (DM), neutral detergent fiber and acid detergent fiber digestibilities were greater ($P<.05$) for the ALF diet than the ALFSMR diet (66.7 vs 58.1%, 63.3 vs 52.5%, and 59.7 vs 45.6%, respectively). Diet protein digestibilities did not differ ($P>.20$). Fecal energy loss was greater for the ALF diet than the ALFSMR diet (41.8 and 34.9% of gross energy intake, $P<.01$), while urine and methane energy losses did not differ (2.6 vs 2.3% and 5.1 vs 4.8% of gross energy intake, respectively, $P>.20$). Diet digestible and metabolizable energy estimates (Mcal/kg of DM) were 2.56 and 2.21 for ALF and 2.83 and 2.51 for ALFSMR, respectively. Partial efficiencies of ME use for maintenance (k_m) and gain (k_g) did not differ between diets ($P>.20$). Using pooled k_m and k_g values, diet NE_m and NE_g estimates (Mcal/kg of DM) were 1.61 and .83 for ALF and 1.81 and .93 for ALFSMR, respectively. These data suggest that soyhulls, the major component of SMR, had NE_m and NE_g values of 1.98 and .99 Mcal per kg of DM, respectively.

Key Words: Soybean Mill Run, Soyhulls, Net Energy, Cattle

Introduction

Energy supplements are frequently used to support greater levels of production in cattle fed forage diets. The use of grain as an energy source in these situations can result in two problems. First, acidosis resulting from grain consumption that is too great or too rapid for the rumen to handle can reduce animal performance and health. Second, the drop in rumen pH reduces digestion of fiber provided by the forage.

The use of soyhulls instead of grain offers an alternative for energy supplementation that avoids these problems because soyhulls are highly digestible yet high in fiber and more slowly digested than grain. Net energy values for soyhulls and products containing soyhulls have been inferred from a variety of measures such as chemical analysis and animal performance but have not been directly determined.

Soybean mill run (SMR) is a widely available by-product of soybean processing that typically contains about 90% soyhulls. The objective of this study was to determine the net energies for maintenance (NE_m) and gain (NE_g) of SMR for growing cattle.

[1]Assistant Professor.
[2]Former Graduate Assistant.

Materials and Methods

Six crossbred steers averaging 288 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 complete pelleted test diets containing either 96.6% sun-cured alfalfa (ALF) or 46.6% sun-cured alfalfa and 50.0% SMR (ALFSMR, Table 1). Alfalfa pellets were reground prior to mixing with other ingredients. SMR appeared to have been coarsely ground and was used as received. Based on chemical analysis, SMR was estimated to contain 90.9% soyhulls and 9.1% split soybeans. Test diets were fed at 90% of ad libitum for 7 days immediately prior to and 6 days during collection periods 1 and 3. Intakes were restricted to what was estimated to be 1.1 times the maintenance requirement for 7 days prior to and 6 days during collection periods 2 and 4. Groups were switched between test diets after collection period 2. Intakes ranged from 4.0 to 8.6 kg and 3.2 to 8.1 kg of dry matter (DM) for ALF and ALFSMR diets, respectively.

Table 1. Test diet compositions (dry matter basis)

	Diets	
Item	ALF	ALFSMR
Ingredient	Percent	
Alfalfa	96.6	46.6
Soybean mill run		50.0
Molasses	2.0	2.0
Trace mineral salt	.7	.7
Dicalcium phosphate	.7	.7
Analysis		
Gross energy, kcal/g	4.39	4.31
Crude protein, %	16.4	15.2
Neutral detergent fiber, %	51.0	52.4
Acid detergent fiber, %	33.0	34.3
Acid detergent lignin, %	8.2	3.6
Ash, %	9.0	7.7

Weights of feed offerings and refusals, feces, and urine were recorded during each collection period. With the exception of urine, samples were analyzed for DM, neutral detergent fiber (NDF), acid detergent fiber (ADF), acid detergent lignin (ADL), and ash. All samples were analyzed for gross energy (GE) by complete combustion and crude protein (CP).

During each collection period, every steer spent two 23-hour periods in one of four indirect, respiration calorimeters for determination of oxygen consumption and carbon dioxide and methane production from which heat production was calculated. 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. After collection period 4, the steers were fed the ALF diet at 1.65 times the estimated maintenance requirement for 2 weeks and then fasted for 5 days. Additional calorimetry measurements were taken on days 4 and 5 of the fast.

Digestible energy was calculated as feed GE minus energy lost in the feces (FE). Metabolizable energy (ME) was calculated as GE minus FE, urinary energy (UE), and energy in the form of methane (CH_4E). The partial efficiencies with which ME was used for maintenance (k_m) or gain (k_g) represent the change in energy retained in the body per unit change in ME consumed and were derived from a semilog regression of heat production on ME intake. Net energies for maintenance and gain were the product of ME and the respective partial efficiencies. The ME requirement for maintenance (ME_m) was the ME intake necessary to result in no gain or loss of energy by the animal.

The data were statistically analyzed for the discrete effects of diet and steer, with intake level included as a continuous variable. Least squares means adjusted for steer and intake are reported by diet.

Results and Discussion

Digestibility data are presented in Table 2. Dry matter, NDF, and ADF digestibilities were 14.8, 20.6, and 30.1% greater for the ALFSMR diet than the ALF diet ($P<.05$). In contrast, diet CP digestibilities were not different ($P>.20$). Differences in DM and fiber digestibilities are likely due to a large extent to less lignification of soyhull fiber as indicated by the acid detergent lignin (ADL) content of the ALFSMR diet compared to ALF (Table 1). The data suggest that SMR is considerably more digestible than forages, although not as digestible as corn grain. In general, level of intake did not affect digestibilities ($P>.20$). This may have been due to the fact that the diet components were of relatively small particle size prior to pelleting and would have had high rates of passage even at low intakes.

The partitioning of feed GE differed between diets only with respect to FE losses (Table 3). Fecal energy accounted for 34.9% of ALFSMR diet GE compared to 41.8% for the ALF diet ($P<.01$). Losses of UE and CH_4E did not differ between diets ($P>.20$) and were 2.6 and 5.1% of GE for ALF and 2.3 and 4.8% for ALFSMR diets, respectively. The DE and ME estimates for ALF were 2.56 and 2.21 Mcal per kg of DM and for ALFSMR were 2.83 and 2.51 Mcal per kg of DM, respectively.

Neither k_m nor k_g were affected by diet ($P>.20$). It is generally accepted that diet composition has little effect on k_m and test diet values were similar to those predicted by published equations. However, k_g usually increases with increasing metabolizability of the diet. As such, ALFSMR would be expected to have a k_g .06 units greater than ALF. Previous work suggests that pelleting eliminates metabolizability differences in k_g between forages. Additionally, because of their high fiber content, soyhulls result in a rumen volatile fatty acid profile more closely resembling that of forages than mixed diets with comparable ME content. Because partial efficiencies are typically estimated from metabolizability, either of these two factors, if not considered, could result in overprediction of k_g and ultimately NE_g.

Due to the absence of a diet effect on k_m and k_g, pooled estimates (k_m = .73, k_g = .37) were used in the calculation of NE_m and NE_g values. The ALFSMR diet contained 12% more NE_m and NE_g per kg DM than the ALF diet (NE_m = 1.81 vs 1.61, NE_g = .93 vs .83). Estimates of SMR NE_m and NE_g, calculated by difference, were 2.00 and 1.03 Mcal per kg DM. Assuming published NE_m and NE_g values for dehulled soybeans of 2.27 and 1.57 Mcal per kg DM, cleaned soyhulls would contain 1.98 and .99 Mcal NE_m and NE_g per kg DM, respectively. Previously reported estimates have ranged from 1.44 to 1.86 per Mcal NE_m and .86 to 1.22 Mcal NE_g per kg DM.

In summary, greater NE content of SMR compared to alfalfa was due solely to less FE loss. No differences in UE, CH_4E, or heat increment relative to GE content were observed.

Table 2. Test diet component digestibilities[a]

Component	Diet[b] ALF	ALFSMR	RSD[c]
	Percent		
Dry matter[d]	58.1	66.7	3.1
Crude protein	69.0	69.3	2.7
Neutral detergent fiber[d]	52.5	63.3	5.3
Acid detergent fiber[d]	45.6	59.7	6.3

[a]Covariately adjusted for intake level when significant.
[b]ALF = alfalfa diet, ALFSMR = alfalfa-soybean mill run diet.
[c]Residual standard deviation.
[d]Diet effect significant (P<.05).

Table 3. Energy partitioning[a]

Component	Diet[b] ALF	ALFSMR	RSD[c]
Fecal energy, $kcal \cdot BW^{-.75} \cdot d^{-1}$[def]	129.7	108.4	15.9
Urinary energy, $kcal \cdot BW^{-.75} \cdot d^{-1}$[e]	8.1	7.1	2.2
Methane energy, $kcal \cdot BW^{-.75} \cdot d^{-1}$[e]	15.9	15.3	1.6
Energy digestibility, %	58.2	65.7	14.4
Energy metabolizability, %	50.4	58.1	4.5
ME_m, $kcal \cdot BW^{-.75} \cdot d^{-1}$[g]	98.8	100.3	
k_m[h]	.73	.72	
k_g[i]	.40	.36	
Digestible energy, Mcal/kg DM	2.56	2.83	
Metabolizable energy, Mcal/kg DM	2.21	2.51	
Net energy for maintenance, Mcal/kg DM	1.61	1.81	
Net energy for gain, Mcal/kg DM	.83	.93	

[a]Covariately adjusted to gross energy intake of 310.4 $kcal \cdot BW^{-.75} \cdot d^{-1}$.
[b]ALF = alfalfa diet, ALFSMR = alfalfa-soybean mill run diet.
[c]Residual standard deviation.
[d]Diet effect significant (P<.01).
[e]Gross energy intake significant (P<.01).
[f]Diet x GE intake significant (P<.05).
[g]Metabolizable energy required for maintenance.
[h]Partial efficiency of ME used for maintenance.
[i]Partial efficiency of ME used for gain.