Effects of Dietary Energy Density on Diet and Nutrient Digestibility in Beef Cattle Diets

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Summary

Steers were fed diets containing energy concentrations of 2.4, 2.7, or 3.0 Mcal of ME/kg of DM to evaluate nutrient and diet digestibility and to determine the existence of associative effects when feeding diets with varying forage and concentrate ratios. The steers were placed in metabolism crates for total fecal collection. Dry matter digestibility was higher for diets with greater energy density. The 2.7 Mcal/kg diet showed a small negative associative effect on digestibility and the non-fiber carbohydrate fraction was the nutrient that had an inhibition on digestion. The results indicated that diets varying in concentration of forage and concentrate may have different digestibilities and nutritional values.

Introduction

There is a strong relationship among dietary energy density, diet digestibility, and performance of cattle. Diets with higher energy density usually have higher digestibility, and diets with lower energy density have lower digestibility. In addition, cattle fed diets with higher energy density are more efficient than cattle fed diets with lower energy density. The inclusion of forage in feedlot cattle diets decreases animal efficiency and also forage is usually more expensive than concentrate feeds when based on cost per unit of net energy. However, forage is an essential component of the diet to maintain rumen function, regulate rumen pH, reduce acidosis and rumen disorders, stimulate chewing and rumination, decrease incidence of liver abscess, and optimize rate of feed passage and retention time in the rumen. The efficacy with which forage supplementation will influence performance and digestibility depends on dietary concentration, physical form, and source.

Apparent digestibility of a mixture of ingredients in a diet may be different from the sum of the apparent digestibility of its individual constituents, which are called associative effects. Therefore, a mixture or combination of feeds may have a different nutritional value than the sum of the values of its individual components. This phenomenon occurs when concentrates and forages are fed together.

This study was designed to evaluate nutrient and diet digestibility of diets varying in energy concentrations and also to examine the existence of associative effects when feeding different forage:concentrate ratios (F:C).

Materials and Methods

Six crossbred steers with an initial average weight of 452 kg were placed in metabolism crates for total fecal collection. The steers were used in a 3 x 3 Latin Rectangle design repeated two times. Each experimental period consisted of 14 days, with diet adaptation during days 1-9 and sampling during days 10-14. The steers were randomly assigned for each of the three dietary treatments. The treatments were composed of diets with energy concentrations of 2.4, 2.7, or 3.0 Mcal of ME/kg of DM (65:35, 37:63, or 12:88 F:C, respectively). Dietary treatments are shown in Table 1. The steers were fed *ad libitum* twice daily at 7:30 a.m. and 7:30 p.m., except during days 8-14 the steers were fed at 90% of previous *ad libitum* intake. Restricting feed intake at 90% level minimized feed refusals. Feed intake was recorded daily. The steers were kept in a room with constant 16 hours of light and 8 hours of dark at approximately 20°C.

Approximately 250 grams were collected twice/day during feeding from each diet on days 8-14 of each experimental period. The daily samples were mixed together and the composite samples were used for analysis. Individual feeds were also collected for analysis. Total feed refusals for each animal were collected on days 8-14 and analyzed for dry matter. Total feces collection was performed daily during days 10-14. Daily feces from each animal were weighed, well mixed, and 5% of the weight kept as a sample. Each sample was stored at 4°C in a plastic bag during the collection period (days 10-14). Thymol as a preservative was added daily with the sample. At end of the collection period, fecal samples for each animal were mixed. One portion of the composite sample was dried and stored for later analysis. Another portion was frozen at –20°C for later nitrogen analysis.

Data were analyzed as 3 x 3 Latin Rectangle repeated twice using the PROC GLM procedure of SAS. Data were considered statistically significant at $P<.05$.

Table 1. Composition of the diets (% of dry matter).

	Diet Mcal ME/kg		
Ingredient	2.4	2.7	3.0
Alfalfa hay	64.99	37.26	11.52
Cracked corn	33.23	58.12	76.81
Cane molasses	1.03	0.89	0.92
Soybean meal	0.00	2.24	8.45
Urea	0.30	1.04	0.62
Premix[a]	0.15	0.15	0.15
Salt	0.30	0.30	0.30
Limestone	0.00	0.00	1.23

[a] Provided trace minerals, sulfur, and vitamin A.

Results and Discussion

Digestibilities of the three diets are shown in Table 2 and Figure 1. Dry matter (DMD) and organic matter digestibility (OMD) were significantly different among treatments (P<.05). There seemed to be a negative associative effect on digestion of DM and OM for the 2.7 Mcal/kg diet when compared with the other two diets. Diets containing combinations of forages and concentrates might be less digestible than predicted from the digestibility of the individual ingredients. When forage is added to grain-based diets, there is an increase in saliva, rumination, and rumen contractions. Then, there is an increase in pressure in the liquid fraction, so that liquid fraction and small particles leave the rumen more rapidly and substantial quantities of starch can be excreted in the feces. In this study, non-fiber carbohydrate (NFC) was the nutrient fraction that was less digestible in the 2.7 Mcal/kg dietary treatment when compared with the other two treatments. NFC digestion was significantly higher (P<.05) for the higher energy level (3.0 Mcal/kg) than the other two levels, despite its higher NFC content. Feeding high concentrate and readily available carbohydrate-based diets increases microbial growth in the rumen, primarily amylolytic bacteria. Crude protein digestion was greater for diets with higher energy density. Cattle fed high concentrate diets have greater rumen microbial growth and protein utilization, and carbohydrate digestion in the rumen is the most important predictor of microbial protein synthesis. Diets with higher fiber concentration had lower acid detergent fiber (ADF) and neutral detergent fiber (NDF) digestibility than diets with low fiber content. Fiber is the diet component that primarily limits apparent digestibility of ruminant diets.

The nutrient concentrations in the diets are shown in Table 3, and they are based on analysis of ingredients. The alfalfa hay fed in this study contained: 13.1% CP, 52.0% NDF, 42.5% ADF, and 93.4% OM as percentage of DM.

Table 2. Effects of dietary treatments on apparent total tract digestibility.

	Diets (Mcal of ME/kg)			
Component	2.4	2.7	3.0	SE[d]
Apparent total tract digestion, %				
Dry matter	66.03[c]	69.45[b]	79.26[a]	0.86
Organic matter	67.10[c]	70.76[b]	81.19[a]	0.82
Non-fiber carbohydrate	81.06[b]	78.38[b]	86.64[a]	1.08
Neutral detergent fiber	50.25[b]	53.81[ab]	56.11[a]	1.78
Acid detergent fiber	50.55[b]	51.75[b]	55.55[a]	1.13
Crude protein	66.10[c]	70.15[b]	74.90[a]	0.91
Fat	67.13[a]	62.55[b]	64.88[ab]	1.27

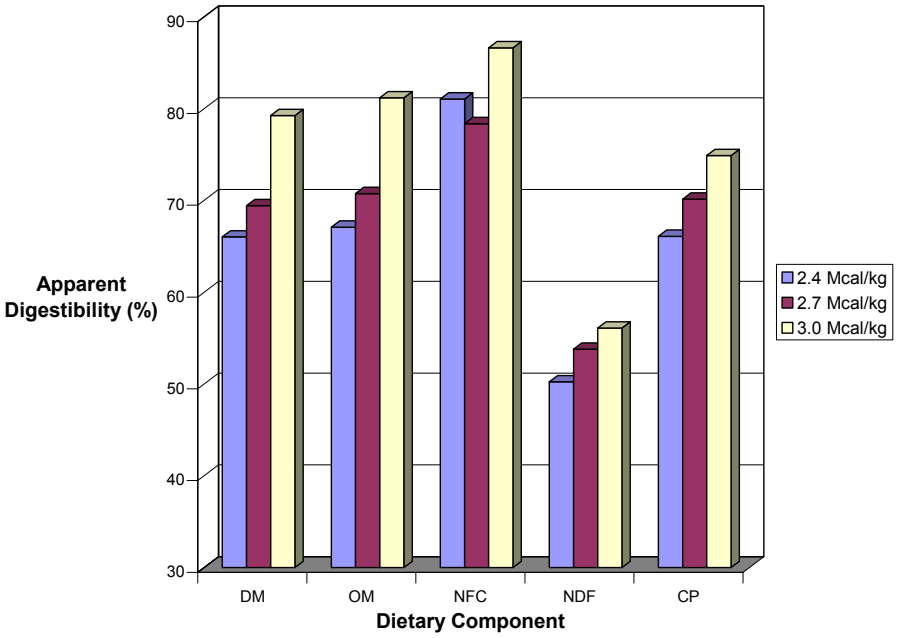
[a, b, c,] Means within rows with different superscripts differ (P<.05).

[d,] Standard error of means (SEM).

Table3. Nutrient composition of diets.

	Diets (Mcal of ME/kg of DM)		
Variable	2.4	2.7	3.0
Dry matter %	90.2	90.4	90.8
Nutrient as % DM			
Organic matter	96.1	96.3	96.6
Crude protein	12.2	13.9	14.0
Neutral detergent fiber	36.4	24.1	12.8
Acid detergent fiber	28.5	17.5	7.5
Non-fiber carbohydrate	45.7	55.9	67.0
Fat	1.8	2.4	2.8

Figure 1. Effects of dietary treatments on apparent total tract digestibility.



Implications

Feeding diets containing forage and concentrates in different ratios may affect digestibility and nutritional value of its components. These effects are due to associative effects as a result of feeding combinations of forage and concentrates.