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Determination of the Metabolizable Energy Concentration of Three Corn Hybrids Fed to Growing Pigs

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Story in Brief

Corn is the major cereal grain source used in swine diets in the United States. In addition, energy is the most expensive "nutrient" in swine diets. As well, the reported variability in energy concentration in feedstuffs calls for a more accurate determination of energy content of specific feedstuffs resulting in more specific diet formulation. This study was designed to estimate energy and nitrogen balance of pigs fed three commercially available corn hybrids (A, B, and C). Eight sets of three littermate barrows (initial weight = 56.4 lb) were fed one of three experimental diets each containing one of the three corn hybrids at 90.48%. Pigs were housed individually in metabolism chambers and were equally fed within replicate. Pigs were allowed a 7-d adjustment period to the diets followed by a 5-d collection of feces and urine. Although dry matter gross energy concentration (kcal/kg) of the diet containing Hybrid C was greater (4337) than the diets containing Hybrids A and B (4306 and 4317), the metabolizable energy (kcal/kg) of the diets containing the three hybrids were 3811, 3838, and 3773 for A, B, and C, respectively. Thus, metabolizable energy was 88.51, 88.92, and 86.99% of gross energy for the diets containing the three hybrids, respectively. In addition, nitrogen absorption, as a percentage of intake, was 85.49, 85.56, and 81.61% for the diets containing Hybrids A, B, and C, respectively. These results suggest only minor differences in the metabolizable energy content of the three corn hybrids; however, based on these data, gross energy of corn is not indicative of the metabolizable energy concentration. As well, nitrogen absorption varies among corn hybrids.

Key Words: Pigs, Corn, Metabolizable Energy, Nitrogen

Introduction

Because corn is the major grain source fed to pigs in the United States and energy is the most costly "nutrient" in swine diets, formulating rations using feedstuffs of known metabolizable energy concentration would be ideal. However, Cromwell et al. (1999) reported that samples of corn varied in their nutrient composition, including variations in lysine content, depending on the area of origin. With this in mind, variations in energy density may not only exist across types of feedstuffs, but also may vary within a specific feedstuff. Many studies have reported a wide range of energy values for corn fed to pigs. For example, Wiseman et al. (1982) reported a metabolizable energy concentration of 3262 kcal/kg for corn, while Morgan et al. (1975) reported a value of 3522 kcal/kg. According to the NRC (1998), the metabolizable energy of corn is 3420 kcal/kg. Heartland Lysine (1996) also reports a metabolizable energy concentration of 3397 kcal/kg for corn. Thus, determining the metabolizable energy for feedstuffs, or different hybrids, would allow for more specific diet formulation. The objective of this study was to determine metabolizable energy concentrations of three corn hybrids (A, B, and C).

Materials and Methods

Balance Procedure. Twenty-four barrows, initially averaging 56.4 lb body weight, were allotted to three dietary treatments with eight replicates per treatment. The barrows were allotted based on weight, keeping average replicate weights similar and littermates spread across treatments. Three diets were formulated to contain 90.48% of one of three commercially available corn hybrids (A, B, and C) (Table 1). The hybrids were grown in the same location during the same year, and they were ground to a common particle size prior to mixing the experimental diets. Casein and amino acids were added to the diets to meet or exceed amino acid requirements and limestone and dicalcium phosphate were utilized as sources of calcium and phosphorus. Pigs were fed in stainless steel feeders and were housed in metabolism chambers that allowed for the separate collection of urine and feces. Pigs had *ad libitum* access to water and an effort was made to keep feed intakes similar within replicate.

Prior to collection, pigs underwent a 7-d adjustment period. Then a 5-d period was used for total but separate collection of feces and urine. Chromic oxide (.2%) was fed in the morning feeding on d 0 and 5 to mark the beginning and ending of the collection period. During the collection period, feces, urine, and refused feed were collected. Fecal weight and urine volume were recorded daily and were frozen for subsequent lab analysis.

Feed and Fecal Analysis. Dry matter was determined for the corn hybrids, the three treatment diets, and the fecal samples by drying a subsample of each at 100^{0}C for 24 h. Freeze dried fecal samples and as-is samples of the corn hybrids and the three treatment diets were analyzed for gross energy using bomb calorimetry. Nitrogen content of the feces and diets was determined by a combustion method1 in accordance with AOAC (1995).

Urine Analysis. Solkafloc® samples, a cellulose product, were dried at 100^{0}C for 24 h to achieve a dry matter state and were weighed prior to and

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following drying. A two mL subsample of each composited urine sample was added to approximately 0.5 g of dry Solkafloc®. This wet mixture was weighed and then dried at 50^0C for 24 h. The samples were then weighed and each sample was pelleted and later combusted to determine gross energy in a bomb calorimeter. Calculations were then made to determine the actual gross energy of the urine portion.

Data were analyzed as a randomized complete block design using analysis of variance procedures as described by Steel et al. (1997). Pre-planned non-orthogonal contrasts were used to test treatment means. Pig served as the experimental unit.

Results and Discussion

All data are reported on a dry matter basis unless otherwise noted. Average daily feed intake was similar (P>.10) across all three diets (Table 2). Daily urine excretion was similar (P>.10) for all three treatments. Daily fecal excretion was higher (P<.04) for the diet containing Hybrid C as compared with the diet containing Hybrid B.

Energy. The gross energy concentrations of the three corn hybrids were 4349, 4323, and 4467 kcal/kg, and the gross energy concentrations of the diets were 4306, 4317, and 4337 kcal/kg, respectively (Table 2). Fecal energy concentrations were lower (P<.01) for the diet containing Hybrid B (4368 kcal/kg) than the diets containing Hybrid A (4494 kcal/kg) and Hybrid C (4481 kcal/kg). The diet containing Hybrid C resulted in a greater (P<.03) excretion of fecal energy as compared with the diet containing Hybrid B. By subtracting the energy excreted in the feces from gross energy intake and adjusting for average daily feed intake, the resulting digestible energy concentrations were 3884, 3909, and 3836 kcal/kg with the diet containing Hybrid B being greater (P<.09) than the diet containing Hybrid C. The digestible energy minus the urinary gross energy excretion, along with adjustment for average daily feed intake, resulted in metabolizable energy concentrations of 3811, 3838, and 3773 kcal/kg. For each of the treatments, the digestible energy as a percentage of gross energy, was 90.21, 90.56, and 88.45%, respectively. The diet containing Hybrid C was lower (P<.10) than the diets containing Hybrids B and A. Metabolizable energy was found to be 98.12, 98.19, and 98.34% of digestible energy for the three respective treatments. The metabolizable energy, as a percentage of gross energy, was also found to be lower (P<.06) for the diet containing Hybrid C (86.99%) than the diet containing Hybrid B (88.92%).

Nitrogen. The nitrogen content of the three diets was 2.287, 2.185, and 2.215% (Table 2). Given the average daily feed intake of each dietary treatment, daily nitrogen intakes were similar for the three treatments. After determining the nitrogen content of the fecal samples, fecal nitrogen excretion was greater (P<.03) for the diet containing Hybrid C as compared with the diet containing Hybrid B. Nitrogen absorption, as a percentage of intake, was lower ($P<.06$) for the diet containing Hybrid C compared with the diets containing Hybrids A and B.

Metabolizable energy concentrations of the dietary treatments were corrected to a metabolizable energy concentration, on an as-fed basis, for each of the corn hybrids. An assumption was made that casein contributed 218 kcal/kg to each diet (Heartland Lysine, 1996). Following removal of casein from the metabolizable energy value of the diet, it was assumed that the remaining metabolizable energy was attributed to each corn hybrid. This remaining metabolizable energy was then divided by the percentage of each corn hybrid in their respective diets (90.48%) to give a metabolizable energy concentration for each corn hybrid (Figure 1). These resulting metabolizable energy concentrations were 3523, 3560, and 3493 kcal/kg for Hybrids A, B, and C, respectively. The lower value for Hybrid C may be a result of the increased fecal nitrogen excretion from that dietary treatment due to the loss of energy associated with the excretion of nitrogen. The metabolizable energy concentrations for the corn hybrids used in this study are higher than the metabolizable energy concentrations for corn as reported by Wiseman et al. (1982), Heartland Lysine (1996), and NRC (1998) of 3262, 3397, and 3420 kcal/kg, respectively. However, the metabolizable energy concentrations determined in this study are similar to those found by Morgan et al. (1975) who reported a metabolizable energy concentration for corn of 3522 kcal/kg.

Implications

This study indicates that variations in energy concentration, as well as nitrogen absorption, existed in the three corn hybrids tested. Based on these data, gross energy concentration of corn is not an accurate indicator of the metabolizable energy concentration as shown by the variation in metabolizable energy to gross energy ratios for the three corn hybrids. Determination of metabolizable energy concentration is needed for various hybrid grains in order to perform more specific diet formulation.

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Table 1. Composition of diets (as-fed basis).

Ingredient	**% of Diet**
Corn[a]	90.48
Casein	5.04
L-lysine HCl	.50
DL-methionine	.17
L-threonine	.25
L-tryptophan	.08
L-isoleucine	.13
L-valine	.04
Dicalcium phosphate	2.19
Limestone	.57
Salt	.25
Trace mineral/Vitamin premix	.30
Calculated composition (%)	
Total lysine	1.00
Calcium	.80
Phosphorus	.70

[a] Hybrids A, B, and C were added to constitute the three dietary treatments.

Table 2. Energy and nitrogen balance for pigs fed three corn hybrids[a].

Diet:	1	2	3	
Hybrid:	A	B	C	SE
DM basis:				
Corn GE, kcal/kg	4349	4323	4467	
ADF, g/d	1037	990	1065	3.8
GE (diet), kcal/kg	4306	4317	4337	
GE intake, kcal/d	4464	4271	4671	161
Daily fecal excr, g/d	94.4[bc]	88.9[b]	114.2[c]	7.7
Fecal GE excr, kcal/d	4494[b]	4368[c]	4481[b]	27.3
Daily urine excr, g/d	34.7	32.4	32.8	1.5
Urine GE, kcal/kg	2179	2154	2081	43.5

Urine GE excr, kcal/d	75.2	70.3	68.1	3.4
DE, kcal/d	4025	3867	4085	140
DE, kcal/kg	3884[bc]	3909[b]	3836[c]	28.6
ME, kcal/d	3950	3979	4017	139
ME, kcal/kg	3811	3838	3773	28.1
DE:GE, %	90.21[b]	90.56[b]	88.45[c]	.66
ME:DE, %	98.12[b]	98.19[bc]	98.34[c]	.08
ME:GE, %	88.51[bc]	88.92[c]	86.99[b]	.65
Diet N, %	2.287	2.185	2.215	
N Intake, g/d	23.69	21.62	23.59	.84
Fecal N excr, g/d	3.454[bc]	3.129[b]	4.332[c]	.35
N absorbed, g/d	20.34	18.49	19.26	.70
N absorption, %	85.49[b]	85.56[b]	81.61[c]	1.3

[a]Least squares means of eight individually penned pigs per treatment.
[b,c]Means within a row with different superscripts differ (P<.10).

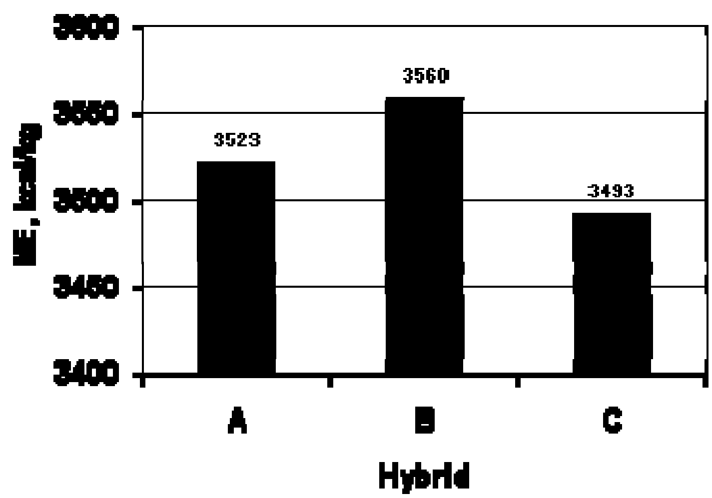

Figure 1. Metabolizable energy concentration of the three corn hybrids on an as-fed basis.

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