Energy and Nitrogen Balance of Pigs Fed Commercial Red Sorghum, Identity-Preserved White Sorghum, or Corn

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Story in Brief

With the possible increased use of sorghum in swine diets in areas where it is more accessible than corn, evaluation of the energy availability of sorghum is critical in determining its true economic value. This experiment was conducted to determine the metabolizable energy (ME) concentration and nitrogen digestibility of one corn and two sorghum samples grown within a 50-mile radius during the same crop year. Twelve sets of three littermate barrows (57.1 lb) were housed individually and allotted randomly to three dietary treatments. Experimental diets (1.08% Lys) consisted of mill-run corn (C), mill-run red sorghum (RS), or an identity-preserved white endosperm sorghum variety (WS) at 90.0% of the diet. Pigs were allowed a 5-d adjustment period to the diets followed by a 4-d collection of feces and urine. Only slight differences were observed in gross energy content of the diets (4,427, 4,312, and 4,301 kcal/kg for the corn, red sorghum, and white sorghum diets). Energy from corn was more efficiently utilized by pigs, as shown by an increase in ME as a percentage of gross energy (89.3%), while the white sorghum (85.0%) and red sorghum (83.8%) were slightly different. The adjusted ME concentrations of the corn, red sorghum, and white sorghum grains, on an as-fed basis, were 3,600, 3,325, and 3,370 kcal/kg. The corn diet also resulted in higher nitrogen absorption and retention than the sorghums. These results suggest that energy and nitrogen digestibilities are lower in sorghum versus corn, but are similar between mill-run red sorghum and white sorghum.

Key Words: Metabolizable Energy, Sorghum, Corn, Pigs

Introduction

Cereal grains are the primary ingredients in diets fed to pigs, and thus the energy availability of these cereals is economically critical. Least-cost formulation of diets should be based on accurate estimations of available energy of grains being used. Although corn is the major grain source fed to pigs in the United States, grain sorghum is more easily grown in the southern portion of the United States. Due to the accessibility of sorghum in these regions, it may be a more economically feasible form of energy in swine diets. Diggs et al. (1965) reported the ME concentrations of corn and sorghum, on an as-fed basis, were 3,339 and 3,169 kcal/kg, respectively. Lin et al. (1987) determined ME content of corn and sorghum to be 3,478 and 3,498 kcal/kg, respectively. According to NRC (1998), the metabolizable energy concentration of corn is 3,420 kcal/kg, and the ME content of sorghum is 3,340 kcal/kg. Due to the variation in published energy values of sorghum, analysis of new varieties for ME content would prove useful in diet formulation.

The reduced amount of pigment in white sorghums results in a whiter colored fat tissue in pigs fed these grains. Because buyers of exported U.S. pork will pay a premium for pork containing whiter fat, the use of these grains in swine diets is being evaluated. The objective of this study was to compare the metabolizable energy concentration of sorghum versus mill-run corn and also to compare mill-run red sorghum with an identity-preserved white sorghum through the use of a total collection energy and nitrogen balance experiment.

Materials and Methods

Twelve sets of three littermate barrows, initially averaging 57.1 lb BW, were allotted in a randomized complete block design 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 90.0% of one of three grain samples (mill-run corn, mill-run red sorghum, and a white endosperm sorghum variety) grown within a 50-mile radius in southwest Kansas and the Oklahoma panhandle during the same crop year (Table 1). 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. The three grains were each mixed thoroughly with the specified ingredients in a horizontal paddle mixer for production of the experimental diets.

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

Ingredient	**%**
Corn/sorghum	90.00
Casein, dried	6.14
L-Lysine HCl	.50
DL-Methionine	.14
L-Threonine	.19
L-Tryptophan	.08
L-Isoleucine	.10
L-Valine	.03
Dicalcium phosphate	1.61
Limestone	.66
Salt	.25
Trace mineral/vitamin	.30
Calculated composition (%)	
Total lysine	1.08
Calcium	.70
Phosphorus	.60

[a]Corn, red sorghum, and white sorghum were added to constitute the three diets.

Figure 1. Samples of red and white sorghum used in this study with Minolta color scores. Higher L*, a*, and b* values indicate higher degrees of whiteness, redness, and yellowness, respectively.

Red sorghum

L*	75.51
a*	4.06
b*	14.46

White sorghum

L*	78.74
a*	2.81
b*	12.28

Pigs were individually housed in metabolism chambers that allowed for the separate collection of feces and urine. Pigs had *ad libitum* access to water and an effort was made to keep feed intakes similar within replicate. The amount of feed consumed and feed wastage were also measured over the 4-d collection period. Prior to collection, pigs underwent a 5-d adjustment period to the chambers and their respective dietary treatments. Then a 4-d period was used for the total but separate collection of feces and urine. Chromic oxide (.2%) was fed in the morning feeding on days 0 and 4 of the collection period for the purpose of a fecal marker to signify the beginning and ending of fecal collection. Collection procedures and feed, fecal, and urine analyses were performed as described by Fent et al. (2001). Minolta color scores were performed on the two sorghum samples to determine their relative color differences by light reflectance (Figure 1).

Data were analyzed as a randomized complete block design using analysis of variance procedures as described by Steel et al. (1997). The model included the effects of block (rep), treatment, and block x treatment, which served as the error term. Average daily feed intake was included as a covariate in order to equalize feed intake across treatments. Orthogonal contrasts, which consisted of corn versus the average of the two sorghums and the red sorghum versus the white sorghum, were used to test treatment means. Pig served as the experimental unit.

In a previous experiment in our lab, the metabolizable energy concentration of casein for pigs was determined. This analyzed ME on a DM basis was 4,560 kcal/kg. In order to determine the ME concentration of the grains in the experimental diets, the ME supplied by casein was subtracted from the ME of the diets, assuming that the only other ME supplied in the diet was supplied by casein. Since casein was included at 6.14% of the diet, then the ME supplied by casein was 280 kcal/kg (4560 * 0.0614). After subtracting this value, the resulting value was divided by the percentage of grain in the diet (90.0%), which resulted in ME of the grains on a DM basis.

Results and Discussion

All data are reported on a dry matter basis unless otherwise noted. Nutrient composition of the grains and diets are included within Tables 2 and 3. Daily fecal excretion was lower ($P<.01$) for pigs consuming the corn diet as compared with those fed sorghum. Daily fecal excretion was greater ($P<.03$) for pigs fed the red sorghum as compared with white sorghum. Daily urine excretion was greater ($P<.05$) for pigs fed corn as compared with those fed sorghum, but it was similar ($P>.10$) for pigs fed the two sorghums.

Energy. All energy balance data are reported in Table 2. The gross energy concentrations of the corn, red sorghum, and white sorghum grains were 4,495, 4,379, and 4,420 kcal/kg, and the gross energy of the respective diets was 4,427, 4,312, and 4,301 kcal/kg. Fecal energy concentration was lower ($P<.01$) for pigs fed the corn diet compared with those fed sorghums, and it was greater ($P<.01$) for pigs fed white sorghum as compared with those fed red sorghum. However, fecal energy excretion (kcal/d) was greater ($P<.01$) for pigs consuming sorghum as compared with those fed corn, but little difference ($P=.18$) was observed between pigs fed the two sorghums. After substracting the energy excreted in the feces from the gross energy intake, the resulting digestible energy concentration of corn was higher ($P<.01$) than the sorghums, but only a slight difference was observed between the two sorghums ($P=.18$). Pigs fed sorghum had higher ($P<.01$) urinary energy concentration ($P<.01$) versus those fed corn, with no difference ($P>.10$) observed for pigs fed white vs red sorghum. Urinary energy excretion per day was similar for pigs fed all treatments ($P>.10$). Upon subtraction of urinary gross energy excretion from the digestible energy concentration, the resulting ME concentration of the corn diet was greater ($P<.01$) than the sorghums, but the red and white sorghum diets were similar ($P>.10$). Digestible energy, as a percentage of gross energy, was greater ($P<.01$) for the corn diet versus the sorghum diets, and the white sorghum was greater (P<.10) than the red sorghum diet. Additionally, ME, as a percentage of gross energy, of the corn diet was greater (P<.01) than sorghums, and the white sorghum diet was slightly greater (P=.15) compared with the red sorghum diet. ME:DE was similar (P>.10) for the three treatments.

Table 2. Energy balance of pigs fed corn and sorghum (DM basis)[a]

Diet:	1	2	3		P<:	
Item Grain:	Corn	Red sorg	White sorg	SE	C vs S[b]	R vs W[c]
Grain GE, kcal/kg	4,495	4,379	4,420			
Grain ash, %	1.295	2.533	2.215			
Grain fat, %	4.447	2.337	2.185			
GE (diet), kcal/kg	4,427	4,312	4,301			
GE intake, kcal/d	5,335	5,198	5,186	7.92	.01	.30
Daily fecal excr., g/d	107.2	165.2	144.3	6.22	.01	.03
Fecal GE, kcal/kg	4,803	4,763	5,069	26.3	.01	.01
Fecal GE excr., kcal/d	514	785	728	28.3	.01	.18
Daily urine excr., g/d	28.0	18.8	19.5	3.11	.05	.88
Urine GE, kcal/kg	2320	2,672	2,766	53.2	.01	.23
Urine GE excr., kcal/d	65.7	50.7	55.0	8.99	.29	.74
DE, kcal/d	4,822	4,413	4,458	33.2	.01	.36
DE, kcal/kg	4,006	3,657	3,704	24.6	.01	.19
ME, kcal/d	4,756	4,363	4,403	32.6	.01	.39
ME, kcal/kg	3,950	3,614	3,656	25.0	.01	.26
DE:GE, %	90.51	84.8	86.12	.53	.01	.10
ME:DE, %	98.62	98.84	98.71	.23	.63	.70
ME:GE, %	89.26	83.81	85.00	.55	.01	.15

[a]Least squares means for eight individually-penned pigs per treatment

[b]C vs S = corn vs average of sorghums

[c]R vs W = red sorghum vs white sorghum

Nitrogen. All nitrogen data are reported in Table 3. Nitrogen intake (g/d) of pigs consuming the corn diet was lower (P<.01) than pigs fed the sorghum diets, but no differences (P>.10) were observed between the sorghums. Daily fecal nitrogen excretion was lower (P<.01) for pigs fed corn versus sorghum, but there was no difference (P>.10) between pigs fed the two sorghums. However, no differences (P>.10) were observed for the amount of nitrogen absorbed (g/d), but nitrogen absorption, as a percentage of intake, was greater (P>.01) for pigs consuming corn as compared with pigs fed sorghum, while no difference (P>.10) was observed between the two sorghums. Daily urinary nitrogen excretion was greater (P<.05) in pigs fed the corn diet than those fed sorghums, but pigs fed the two sorghum treatments were essentially the same (P>.10). Consequently, nitrogen retained (g/d) was similar (P>.10) for pigs consuming the three treatments. However, nitrogen retention, as a percentage of intake, was greater (P<.02) for pigs fed corn than those fed sorghum, but pigs fed white and red sorghum diets were similar (P>.10). The proportion of absorbed nitrogen that was also retained was greater (P<.03) for pigs fed the sorghum diets as compared with pigs fed corn, but it was similar (P>.10) for pigs consuming the two sorghum treatments.

Table 3. Nitrogen balance of pigs fed corn and sorghum (DM basis) [a]

Diet:	1	2	3			
Item — Grain:	Corn	Red Sorg	White Sorg	SE	C vs S[b]	R vs W[c]
Grain N, %	1.495	1.676	1.680			
Grain CP, %	9.34	10.48	10.50			
Diet N, %	2.425	2.608	2.611			
Diet CP, %	15.16	16.30	16.32			
N intake, g/d	29.30	31.49	31.51	.07	.01	.84
Fecal N excr., g/d	3.514	5.797	6.165	.26	.01	.34
N absorbed, g/d	25.78	25.69	25.34	.23	.39	.30
N absorption, %	88.17	81.68	80.85	.68	.01	.40
Urine N excr., g/d	4.303	3.546	3.548	.27	.05	.99
N retained, g/d	21.48	22.15	21.80	.28	.20	.40
N retention, %	72.96	69.98	69.42	.91	.02	.67
N retained: N absorbed	.828	.857	.859	.01	.03	.90

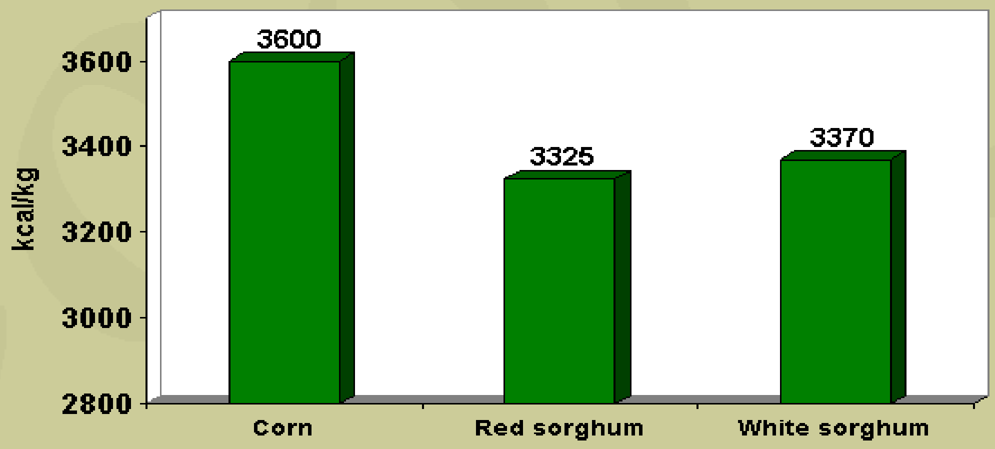
[a]Least squares means for eight individually-penned pigs per treatment

[b]C vs S = corn vs average of sorghums

[c]R vs W = red sorghum vs white sorghum

ME of Corns. The metabolizable energy concentrations of the diets were corrected to a metabolizable energy concentration of each of the respective grains on an as-fed basis. In a previous experiment in our lab, the ME concentration of casein for pigs was determined to be 4,560 kcal/kg (DM basis). Thus, in the present experiment, the ME supplied by casein was subtracted from the ME of the diets, assuming that the only other ME supplied in the diet was supplied by casein. Since casein was included at 6.14% of the diet, then the ME supplied by casein was 280 kcal/kg (4560 * 0.0614). After subtracting this value, the resulting value was divided by the percentage of corn in the diet (90.0%), which resulted in ME of the grains on a DM basis. After adjusting for moisture content, the as-fed metabolizable energy concentrations of the corn, red sorghum, and white sorghum grains were 3,600, 3,325, and 3,370 kcal/kg, respectively (Figure 2). The metabolizable energy concentration of the corn grain used in this study is similar to the ME of three normal corns reported by Fent et al. (2001) which averaged 3,628 kcal/kg (as-fed basis). However, the ME values of corn in this study are higher than those reported by Diggs et al. (1965), Lin et al. (1987), and NRC (1998) which were 3,339, 3,478, and 3,420 kcal/kg, respectively. The sorghums analyzed in this experiment have similar ME content to the value reported by NRC (1998) of 3,340 kcal/kg. However, they are greater in ME than

Figure 2. Adjusted ME of grains (as-fed basis)



those reported by Diggs et al. (1965) (3,169 kcal/kg), but lower than those reported by Lin et al. (1987) (3,498 kcal/kg).

Implications

This study indicates that, of grains grown in the same location during the same crop year, the corn grain was greater in ME content, and pigs fed the corn diet were more efficient in energy utilization and had improved nitrogen balance as compared with those fed the sorghum grains. Metabolizable energy content was similar for the mill-run red sorghum and the white endosperm sorghum variety, and pigs fed the sorghums had similar nitrogen absorption and retention. In this experiment, corn was superior to the sorghums for ME content and nitrogen utilization for pigs. However, more research is needed to determine specific metabolizable energy concentrations of different varieties of sorghum. Cost analysis should also be performed when weighing the value of corn and sorghum fed to pigs in areas were sorghum may be more accessible and purchased at a lower cost than corn.

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