Determination of Amino Acid Digestibility and Calculated Energy Values in High-Protein Sorghum Dried Distillers Grains with Solubles in Growing Pigs[1]

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Summary

An experiment was conducted to determine the digestibility of amino acids (AA) and energy in high-protein sorghum dried distillers grain with solubles (DDGS). Six growing barrows (initially 50 lb) surgically fitted with T-cannulas were randomly assigned to 1 of 2 dietary treatments in a 2-period crossover design. The treatments were a diet with the high-protein sorghum DDGS (50% of the diet) as the only protein source and an N-free diet for determining basal endogenous AA loss. Both diets contained 0.25% chromic oxide as an indigestible marker. Fecal and ileal digesta samples were collected during each period for energy and AA analysis. On the basis of these analyses, apparent (AID) and standardized (SID) ileal digestibility and energy values were calculated. The analyzed CP of the product was 44.5% with a lysine:CP ratio of 3.6%. Crude fat, ADF, and NDF were 2.9, 16.1, and 18.8%, respectively. The AID for lysine, methionine, threonine, and tryptophan were 51.9, 73.0, 60.6, and 71.7%, respectively. The SID values were 53.7, 73.8, 63.0, and 73.8% for lysine, methionine, threonine, and tryptophan, respectively. The analyzed GE of the product was 2,317 kcal/lb of DM. The calculated DE, ME, and NE values were 1,759; 1,610; and 1,023 kcal/lb of DM, respectively. In conclusion, the high-protein sorghum DDGS is higher in CP, AA, Ca, and P but lower in AA digestibility and energy compared with reported values for traditional DDGS.

Key words: amino acid, digestibility, dried distillers grains with solubles, sorghum

Introduction

The United States is the largest producer of sorghum worldwide (472 million bu); Kansas ranks first, producing 40% of U.S. production. Currently, more than 80% of all grain sorghum produced in Kansas is used as livestock feed. Because of the high starch content of sorghum (≈75%), the biofuel industry in Kansas uses sorghum for ethanol production. As of January 2009, a total of 12 dry mill ethanol plants are currently in operation in Kansas with a total capacity of about 450 million gal of ethanol per year. This means that dried distillers grains with solubles (DDGS), a coproduct of ethanol production, is becoming more available for livestock producers in Kansas.

With the technological improvements in ethanol production, companies are also continuously developing value-added ethanol coproducts. White Energy Inc., through its ethanol plant in Russell, KS, produces a high-protein, sorghum-based DDGS for

[1] Appreciation is expressed to White Energy, Inc., Russell, KS, for supplying the high-protein DDGS product.

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use in feeding livestock. The high-protein DDGS is produced by a method called post-fermentation fractionation, which removes a majority of the fiber and oil from a traditional DDGS coproduct. Because this is a relatively new coproduct with potential for use in swine diets, determining the digestibility of nutrients in this DDGS product is needed for more accurate diet formulation. The objective of this experiment was to establish the amino acid (AA) and energy digestibility of a high-protein sorghum DDGS in growing pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocols used in this experiment.

Six growing barrows (initially 50 lb) fitted with a T-cannula on their right flank were randomly allotted to 1 of 2 test diets in a crossover design. The first diet contained 50% of a sorghum-based DDGS; the second diet was N-free for determining basal AA endogenous losses from the small intestine (Table 1). Both diets had chromic oxide added at 0.25% as an indigestible marker. Before the start of the trial, all pigs were put on a common diet for 9 d. The pigs were housed in individual stainless steel metabolism crates with a nipple drinker that allowed unlimited access to water. There were 2 periods in the experiment. Each period consisted of 4 d of adaptation to the diet, fecal sample collection (grab samples) on d 5 and 6, and ileal digesta collection for 10 h each day on d 6 and 7. Each pig was weighed at the beginning of each period before being fed with the next dietary treatment to determine the amount of feed needed per day at a level 3 times the estimated maintenance requirement for energy. Daily feed allocation was divided into 2 equal amounts and was given twice daily at 0600 and 1800 h. Feed was withdrawn at the end of the first period before giving the next test diet to avoid carryover effect. Fecal samples were collected in the mornings of d 5 and 6 and stored in a freezer. Digesta samples were collected by attaching a latex balloon to the cannula. Balloons were removed every 30 min or as soon as they became full and were emptied in a 1-L plastic collection container. All collected samples were stored in a freezer until further processing and chemical analysis were conducted.

At the end of the collection phase, each period's worth of fecal and digesta samples from each pig were combined and homogenized. Subsamples were obtained from the homogenized feces, dried in a forced-air oven at 140°F, and ground for energy analysis. Subsamples of the homogenized digesta were freeze-dried and ground for AA analysis. Energy concentration in the diets, DDGS, and fecal samples were determined using bomb calorimetry. Proximate and AA analyses were conducted on the high-protein sorghum DDGS, diets, and digesta samples. Atomic absorption spectroscopy was used to determine chromic oxide concentration in the diet, fecal samples, and digesta samples. Amino acid analysis for the diets, sorghum DDGS, and ileal digesta samples was conducted at the Agriculture Experiment Station Chemical Laboratories at the University of Missouri-Columbia.

The apparent ileal digestibility (AID) for AA (%) in the high-protein sorghum DDGS diet was calculated using the equation:

$$AID = [1 - (AAd/AAf) \times (Crf/Crd)] \times 100\%$$

where AAd is the concentration of the AA in the ileal digesta (g/kg of DM), AAf is the concentration of the AA in the diets (g/kg of DM), Crf is the chromium concentration in the diet (g/kg of DM), and Crd is the chromium concentration in the ileal digesta (g/kg of DM).

The basal endogenous loss of each AA (g/kg of DMI) at the ileum was determined from the digesta samples obtained when the pigs were fed with the N-free diet with the equation:

$IAA_{end} = [AAd \times (Crf/Crd)]$

By using the values for AID and IAA_{end}, the standardized ileal digestibility (SID) value for each AA (%) was then calculated as:

$SID = [AID + (IAA_{end}/AAf)]$

Digestible energy, ME, and NE values of the high-protein sorghum DDGS were calculated using the following equations:

$DE = -174 + (0.848 \times GE) + \{2 \times [100 - (CP + EE + Ash + NDF)]\} - (16 \times \% ADF)$
(Ewan, 1989)[3]

$ME = 1 \times DE - 0.68 \times CP$
(Noblet and Perez, 1993)[4]

$NE = (.726 \times ME) + (13.3 \times EE) + (3.9 \times starch) - (6.7 \times CP) - (8.7 \times ADF)$
(Noblet et al., 1994)[5]

Results and Discussion

The nutrient composition of the high-protein sorghum DDGS used in the experiment is reported in Table 2. The analyzed CP of the product was 44.5% on an as-fed basis, which is approximately 17% higher than the published average CP value in traditional corn DDGS. The crude fat concentration was only 2.9%, which is lower than the average amount of fat found in traditional DDGS. The ADF value of 16.1% for the high-protein sorghum DDGS product was higher and the NDF value of 18.8% was lower than published traditional corn DDGS values. In addition, both Ca and P concentrations were higher in the high-protein sorghum DDGS than in traditional DDGS.

Amino acid analysis of the DDGS product showed that all AA were present in higher proportions as a result of the high CP value. The recommended lysine:CP ratio for a good-quality DDGS is at least 2.8%. The lysine content of the product was 1.6% on an

[3] Ewan, R.C. 1989. Predicting the energy utilization of diets and feed ingredients by pigs. Pages 271-274 in Energy Metabolism, European Association of Animal Produciton, Bulletin no. 43. Y. van der Honing, W.H. Close, eds. Pudoc, Wageningen, Netherlands.
[4] Noblet, J., and J. M. Perez. 1993. Prediction of digestibility of nutrients and energy values of pig diets from chemical analysis. J. Anim. Sci. 71:3389-3398
[5] Noblet, J., H. Fortune, X. S. Shi, and S. Dubois. 1994. Prediction of net energy value of feeds for growing pigs. J. Anim. Sci. 72(2):344-354.

as-fed basis, which is approximately double what is found in traditional DDGS. This translates to a lysine:CP ratio of 3.6%, indicating a good-quality DDGS.

Although CP and AA profile values of a feed ingredient can indicate its quality, determining how much of the available AA can actually be digested and absorbed in the small intestine is more important when formulating diets and evaluating the product. The AID for lysine, methionine, threonine, and tryptophan were 51.9, 73.0, 60.6, and 71.7%, respectively (Table 3). After the AID values were corrected for basal endogenous AA loss, the SID values were calculated to be 53.7, 73.8, 63.0, and 73.8% for lysine, methionine, threonine, and tryptophan, respectively. These values are lower than those found in traditional corn DDGS with the exception of tryptophan. The overall poorer digestibility of AA was expected because sorghum is known to have lower digestibility of proteins compared to corn, but other factors during processing may have contributed to the lower digestibility of these nutrients.

The calculated energy values for the high-protein sorghum DDGS are listed in Table 4. The DE for this DDGS product was 1,759 kcal/lb of DM, which, as expected, was lower than the DE in traditional DDGS (1,854 kcal/lb DM) because of its lower fat content. The values for ME and NE were 1,610 and 1,023 kcal/lb of DM, respectively.

The results of this experiment showed that the high-protein sorghum DDGS has a higher level of CP and higher proportions of AA, Ca, and P than traditional DDGS. However, this ethanol coproduct has lower AA digestibility and lower energy than traditional DDGS. Therefore, specific AA digestibility and energy values for this high-protein sorghum DDGS product may be used in formulating diets to meet the nutritional requirements of swine.

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

Ingredient, %	Sorghum DDGS	N-free
Cornstarch	43.40	80.90
High-protein sorghum DDGS[1]	50.00	---
Soybean oil	1.00	3.00
Monocalcium P (21% P)	0.00	1.75
Limestone	1.35	0.40
Salt	0.35	0.45
Vitamin premix	0.25	0.25
Trace mineral premix	0.15	0.15
Sow add pack	0.25	0.25
Potassium chloride	---	0.50
Magnesium oxide	---	0.10
Chromic oxide	0.25	0.25
Solka-Floc	---	3.00
Sucrose	3.00	9.00
Total	100.0	100.0
Calculated analysis, %		
Total lysine	0.57	0.00
CP	24.00	0.00
Ca	0.59	0.48
P	0.73	0.37
Available P	0.56	0.37

[1] Dried distillers grains with solubles from White Energy, Inc., Russell, KS.

Table 2. Analyzed nutrient composition of high-protein sorghum DDGS[1]

Nutrient, %	DM basis	As-fed basis
DM	100.00	92.29
CP	48.22	44.50
Crude fat	3.14	2.90
ADF	17.45	16.10
NDF	20.37	18.80
Ca	0.13	0.12
P	0.82	0.76
Ash	5.01	4.62
Amino acids, %		
Arginine	1.85	1.71
Histidine	1.11	1.02
Isoleucine	2.18	2.01
Leucine	5.89	5.44
Lysine	1.73	1.60
Methionine	0.85	0.78
Phenylalanine	2.47	2.28
Threonine	1.79	1.65
Tryptophan	0.39	0.36
Valine	2.63	2.43
Alanine	3.86	3.56
Aspartic acid	3.48	3.21
Cysteine	0.80	0.74
Glutamic acid	7.68	7.09
Glycine	1.64	1.51
Proline	3.11	2.87
Serine	1.96	1.81
Tyrosine	1.87	1.73

[1] Dried distillers grains with solubles from White Energy, Inc., Russell, KS.

Table 3. Standardized and apparent ileal digestibility (%) of amino acids in high-protein sorghum DDGS[1,2]

Amino acid	SID[3]	AID[4]
Indispensable amino acids		
Arginine	77.97	76.08
Histidine	62.62	61.38
Isoleucine	69.71	68.64
Leucine	73.74	73.09
Lysine	53.71	51.86
Methionine	73.78	73.04
Phenylalanine	72.85	71.89
Threonine	63.01	60.57
Tryptophan	73.84	71.72
Valine	68.08	66.52
Dispensable amino acids		
Alanine	68.39	67.42
Aspartic acid	63.67	62.02
Cysteine	65.51	63.70
Glutamic acid	69.60	68.73
Glycine	46.31	40.10
Proline	59.95	54.27
Serine	70.72	68.76
Tyrosine	71.56	70.46

[1] Values are means of 6 pigs (initially 50 lb) used in a crossover design.
[2] Dried distillers grains with solubles from White Energy, Inc., Russell, KS.
[3] Standardized ileal digestibility.
[4] Apparent ileal digestibility.

Table 4. Energy values of high-protein sorghum DDGS[1,2]

Energy, kcal/lb	DM basis	As-is basis
GE	2,317	2,129
DE[3]	1,759	1,616
ME[3]	1,610	1,479
NE[3]	1,023	940

[1] Values are means of 6 observations per treatment.
[2] Dried distillers grains with solubles from White Energy, Inc., Russell, KS.
[3] See procedures section for equations used to calculate DE, ME, and NE.