Kansas Agricultural Experiment Station Research Reports

Volume 0
Issue 10 *Swine Day (1968-2014)*

Article 1223

2008

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J Y. Jacela

H L. Frobose

Joel M. DeRouchey

See next page for additional authors

Recommended Citation

Jacela, J Y.; Frobose, H L.; DeRouchey, Joel M.; Tokach, Michael D.; Nelssen, Jim L.; Goodband, Robert D.; and Dritz, Steven S. (2008) "Amino acid digestibility of high-protein corn dried distillers grains with solubles in pigs," *Kansas Agricultural Experiment Station Research Reports*: Vol. 0: Iss. 10. https://doi.org/10.4148/2378-5977.7063

AMINO ACID DIGESTIBILITY OF HIGH-PROTEIN CORN DRIED DISTILLERS GRAINS WITH SOLUBLES IN PIGS[1]

J. Y. Jacela[2], H. L. Frobose, J. M. DeRouchey, S. S. Dritz[2], M. D. Tokach, J. L. Nelssen, and R. D. Goodband

Summary

The objective of this experiment was to determine the digestibility of amino acids (AA) in a high-protein dried distillers grains with solubles (DDGS) product. Six growing barrows (initially 50 lb) were surgically fitted with a T-cannula at the terminal ileum to allow for ileal digesta collection. After recovery, the pigs were randomly allotted to 2 dietary treatments in a crossover design with 2 periods. The first diet contained high-protein DDGS (67% of the diet) as the sole protein source; the second was a nitrogen-free diet for determining basal endogenous AA loss. Chromic oxide was added to both diets as an indigestible marker. Ileal digesta samples were collected each period and analyzed for AA concentration. Standardized and apparent ileal digestibilities (SID and AID, respectively) of AA were calculated after chemical analysis of the high-protein DDGS, diets, digesta, and fecal samples. Nutrient composition analysis of the high-protein DDGS showed a CP value of 36.5%, crude fat of 4.8%, and phosphorous content of 0.38%. The AID for lysine, methionine, threonine, and tryptophan were 65.9, 87.0, 72.8, and 76.2%, respectively. Values for SID AA were calculated to be 67.8, 87.5, 75.0, and 78.6% for lysine, methionine, threonine, and tryptophan, respectively. In conclusion, this high-protein DDGS product has greater AA digestibility values than traditional DDGS. Therefore, this product appears well-suited for use in swine diets but needs further evaluation to determine its effects on pig growth performance.

Key words: amino acids, digestibility, dried distillers grains with solubles, swine

Introduction

As the biofuel industry continues to evolve and mature, improvements and new technologies in ethanol fuel production are being adapted by the ethanol biorefineries to cut costs and increase efficiency and profitability. This has resulted in production of more coproducts and increased attention being paid to the quality of these coproducts. LifeLine Foods is a company that, in addition to from food products for human consumption, produces ethanol from corn by utilizing the dry defractionation method. Dry defractionation is a relatively new technology that optimizes the use of corn by separating the kernel into its bran, germ, and endosperm components before fermentation. The process involves tempering the seed with warm water to make it expand, enabling the removal of bran (pericarp) from the kernel. The germ (oil-rich fraction) is then removed, and the remaining portion of the kernel is sent to the food mill

[1] Appreciation is expressed to LifeLine Foods, St. Joseph, MO, for supplying the high-protein dried distillers grains with solubles product and partial funding.

[2] Food Animal Health and Management Center, College of Veterinary Medicine, Kansas State University.

where the hard yellow endosperm is removed for food companies. The soft endosperm (starch) is then sent to the ethanol facility for fermentation. The distillers grains that remain after fermentation are dried with steam instead of direct heat, resulting in a product that may have increased quality and digestibility. Also, as a result of breaking down and segregating the kernel into its components, CP becomes more concentrated, whereas the crude fat is lower in the final high-protein product compared with traditional dried distillers grains with solubles (DDGS). Although this product may command a higher value than conventional DDGS because of its higher CP content, this product needs to be valued on the basis of digestibility of its nutrients. Therefore, this study was conducted to determine the digestibility of amino acids (AA) in high-protein DDGS in growing pigs.

Procedures

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

Six growing barrows (PIC, initially 50 lb BW) were surgically fitted with a T-cannula on their right flank approximately 6 in. anterior to the ileocecal valve. The pigs were allowed to recover from surgery and were then placed in individual stainless steel metabolism cages in an environmentally controlled building. Each cage was equipped with a feeder and a nipple waterer for ad libitum access to water. During the first 9 d post-surgery (recovery period), the pigs were fed a common diet. On d 10 post-surgery, the pigs were randomly allotted to 1 of 2 dietary treatments in a crossover design. The first diet contained 67% of a high-protein corn DDGS; the second diet was formulated to be nitrogen-free to allow for the determination of basal AA endogenous losses (Table 1). Chromic oxide was added to both diets at 0.25% as an indigestible marker. There were 2 periods in the experiment; each period consisted of 7 d. The first 5 d of each period were used to allow pigs to adapt to the dietary treatment. Ileal digesta was collected on d 6 and 7 over a 10-h period (between 0700 and 1700 each day). Pig weights were determined at the start of each period prior to switching to the next diet to determine the daily feed allocation. Daily feed allocation was divided into 2 equal amounts and given twice a day at 0600 and 1800 hours. No feed was given at the end of each period before the next experimental diet was fed the following morning.

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

Ingredient, %	High-protein DDGS[1]	N-free
Corn starch	26.20	80.90
High-protein DDGS	66.70	---
Soybean oil	1.00	3.00
Monocalcium P (21% P)	1.05	1.75
Limestone	0.80	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
Magnessium oxide	---	0.10
Chromic oxide	0.25	0.25
Solka floc	---	3.00
Sucrose	3.00	9.00
Total	100.00	100.00
Calculated analysis, %		
Total lysine	0.41	0.00
CP	25.15	0.00
Ca	0.60	0.48
P	0.45	0.37
Available P	0.40	0.37

[1] Dried distillers grains with solubles from Life-Line Foods LLC, St. Joseph, MO.

During collection days, each pig's cannula was opened to allow the digesta to flow out of the ileum; ileal digesta was collected by attaching a latex balloon to the cannula. The balloons were checked for the level of fill and removed every 30 min or as soon as they were full. The contents of the balloons were then transferred to a 1-L plastic container and stored in a freezer until further chemical analyses were conducted. After the collection phase of the experiment, digesta samples from each period from each animal were thawed and homogenized. A subsample from each homogenized ileal digesta was then transferred to a 1.25-in. × 6-in. × 8.5-in. aluminum pan, freeze-dried, and ground for AA analysis.

The amount of chromic oxide in the diets, digesta, and fecal samples was determined by using atomic absorption spectroscopy. Chromic oxide served as the indigestible marker for calculating AA digestibility values. The high-protein DDGS, 2 diets, and digesta samples were also analyzed for DM, CP, and AA. Amino acid analysis for the diets, high-protein 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 DDGS diet was calculated by 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 on the basis of the digesta samples obtained when the pigs were fed with the nitrogen-free diet by using 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:

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

Results and Discussion

The nutrient profile of the high-protein DDGS used in the experiment is reported in Table 2. The CP level was 36.5%, which is about 9% higher than the published average CP value in traditional DDGS. In addition, the fat content of the high-protein DDGS was 4.8%, which, as expected, is less than half of the average amount typically found in traditional DDGS. The lower fat content found in the high-protein DDGS was a result of the mechanical separation of the germ portion from the rest of the corn kernel components during defractionation. On the other hand, though ADF and NDF for the high-protein DDGS were expected to be lower because of the separation of the bran during the defractionation process, the values were even higher than published book values for traditional DDGS. The ADF and NDF values for the product used in this experiment were 20.50 and 32.80%, respectively. It is possible that there was a significant amount of bran added back to the final DDG product. Although the amount of calcium in the high-protein DDGS was almost similar to traditional DDGS at 0.04%, phosphorus content was relatively low at only 0.38%. The lower phosphorus content may be due to the minimal amount of solubles present in the final product. The higher CP content of the high-protein DDG resulted in every AA being higher when compared with the amount of AA in traditional DDGS. The lysine content of the DDGS product was 1.22%, resulting in a lysine:CP ratio of 3.34%. A lysine:CP ratio of not less than 2.8% is the recommended value when evaluating the quality of DDGS for use in swine diets. Thus, the high ratio found in the high-protein DDGS indicates the product should have high lysine digestibility.

Swine diets are ideally formulated on the basis of the digestibility of the nutrients found in each ingredient that goes with the diet. More specifically, these diets should be formulated on the basis of SID AA. This study was conducted with the aim of establishing digestibility coefficients for AA values for the high-protein DDGS. In this product, the AID for lysine, methionine, threonine, and tryptophan were 65.9, 87.0, 72.8, and 76.2%, respectively (Table 3). These values were higher than published AID values for traditional DDGS. After correcting the AID values for basal ileal endogenous AA loss, the SID values were calculated to be 67.8, 87.5, 75.0, and 78.6% for lysine, methionine, threonine, and tryptophan, respectively. These values are also higher than those found in traditional DDGS. The most significant difference between the high-protein DDGS and traditional DDGS appears to be the high digestibility coefficient for lysine. Lysine is considered the most variable among the AA because of the heating process involved in the production of conventional DDGS. The high amount of lysine in the high-protein DDGS and its high digestibility values increased its overall AA value in swine diets compared with traditional DDGS.

This experiment established the values for the digestibility coefficients of AA for the high-protein DDGS for use in swine diet formulation. The results of this experiment suggest a coproduct of high quality and value in terms of CP, AA content, and AA digestibility. However, this product has a relatively lower phosphorus content compared with traditional DDGS. Further evaluation of this coproduct is needed to determine its effects on pig growth performance.

Table 2. Analyzed nutrient composition of a high-protein corn DDGS product[1]

Nutrient, %	DM basis	As-fed basis
DM	100.00	89.54
CP	40.76	36.50
Crude fat	5.36	4.80
ADF	22.89	20.50
NDF	36.63	32.80
Ca	0.04	0.04
P	0.42	0.38
Ash	1.84	1.65
Indispensable amino acids		
Arginine	1.84	1.65
Histidine	1.16	1.04
Isoleucine	1.69	1.51
Leucine	5.45	4.88
Lysine	1.36	1.22
Methionine	0.88	0.79
Phenylalanine	2.14	1.92
Threonine	1.45	1.30
Tryptophan	0.26	0.23
Valine	2.21	1.98
Dispensable amino acids		
Alanine	3.06	2.74
Aspartic acid	2.66	2.38
Cysteine	0.85	0.76
Glutamic acid	6.99	6.26
Glycine	1.49	1.33
Proline	3.17	2.84
Serine	1.72	1.54
Tyrosine	1.66	1.49

[1] Dried distillers grains with solubles from LifeLine Foods, LLC St. Joseph, MO.

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

Amino acid	SID[3]	AID[4]
Indispensable amino acids		
Arginine	85.32	83.79
Histidine	80.00	79.04
Isoleucine	81.35	80.23
Leucine	88.87	88.31
Lysine	67.82	65.91
Methionine	87.53	86.96
Phenylalanine	86.10	85.24
Threonine	75.00	72.75
Tryptophan	78.61	76.23
Valine	79.70	78.13
Dispensable amino acids		
Alanine	84.37	83.40
Aspartic acid	73.83	72.13
Cysteine	76.84	75.51
Glutamic acid	85.73	84.94
Glycine	66.69	61.34
Proline	79.12	74.52
Serine	82.87	81.24
Tyrosine	86.07	85.10

[1] Values are means of 6 pigs (initially 50 lb) used in a crossover design.
[2] Dried distillers grains with solubles from LifeLine Foods LLC, St. Joseph, MO.
[3] Standardized ileal digestibility.
[4] Apparent ileal digestibility.