AMINO ACID DIGESTIBILITY AND ENERGY CONTENT OF TWO DIFFERENT SOY HULL SOURCES FOR SWINE

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Summary

This trial was conducted to determine and compare the digestibility of amino acids and energy of soy hulls from two different sources. Five growing barrows (initially 150 lb) fitted with T-cannulas were each fed three different diets in a crossover design. Each of the first two diets contained 66.7% soy hulls from two different sources (Soy hulls A and Soy Hulls B). The third experimental diet was N-free and based on corn starch and sucrose for determining basal endogenous amino acid (AA) losses. Ileal digesta and fecal samples were collected during each period and analyzed for amino acid and energy contents. Due to poor flowability of digesta through the T-cannula of one pig when fed diets containing soy hulls, it was removed from the experiment and thus, only four pigs were used in all data analyses. Apparent (AID) and standardized (SID) ileal digestibilites, and gross (GE), digestible (DE), metabolizable (ME), and estimated net (NE) energy values were then calculated from these analyses. Both samples were analyzed for particle size using Ro-Tap shaker with a stack of Tyler screens. Particle size of soy hulls A and soy hulls B were 619 and 691µ, respectively. The results of the trial showed differences in nutrient composition and in amino acid and energy digestibilities between the two soy hulls. Apparent ileal digestibility values of lysine, methionine, and threonine in soy hulls A were 58.38, 65.93, and 50.68%, respectively and 51.10, 57.51, and 37.54%, respectively in soy hulls B. Standardized ileal digestibility values of the same amino acids were 61.13, 69.53, and 62.25%, respectively for soy hulls A and 54.60, 62.32, and 51.96%, respectively for soy Hulls B. As a percentage of CP, standardized ileal digestible lysine, methionine, and threonine values were 4.09, 0.83, and 2.16% for soy hulls A; and 4.01, 0.85, and 2.01% for soy hulls B, respectively. The ME, DE, and estimated NE values were 1,037; 1,097; and 722 kcal/lb for soy hulls A and 989, 1,030, and 680 kcal/lb for soy hulls B, respectively.

(Key words: feed ingredients, soy hulls, digestibility.)

Introduction

Soybean hulls, or soy hulls, is an inexpensive co-product of soybean processing for oil and meal production. This product is very high in fiber containing mainly insoluble non-starch oligosaccharides, which is mostly cellulosic in nature. Although they are well digested and a rich source of energy in ruminants, high fiber feed products like soy hulls are poorly digested by non-ruminants such as pigs. The high fiber content of soy hulls has also been shown to have some drastic effects on nutrient digestibility like that of protein and

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energy. Thus, its recognized potential use in pigs has been mainly in sow diets to increase gut-fill in sows during gestation. With the increased availability of soy hulls for livestock, several studies have examined the effects of the soy hulls in the performance of growing pigs and odor production. However, limited data exists on the nutrient digestibility of soy hull products available in the market today. In addition, variability in nutritive and energy values may exist between soy hulls from different sources. Thus, the objective of this experiment was to determine and compare the digestibility of amino acids and energy in two sources of soy hulls.

Procedures

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

This experiment was done concurrently with a digestibility study with another feed ingredient utilizing the same animals. Five growing barrows (initially 65 lb) were fitted with a T-cannula on their right flank about 15-cm anterior to the ileocecal valve. After surgery, the pigs were housed individually in stainless steel metabolism crates in an environmentally controlled building and allowed to recover. After recovery, the pigs were utilized in a separate digestibility study for 5 weeks and then fed a common corn-soybean meal diet for 7 d. The pigs were then randomly allotted to 1 of 3 dietary treatments in a crossover design with an initial starting weight of 150 lb. Diets A and B contained 66.7% each of soy hulls A and soy hulls B, respectively, while the third diet was a N-free diet based on corn starch and sucrose for determining the basal AA endogenous losses. Due to poor flowability of digesta through the T-cannula of one pig when fed diets containing soy hulls, it was removed from the experiment and thus, only four pigs were used in all data analyses. All diets contained 0.25% chromic oxide as an indigestible marker. There were 7 d in each period where the first 4 d served as an adaptation period to the diet. Grab-samples of feces were collected on d 5 and 6, while ileal digesta collection was completed throughout a 10 h period (between 0600 and 1800) on d 6 and 7. Each pig's weight was determined at the beginning of each period and used to calculate the daily feed amount to be allocated for each period. Feed was provided at a daily level of 3 times the estimated maintenance requirement for energy. The pigs were fed half of the daily feed allocation twice a day at 0600 and 1800. At the end of each period feed was withheld from all pigs overnight and pigs were given the next experimental diet the following morning to avoid carry-over effect. Water was provided *ad libitum* through a nipple waterer throughout the duration of the trial.

Table 1. Diet Composition (as-fed basis)

Ingredient, %	Soy hulls A & B	N-Free
Corn starch	27.05	81.15
Soy hulls A or B	66.70	---
Soybean oil	1.00	3.00
Monocalcium P (21% P)	1.25	1.75
Limestone	---	0.40
Salt	0.35	0.45
Vitamin premix	0.25	0.25
Trace mineral premix	0.15	0.15
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

Ileal digesta collection was done using latex balloons attached to the cannula. Balloons were removed periodically or as soon as they were filled with digesta, transferred in a collection container, and stored in a freezer. At the end of the collection phase of the experiment, each pig's ileal samples from each period was thawed and homogenized. A subsample was taken from each homogenized sample, freeze-dried and ground for AA analysis. Fecal samples from each period were also frozen after every collection. These samples were then thawed after the collection phase of the trial and homogenized within each pig and diet. Subsamples were taken and dried in a forced air oven, and ground for analysis. Energy concentration in diets, the two soy hulls, and fecal samples were determined using bomb calorimetry. Chromic oxide served as the indigestible marker to calculate AA and energy digestibility values. The two soy hulls, diets, and digesta samples were also analyzed for DM and CP. Particle size analysis of the two soy hulls was done using a Ro-Tap shaker with a stack of Tyler screens.

The AID for AA in the two soy hull diets was calculated as:

AID = [1 - (AAd/AAf) × (Crf/Crd)] × 100%,

where AID is the apparent ileal digestibility of an AA (%), AAd is the concentration of that AA in the ileal digesta (g/kg of DM), AAf is the concentration of that 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 at the ileum was determined based on the digesta samples obtained after feeding the N-free diet using the equation:

IAAend = [AAd × (Crf/Crd)],

where IAAend is the basal ileal endogenous loss of an AA (g/kg of DMI).

Standardized ileal digestible value for each AA was calculated using the equation:

SID = [AID + (IAAend/AAf)],

where SID is the standardized ileal digestibility of an AA (%).

Digestible Energy value (DE) of the soy hull diets were calculated using the same equation for AID to determine the apparent total tract digestibility (ATTD) of energy. This value was then multiplied by the analyzed concentration of GE in the diets to get the DE of the diet. DE of the two soy hulls were calculated by subtracting 33% of the N-free DE from the DE of the soy hull diets and dividing by 0.67 to correct back to 100% of the ingredient value. Metabolizable Energy (ME) and Net Energy (NE) were calculated using the following equations:

ME = 1 * DE – 0.68 * CP

NE = (0.87 * ME) – 442

Data was analyzed using PROC MIXED procedure of SAS with the pig as the experimental unit and with soy hulls source and pig as main effects. Least squares means was used to determine differences between treatments.

Results and Discussion

The results of the analysis for the two soy hulls' nutrient composition are shown in Tables 2 and 3. Amino acid composition as a percentage of CP is also presented in Table 3. Both soy hulls had higher CP and amino acid values than published book values. Comparing the two samples in this study, the AA in soy hulls A were higher than those in soy hulls B on an as-fed basis. However, most of the AA from soy hulls B were higher on a CP basis except for tryptophan and glutamic acid. Crude fat (2.3%), ADF (40.3%), NDF (53.6%), and calcium (0.72%) levels were higher in soy hulls B than in soy hulls A (1.60, 37.50, 50.80, and 0.59%, respectively). Calcium and phosphorous levels of the two soy hulls were higher than published book values.

Apparent ileal digestibility values and most AA in of soy hulls A were higher (*P*<0.05) than those of soy hulls B except for histidine, lysine, phenylalanine, threonine, aspartic acid, cysteine, glycine, and proline, which were not significantly different (Table 4). Methionine AID value was 8 percentage points higher (*P*<0.05) in soy hulls A than in soy hulls B. Lysine, methionine, and threonine had AID values of 58.38, 65.93, and 50.68%, respectively in soy hulls A and 51.10, 57.51, and 37.54%, respectively, in soy hulls B.

Soy hulls A SID AA values for arginine, isoleucine, methionine, valine, alanine, glutamic acid, serine, and tyrosine were higher (*P*<0.05) than those in soy hulls B (Table 5). Standardized ileal digestible lysine, methionine, and threonine were 61.13, 69.53, and 62.25% for soy hulls A; and 54.60, 62.32, and 51.96% for soy hulls B, respectively. As a percentage of CP (Table 5), SID lysine, methionine, and threonine were 4.09, 0.83, and 2.16% for soy hulls A and 4.01, 0.85, and 2.01% for soy hulls B, respectively. For many of the major amino acids, it appears that expressing SID amino acids as a percentage of analyzed crude protein for the soy hulls may provide a relatively accurate estimate of the SID amino acid content.

Particle size has been shown to influence nutrient digestibility of soybean meal and, in this case, may partially explain the lower nutrient digestibility in soy hulls B, which had a greater particle size of 691µ compared to soy hulls A which was 619µ (Table 6).

Although soy hulls A had higher GE (*P*<0.05), DE, ME, and estimated NE values of the two soy hulls were not significantly different with 1,097; 1,037; and 722 kcal/lb in soy hulls A and 1,030; 989; and 680 kcal/lb in soy hulls B, respectively (Table 7).

This study shows that AID and SID of soy hulls may differ from one source to another. High fiber feed ingredients are poorly digested in pigs and this may explain the low nutrient digestibilities of soy hulls, regardless of source in this study. Particle size may also partially explain the difference in digestibility between the two soy hulls but other factors such as plant source (processing efficiency), and quality of the soy hulls may also account for the variability in nutrient and digestibility values. It may be necessary to source soy hulls from one supplier to aid in consistency for diet formulation. In addition, routine nutrient analyses should be completed to ensure consistency in nutrient content. Further research is necessary to test a wider range of soy hull sources to develop a database of digestibility by source.

Table 2. Proximate Analysis of Two Soy Hull Sources

	DM Basis		As-fed Basis	
Nutrient, %	Soy Hulls A	Soy Hulls B	Soy Hulls A	Soy Hulls B
DM	100.00	100.00	90.99	90.68
Crude protein	17.50	13.30	15.90	12.10
Crude fat	1.70	2.60	1.60	2.30
ADF	41.20	44.50	37.50	40.30
NDF	55.90	59.10	50.80	53.60
Ca	0.65	0.79	0.59	0.72
P	0.23	0.22	0.21	0.20
Ash	5.62	6.20	5.11	5.62

Table 3. Analyzed Amino Acid Composition of Two Soy Hull Sources

Nutrient, %	As-fed Basis			CP Basis		
	Soy hulls A	Soy Hulls B	Average	Soy Hulls A	Soy Hulls B	Average
Crude protein	15.90	12.10	14.00	100.00	100	100.00
Indispensable amino acids						
Arginine	0.87	0.69	0.78	5.44	5.67	5.55
Histidine	0.41	0.33	0.37	2.55	2.76	2.66
Isoleucine	0.65	0.52	0.58	4.09	4.27	4.18
Leucine	1.08	0.87	0.98	6.79	7.21	7.00
Lysine	1.06	0.89	0.98	6.69	7.35	7.02
Methionine	0.19	0.17	0.18	1.20	1.37	1.28
Phenylalanine	0.66	0.50	0.58	4.13	4.15	4.14
Threonine	0.55	0.47	0.51	3.47	3.86	3.66
Tryptophan	0.08	0.06	0.07	0.50	0.50	0.50
Valine	0.72	0.59	0.65	4.55	4.83	4.69
Dispensable amino acids						
Alanine	0.67	0.56	0.62	4.21	4.65	4.43
Aspartic acid	1.52	1.23	1.37	9.53	10.13	9.83
Cysteine	0.25	0.23	0.24	1.58	1.93	1.75
Glutamic acid	2.08	1.54	1.81	13.11	12.71	12.91
Glycine	1.09	0.94	1.02	6.87	7.76	7.32
Proline	0.72	0.61	0.67	4.53	5.04	4.78
Serine	0.72	0.61	0.66	4.52	5.00	4.76
Tyrosine	0.54	0.46	0.50	3.38	3.82	3.60

Table 4. Apparent Ileal Digestibility of Two Soy Hull Sources[a]

Amino acid, %	Soy hulls A	Soy hulls B	SE	*P* value
Indispensable amino acids				
Arginine	71.44	62.82	2.25	0.03
Histidine	57.92	49.63	2.88	0.06
Isoleucine	58.39	43.34	3.79	0.03
Leucine	58.93	45.43	4.12	0.05
Lysine	58.38	51.10	2.42	0.06
Methionine	65.93	57.51	1.90	0.02
Phenylalanine	66.33	57.61	3.06	0.07
Threonine	50.68	37.54	4.58	0.06
Tryptophan	N/A	N/A		
Valine	57.53	43.79	3.76	0.04
Dispensable amino acids				
Alanine	53.23	40.72	3.36	0.03
Aspartic acid	56.59	45.40	3.56	0.05
Cysteine	31.53	19.73	9.45	0.34
Glutamic acid	67.15	56.18	2.70	0.03
Glycine	25.99	24.82	3.80	0.79
Proline	28.19	28.93	9.99	0.95
Serine	46.18	31.10	3.19	0.02
Tyrosine	60.90	48.23	2.46	0.01

[a]Values are means of 4 pigs (initially 150 lb) used in a crossover design.
[b]Values were not determined due to some exceptionally low values in some samples.

Table 5. Standardized Ileal Digestibility of Two Soy Hull Sources[a]

	SID, %				SID AA / CP, %	
Amino acid	Soy hulls A	Soy Hulls B	SE	*P* value	Soy Hulls A	Soy Hulls B
Indispensable amino acids						
Arginine	76.51	69.58	2.10	0.05	4.16	3.94
Histidine	61.93	54.68	2.84	0.08	1.58	1.51
Isoleucine	62.52	48.92	3.80	0.04	2.56	2.09
Leucine	63.07	50.96	4.14	0.06	4.28	3.67
Lysine	61.13	54.60	2.40	0.07	4.09	4.01
Methionine	69.53	62.32	1.91	0.03	0.83	0.85
Phenylalanine	70.35	62.88	3.08	0.09	2.90	2.61
Threonine	62.25	51.96	4.68	0.12	2.16	2.01
Tryptophan[b]	N/A	N/A	7.58			
Valine	62.24	50.12	3.75	0.05	2.83	2.42
Dispensable amino acids						
Alanine	59.76	49.16	3.24	0.05	2.52	2.29
Aspartic acid	61.37	51.57	3.56	0.07	5.85	5.23
Cysteine	38.21	22.04	7.26	0.11	0.60	0.43
Glutamic acid	71.21	61.81	2.66	0.04	9.33	7.86
Glycine	40.08	32.59	8.83	0.46	2.76	2.53
Proline	70.84	73.68	22.02	0.91	3.21	3.71
Serine	53.57	40.88	3.12	0.03	2.42	2.04
Tyrosine	64.42	53.11	2.45	0.02	2.18	2.03

[a]Values are means of 4 pigs (initially 150 lb) used in a crossover design.
[b]Values were not determined due to some exceptionally low values in some samples.

Table 6. Particle Size Analysis of Two Soy Hull Sources

Item	Soy hulls A	Soy hulls B
Particle size, µ	619	691
Standard deviation	2.07	1.84
Surface area (cm^2/g)	95.7	79.1

Table 7. Energy Analysis of Two Soy Hull Sources[a]

	DM basis		As-fed basis		*P* values	
Energy, kcal/lb	Soy hull A	Soy hull B	Soy hull A	Soy hull B	DM basis	As-fed basis
Gross energy	1,901	1,848	1,755	1,676	<.0001	0.02
Digestible energy	1,211	1,088	1,097	1,030	0.13	0.27
Metabolizable energy	1,157	1,047	1,037	989	0.16	0.45
Net energy	806	710	722	680	0.16	0.44

[a]Values are means of 4 pigs (initially 150 lb) used in a crossover design.
[b]The ME value of soy hulls were calculated using the equation: **ME** = 1 * DE – 0.68 * CP (Noblet and Perez, 1993).
[c]The NE value of soy hulls were calculated by using the equation: **NE** = (0.87 * ME) – 442 (Noblet et al., 1994).