Evaluating the Effect of Soybean Hulls on Amino Acid Digestibility in Swine

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Introduction

Due to the advantageous nutrient characteristics of soybean meal, this feedstuff has been the predominant protein source used to formulate swine diets in the United States. As environmental issues continue to gain momentum, more emphasis is being placed upon efficient use of feedstuffs such as soybean meal. One of these concerns lies with minimizing dietary nutrient excretion into the environment while maximizing growth and returns in modern swine production systems.

While soybean meal serves as a good dietary source of amino acids in commercial swine diets, improvements could be recognized through the characterization of inherent factors affecting digestibility of these nutrients. Soybean hulls constitute one of the differences between high- and low-protein soybean meals and therefore are a contributing factor to dietary nutrient utilization. By understanding the impact of soy hulls on nutrient metabolism, not only can this inexpensive alternative feedstuff be utilized, but more precise rations can be formulated while gaining the potential benefits of fiber in growing swine diets. Therefore, this study was designed to quantify the effect of soy hulls on nitrogen and amino acid digestibilities in soybean meal fed to growing swine.

Materials and Methods

Diets and animals. Experimental diets were formulated to contain graded levels of soy hulls at 0, 3, 6, or 9% (Table 1) plus 3 control diets and fed to fourteen cannulated barrows (average initial weight of 73 lbs.) in a replicated 7 × 7 Latin square design. Diets were formulated to meet or exceed current recommendations (NRC, 1998) and were fed twice daily at a rate of 9% of metabolic body weight. Chromic oxide was incorporated into diets as an indigestible marker to calculate apparent ileal nutrient digestibilities.

Digestibility calculations. Apparent digestibilities were calculated for nitrogen and amino acids using the index method with the equation $AD_x = 1 - [(C_i/C_o) * (X_o/X_i)]$, expressed as a percentage. Here, AD_x is the apparent nutrient digestibility value; C_i is the concentration of chromic oxide present in the dietary intake; C_o is the concentration of chromic oxide present in the ileal output; X_o is the nutrient concentration present in the ileal output; and X_i is the nutrient concentration present in the dietary intake. All values are expressed as a percent of dry matter.

Chemical and statistical analyses. Dry matter content was determined by drying samples at 212ºF for 24 h. Amino acid content was analyzed by high-performance liquid chromatography and chromic oxide concentrations were analyzed by atomic absorption spectrophotometry. Nitrogen content was determined by the combustion method using the Model FP2000 combustion analyzer (LECO Corp., St. Joseph, MI) and energy content was determined by bomb calorimetry using the Parr 1261 adiabatic calorimeter (Parr Instrument Co., Moline, IL).

Data were analyzed using the general linear model procedure of SAS (SAS Institute Inc., Cary, NC) based on a replicated 7 × 7 Latin square experimental design. The model for this analysis included pig (14 pigs), period (7 periods), and diet (7 diets: 0, 3, 6, 9% soy hulls and 3 controls). Linear and quadratic contrasts were used to determine the effect of soy hull inclusion.

Results and Discussion

Dietary fiber has been known to serve a number of purposes in swine diets. These include: 1) binding/retaining water in prevention of diarrhea, 2) increasing excrement bulk in cessation of constipation, and 3) decreasing the incidence of prolapses during farrowing. As reported by Kornegay (1981), fiber ingestion by swine, specifically as soy hulls, caused no depression in average daily gain or feed intake with up to 15% inclusion. Therefore, it is plausible that utilizing soy hulls at low levels is possible with few repercussions on growth performance.

Moving to the nutrient metabolism side of the issue, this study specifically assessed the effect of soy hulls on nitrogen and amino acid digestibilities of the growing pig (Table 2). Inclusion of graded levels of soy hulls did not affect apparent ileal digestibility of nitrogen ($P > 0.05$), while dry matter and energy digestibilities decreased linearly ($P < 0.01$). Addition of soy hulls also caused a linear decrease in apparent ileal amino acid digestibilities of arginine ($P < 0.01$) as well as histidine, lysine, phenylalanine, aspartic acid, serine, and tyrosine ($P < 0.05$). Amino acids having a trend for a linear decrease included isoleucine, leucine, methionine, valine, cystine, and glutamic acid ($P < 0.10$). Isoleucine showed a quadratic decrease in apparent ileal digestibility ($P < 0.05$), while methionine and phenylalanine showed only a quadratic trend ($P < 0.10$). Results of this digestibility study are consistent with previous research (Kornegay, 1978; Mitaru et al., 1984) and reiterate the fact that growing pigs have only limited tolerance for dietary fiber.

As observed in this study, soy hull inclusion up to 9% does affect amino acid digestibilities, but decreases do not exceed 4.8 percentage units. Additionally, no apparent ileal essential amino acid digestibility decreased more than 2.6 percentage units. Therefore, inclusion of soy hulls into diets formulated with dehulled soybean meal for growing swine may be possible with minimal impact on nutrient digestion.

Applications

In the current swine industry, more stringent feeding regulations are being enacted in addition to a heavier focus upon environmental concerns due to inefficient utilization of dietary nutrients. This issue will prompt a more extensive study of factors affecting nutrient digestion as well as assessing the possibilities of non-traditional feedstuffs. As soy hulls are routinely extracted from whole soybeans in production of a high-protein meal, determining their impact on nitrogen and amino acid digestibility may lead to benefits for the producer while reducing environmental impacts. This study indicates that a reduction of no more than 2.6 percentage units in apparent ileal digestibility for the essential amino acids results with inclusion of up to 9% soy hulls. Combine these results with the beneficial environmental impact previously reported (DeCamp et. al, 2001) and it becomes possible to develop novel feeding strategies which satisfy current industry demands while exhibiting benefits for the swine producer.

References

DeCamp, S. A., B. Hill, S. L. Hankins, C. T. Herr, B. T. Richert, A. L. Sutton, D. T. Kelly, M. L. Cobb, D. W. Bundy, and W. J. Powers. 2001. Effects of soybean hulls on pig performance, manure composition, and air quality. Purdue Swine Research Report. 84-89.

Kornegay, E. T. 1978. Feeding value and digestibility of soybean hulls for swine. J. Anim. Sci. 47:1272-1280.

Mitaru, B. N., R. Blair, R. D. Reichert, and W. E. Roe. 1984. Dark and yellow rapeseed hulls, soybean hulls and a purified fiber source: their effects on dry matter, energy, protein and amino acid digestibilities in cannulated pigs. J. Anim. Sci. 59:1510-1518.

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

	Diet[a]			
Ingredient, %	**0% SH**	**3% SH**	**6% SH**	**9% SH**
Cornstarch	29.55	27.25	24.95	22.65
Dextrose	10.00	10.00	10.00	10.00
Sucrose	20.00	20.00	20.00	20.00
Soybean meal 48%	33.80	33.10	32.40	31.70
Soybean hulls	0.00	3.00	6.00	9.00
Corn oil	2.00	2.00	2.00	2.00
Iodized salt	0.35	0.35	0.35	0.35
Dicalcium phosphate	3.00	3.00	3.00	3.00
Ground limestone	0.45	0.45	0.45	0.45
Trace mineral premix[b]	0.05	0.05	0.05	0.05
Vitamin premix[c]	0.30	0.30	0.30	0.30
Chromic oxide	0.50	0.50	0.50	0.50
Calculated Composition, %				
Crude Protein	17.0	17.0	17.0	17.0
Lysine	0.98	0.98	0.98	0.98
Ca	0.94	0.94	0.94	0.94
Total P	0.78	0.78	0.78	0.78
K	0.73	0.73	0.73	0.73
Mg	0.11	0.11	0.11	0.11

[a]SH = soybean hulls.

[b]Provides per lb of diet: 40.9 mg Fe (Ferrous sulfate); 2.3 mg Mn (Manganese oxide); 3.6 mg Cu (copper sulfate); 0.09 mg I (potassium iodate); 0.1 mg Se (sodium selenite), and 40.9 mg Zn (Zinc sulfate).

[c]Provides per lb of diet: 909.1 IU Vitamin A; 136.4 IU vitamin D; 9.1 IU vitamin E; 0.45 mg vitamin K (menadione); 1.8 mg thiamine; 6.8 mg niacin; 1.8 mg riboflavin; 5.5 mg pantothenic acid; 6.8 µg vitamin B_{12}; 0.91 mg pyridoxine; 0.05 mg d-biotin; 0.23 mg folic acid; and 0.27 g choline.

Table 2. Apparent ileal digestibility of dry matter, energy, nitrogen, and amino acids in experimental diets

	Diet[a]				
Item, %	**0% SH**	**3% SH**	**6% SH**	**9% SH**	**SD[b]**
Dry matter[c]	82.1	79.7	77.2	75.6	1.91
Energy[c]	84.1	82.0	79.5	78.1	1.91
Nitrogen	83.2	81.5	81.0	81.0	3.28
Amino acids					
Essential					
Arginine[c]	91.8	90.2	89.8	89.4	3.41
Histidine[d]	85.8	83.9	83.6	83.4	2.13
Isoleucine[e]	84.2	82.3	81.4	82.4	2.44
Leucine	83.9	81.8	81.2	81.7	2.29
Lysine[d]	85.0	83.1	82.3	82.4	2.29
Methionine	88.2	86.9	85.7	86.8	1.84
Phenylalanine[d]	85.5	83.6	83.1	83.5	2.01
Threonine	76.4	74.7	73.8	75.1	3.81
Tryptophan	88.9	87.9	87.0	87.5	3.41
Valine	82.4	80.5	79.6	80.4	2.55
Nonessential					
Alanine	79.0	77.5	76.4	77.2	4.46
Aspartic acid[d]	83.3	81.3	80.6	80.6	2.98
Cystine	80.4	78.1	76.1	76.7	8.51
Glutamic acid	87.1	85.9	85.5	85.2	2.47
Glycine	74.5	73.5	71.3	69.7	15.41
Proline	77.4	78.7	78.1	76.3	18.69
Serine[d]	81.7	79.2	78.3	78.3	3.40
Tyrosine[d]	86.2	83.8	83.0	83.1	2.59

[a]SH = soybean hulls.
[b]Standard deviation of the mean.
[c]Linear effect of soy hull inclusion ($P < 0.01$).
[d]Linear effect of soy hull inclusion ($P < 0.05$).
[e]Quadratic effect of soy hull inclusion ($P < 0.05$).