

Determining Amino Acid Digestibility of Soybean Meal from South Carolina Soybean Varieties Fed to Broilers

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Summary

At hatch, 240 male broilers (Ross 308, Aviagen, Sallisaw, OK) were placed in batteries (Petersime Brood Unit, Gettysburg, OH) for a 15-d study to evaluate amino acid digestibility of soybean meal (SBM) from specialty variety soybeans grown in South Carolina. There were 10 replicates per treatment and 6 broilers per cage. Broilers were given a common corn and soybean meal-based diet from d 0 to 9. On d 9, broilers were weighed, and cages were allotted to 1 of 4 dietary treatments within location block. Dietary treatments consisted of 1 of 4 soybean sources varying in quality determined by crude protein (CP) content and processed into SBM. Two sources consisted of soybeans from a similar region and processed either commercially solvent extracted or experimentally solvent extracted at Texas A&M University. Therefore, dietary treatments consisted of a commercially processed SBM with 44% CP (CON) or experimentally processed SBM with 50% CP (PCON), 52% CP (52SBM), or 56% CP (56SBM). Assay diets were dextrose and SBM-based, formulated to supply 20% dietary CP with titanium dioxide as an indigestible marker. On d 15, broilers were euthanized by CO₂ inhalation and ileal samples were collected for determination of apparent ileal digestibility (AID) of AA. Data were analyzed using the GLIMMIX procedure in SAS v. 9.4 (SAS Institute Inc., Cary, NC), with pen as the experimental unit, pen location as the blocking factor and adjusted using Tukey-Kramer multiple comparisons. Broilers fed CON and 56SBM had increased ($P < 0.003$) digestibility of total AA, Arg, His, Lys, Thr, and Trp compared to those fed PCON and 52SBM. Digestibility of Ile and Phe increased ($P < 0.001$) in broilers fed 56SBM compared to CON and 52SBM, while PCON was intermediate to CON and 52SBM. Broilers fed 56SBM had increased ($P < 0.001$) digestibility of Leu compared to all other sources. Digestibility of Met increased ($P = 0.007$) in broilers fed CON and 56SBM compared to 52SBM and there was no evidence for differences between those fed PCON and all other sources. Broilers fed CON and 56SBM had increased ($P < 0.001$) digestibility of Val compared to PCON and 52SBM, with no evidence for differences between those fed CON and PCON. In conclusion, broilers fed commercially processed SBM had improved AA digestibility compared to those fed experimentally processed soybeans from a similar region. The high CP (57% CP) SBM variety had increased AA digestibility compared to the PCON and 52SBM.

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Introduction

Soybean meal (SBM) is the primary protein source used in broiler diets. Recent developments in soybean selection programs have led to increasing protein content of soybeans; therefore, leading to increased CP and AA concentrations of SBM. Determining SBM value can provide opportunity for cost savings through precision diet formulation. One of the main attributes of SBM quality is defined by CP content and AA availability for growth. While traditionally SBM has 46% CP, the opportunity for higher CP and AA content can increase SBM value ultimately decreasing diet inclusion and lowering diet costs. Therefore, it is essential to focus on optimizing SBM quality to improve the economics of poultry production. Selecting for soybean varieties that lead to increased available AA concentrations in SBM will provide an improvement in the feeding value of SBM. Therefore, the objective of this study was to determine the apparent ileal digestibility of AA for select varieties of SBM varying in CP content when fed to broilers.

Materials and Methods

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. A total of 240 one-day-old male broilers (Ross 308, Aviagen, Sallisaw, OK) were obtained and transported to the Kansas State University Poultry Facility (Manhattan, KS) to be used in a 15-d digestibility study. Broilers were placed in 2 Petersime batteries (Petersime Brood Unit, Gettysburg, OH) with 6 broilers per cage (dimensions, 38.0 × 13.0 in.), balanced by BW and provided a common corn, SBM diet. On d 9, cages were randomly assigned to 1 of 4 dietary treatments within location block and balanced by BW with 10 replicates per treatment. Broilers were maintained on a 24-hr lighting schedule in a thermostatically controlled room. Illumination was provided by fluorescent bulbs for the duration of the experiment. A HOBOWare data logger was used to record temperature, relative humidity, and light intensity of the battery room. For the first 9-d, averages were 76.6°F, 53.5%, and 11.4 lum/ft², followed by 73.9°F, 51.2% and 11.4 lum/ft² for the remainder of the experiment for temperature, relative humidity, and light intensity, respectively. Feed was provided *ad libitum* in a 1-pan feeder (capacity approximately 4.4 lb) per pen. Water was provided *ad libitum* through water troughs. Broilers were weighed on day 0, 9, and 15 for allotment to treatment and final BW. Mortalities were recorded daily.

Dietary treatments

Dietary treatments consisted of 1 of 4 soybean sources varying in quality determined by CP content and processed into SBM. Two sources consisted of soybeans from a similar region and processed either commercially solvent extracted or experimentally solvent extracted at Texas A&M University. Therefore, dietary treatments consisted of a commercially processed SBM with 44% CP (CON) or experimentally processed SBM with 50% CP (PCON), 52% CP (52SBM), or 56% CP (56SBM). Assay diets were dextrose and SBM-based and formulated to supply 20% dietary CP with titanium dioxide as an indigestible marker.

Ileal collection

On d 15, broilers were euthanized by CO₂ inhalation and ileal samples were collected for AA analysis. Ileal contents were collected beginning 0.4-in. posterior to the Meckel's diverticulum and ending 0.4-in. prior to the ileocecal junction. Ileal samples were

collected and pooled by pen. Composite samples were stored at -4°F prior to lyophilization (University of Illinois, Champaign, IL). Samples were finely ground to pass through a 0.02-in. screen and sent to the University of Missouri Agricultural Experiment Station (Columbia, MO) for analysis.

Chemical analysis

Individual soybean meal and diet samples were analyzed for proximate analysis and complete AA profile,² and available Lys³ (Table 1). Diets and ileal samples were analyzed for titanium dioxide⁴ as an indigestible marker (Table 3). Ileal contents were analyzed for dry matter and complete AA profile² for determination of apparent ileal digestibility (AID) of AA.

Calculations and statistical analysis

Apparent ileal digestibility of AID was calculated using the following equation⁵:

$$AID_{AA}(\%) = \left[1 - \left(\frac{AA_{\text{diet}}}{AA_{\text{digesta}}} \right) \times \left(\frac{TiO_{2,\text{digesta}}}{TiO_{2,\text{diet}}} \right) \right] \times 100,$$

where AA_{digesta} and AA_{diet} represent the AA concentrations (g/kg) in digesta and diet DM, respectively; and $TiO_{2,\text{diet}}$ and $TiO_{2,\text{digesta}}$ represent the digestible marker concentrations (g/kg) in diet and digesta DM, respectively (Table 4).

Data were analyzed using the PROC-GLIMMIX procedure of SAS (v. 9.4, SAS Institute, Inc., Cary, NC) with cage serving as the experimental unit. Results were considered significant at $P \leq 0.05$.

Results and Discussion

Individual soybean meal samples contained 44.8, 50.1, 52.4, and 56.1% CP, and 2.90, 3.05, 3.11, and 3.47% Lys in the CON, PCON, 52SBM, and 56SBM, respectively (Table 1). The PCON was sourced from the same geographical region as the CON, therefore it was expected these would be similar in CP content. The PCON, 52SBM, and 56SBM were processed into SBM on a pilot scale crush facility at Texas A&M University. These samples had increased DM compared to the CON. Therefore, the CON and PCON had similar CP and Lys when expressed on a DM basis. Individual SBM samples contained 2.79, 2.80, 2.90, and 3.24% available Lys and 0.6, 0.5, 2.1, and 1.1 crude fat in the CON, PCON, 52SBM, and 56SBM, respectively. High CP soybean samples had lower crude fiber where crude fiber was 5.2, 4.9, 4.7, and 4.3 in CON, PCON, 52SBM and 56SBM, respectively. Starch was greatest in CON (3.09%) followed by PCON (1.17%), 56SBM (0.19%), and 52SBM (0.12%).

² AOAC Official Method 982.30 E(a,b,c), chp. 45.3.05, 2006.

³ AOAC Official Method 975.44, chp. 45.4.03, 2006.

⁴ Myers, W. D., P. A. Ludden, V. Nayigihugu, B. W. Hess. 2004. Technical Note: A procedure for the preparation and quantitative analysis of samples for titanium dioxide, *J. Anim. Sci.*, Volume 82, Issue 1, Pg 179–183, <https://doi.org/10.2527/2004.821179x>

⁵ Kong, C., & Adeola, O. (2014). Evaluation of amino acid and energy utilization in feedstuff for swine and poultry diets. *Asian-Australasian Journal of Animal Sciences*, 27(7), 917–925. <https://doi.org/10.5713/ajas.2014.r.02>.

Broilers fed CON and 56SBM had increased ($P < 0.003$) AID of total AA, Arg, His, Lys, Thr, and Trp compared to those fed PCON and 52SBM (Table 3). The AID of Ile and Phe increased ($P < 0.001$) in broilers fed 56SBM compared to CON and 52SBM, while PCON was intermediate to CON and 52SBM. Broilers fed 56SBM had increased ($P < 0.001$) AID of Leu compared to all other sources. The AID of Met increased ($P = 0.007$) in broilers fed CON and 56SBM compared to 52SBM while there was no evidence for differences between those fed PCON and all other sources. Broilers fed CON and 56SBM had increased ($P < 0.001$) AID of Val compared to PCON and 52SBM with no evidence for difference between those fed CON and PCON.

In conclusion, SBM processed from 2 high quality soybean varieties from South Carolina resulted in increased SBM and had improved amino acid digestibility compared to experimentally processed soybean meal from similar sources. The 56SBM had increased digestibility of indispensable AA compared to SBM from PCON and 52SBM when fed to 15-day-old broilers. The increased AID of AA and increased AA content of high CP soybean meal resulted in an increase in digestible amino acid content provided by SBM.

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Table 1. Chemical analysis of individual soybean meal varieties (as-is basis)^{1,2}

Item, %	CON ³	PCON ³	52SBM ³	56SBM ³
Dry matter	89.82	95.51	95.44	91.40
Crude protein	44.81	50.12	52.35	56.17
Crude fat	0.55	0.48	2.08	1.14
Crude fiber	5.17	4.85	4.67	4.27
Starch	3.09	1.17	0.12	0.19
Ash	6.44	7.09	6.67	6.53
Available Lys	2.79	2.80	2.90	3.24
Lys:CP	6.47	6.09	5.94	6.18
Total AA	44.46	49.64	49.90	56.16
Indispensable AA				
Arg	3.20	3.50	3.71	4.29
His	1.17	1.31	1.39	1.46
Ile	2.23	2.46	2.50	2.78
Leu	3.48	3.87	3.91	4.33
Lys	2.90	3.05	3.11	3.47
Met	0.61	0.68	0.62	0.69
Phe	2.30	2.58	2.65	2.92
Thr	1.76	1.98	1.92	2.09
Trp	0.62	0.70	0.69	0.71
Val	2.25	2.52	2.55	2.86

¹At hatch, 240 male broilers (Ross 308, Aviagen, Sallisaw, OK) were placed in battery cages with 6 broilers per cage and 10 replicates per treatment.

²Dietary treatments consisted of 1 of 4 soybean meal (SBM) sources included in diets formulated to 20% CP.

³Dietary treatments consisted of 1 of 4 soybean sources varying in quality determined by crude protein (CP) content and processed into SBM. Two sources consisted of soybeans from a similar region and processed either commercially or experimentally solvent extracted at Texas A&M University. Therefore, dietary treatments consisted of a commercially processed SBM with 44% CP (CON) or experimentally processed SBM with 50% CP (PCON), 52% CP (52SBM), or 56% CP (56SBM).

Table 2. Diet formulation balanced at 20% crude protein^{1,2}

Ingredient, %	CON	PCON	52SBM	56SBM
Soybean meal ³	44.1	40.2	37.7	34.8
Dextrose	49.8	53.7	56.2	59.0
Vegetable oil	2.0	2.0	2.0	2.0
Dicalcium phosphate	1.9	1.9	1.9	1.9
Limestone	1.0	1.0	1.0	1.0
Sodium bicarbonate	0.2	0.2	0.2	0.2
Sodium chloride	0.2	0.2	0.2	0.2
Titanium dioxide	0.5	0.5	0.5	0.5
Vitamin trace mineral premix ⁴	0.3	0.3	0.3	0.3
Total	100.0	100.0	100.0	100.0
Calculated analysis				
ME, kcal/lb	1383	1405	1419	1434
Crude protein, %	20	20	20	20
Digestible amino acids, %				
Lys	1.31	1.19	1.12	1.03
Arg	1.43	1.31	1.22	1.13
His	0.53	0.48	0.45	0.42
Ile	0.98	0.90	0.84	0.78
Leu	1.56	1.43	1.34	1.24
Met	0.29	0.26	0.24	0.23
Total sulfur AA	0.60	0.55	0.51	0.47
Phe	1.04	0.95	0.89	0.82
Total aromatic AA	1.82	1.66	1.55	1.44
Thr	0.78	0.72	0.67	0.62
Trp	0.28	0.26	0.24	0.22
Val	1.02	0.93	0.87	0.80

¹At hatch, 240 male broilers (Ross 308, Aviagen, Sallisaw, OK) were placed in battery cages with 6 broilers per cage and 10 replicates per treatment.

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⁴ Provided per lb of diet: 4% Zn, 2% Fe, 4% Mn, 4500 ppm Cu, 600 ppm I, 60 ppm Se, 1,400,000 IU vitamin A, 500,000 IU vitamin D₃, 3,000 IU vitamin E, 2 mg vitamin B₁₂, 150 mg menadione, 1,200 mg riboflavin, 200 mg thiamine, 1,200 mg pantothenic acid, 5,000 mg niacin, 250 mg vitamin B₆, 125 mg folic acid, 70,000 mg choline, and 6 mg biotin.

Table 3. Effect of soybean meal source on apparent ileal digestibility of amino acids^{1,2,3,4}

Item, %	CON	PCON	52SBM	56SBM	SEM	Probability, <i>P</i>
Total AA	77.29 ^b	71.64 ^a	69.00 ^a	81.49 ^b	1.366	0.001
Indispensable AA						
Arg	85.23 ^b	80.46 ^a	79.57 ^a	88.48 ^b	1.213	0.001
His	80.20 ^b	74.09 ^a	72.15 ^a	83.14 ^b	1.361	0.001
Ile	76.93 ^b	72.80 ^{ab}	70.54 ^a	81.61 ^c	1.384	0.001
Leu	76.50 ^a	72.96 ^a	70.85 ^a	82.10 ^b	1.149	0.001
Lys	79.65 ^b	71.44 ^a	69.24 ^a	82.21 ^b	1.944	0.001
Met	80.15 ^b	73.86 ^{bc}	70.86 ^{ac}	81.33 ^b	2.321	0.007
Phe	77.73 ^b	74.71 ^{ab}	72.50 ^a	83.15 ^c	1.299	0.001
Thr	77.39 ^b	69.82 ^a	66.20 ^a	80.03 ^b	1.127	0.001
Trp	75.74 ^{ab}	73.77 ^a	72.60 ^a	82.47 ^b	1.872	0.003
Val	74.16 ^{bc}	69.71 ^{ab}	66.27 ^a	79.09 ^c	1.570	0.001

¹At hatch, 240 male broilers (Ross 308, Aviagen, Sallisaw, OK) were placed in battery cages with 6 broilers per cage and 10 replicates per treatment.

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³Means within a row followed by a different letter (^{a-c}) are significantly different ($P \leq 0.05$).

⁴AA = amino acids.