

VARIATION IN THE DIGESTIBILITY OF AMINO ACIDS IN SOYBEAN MEAL FROM A SINGLE PROCESSING PLANT^{1,2}

*D. J. Lee, J. D. Hancock, J. M. DeRouchey,
C. A. Maloney, D. W. Dean, and H. Cao*

Summary

Digestibilities of amino acids among samples of soybean meal (SBM) collected during a fall harvest season (4 collections made 15 d apart) were similar, except that true digestibility from tryptophan was lower for a sample collected on d 30 of the experiment vs SBM samples collected on the other dates. Our data suggest that proximate components and amino acid digestibilities of the SBM were very consistent and uniform during the 45 d of sample collection in one processing plant.

(Key Words: Soybean Meal, Digestibility, Amino Acids.)

Introduction

Soybean meal (SBM) is the most commonly used protein source in diets for pigs because of its high protein content and low cost. However, concern still exists about variability in protein content and quality that might result from inconsistencies in processing conditions at soybean crushing plants. To inactivate antinutritional factors, heat is applied during production of SBM. However, if too much heat is applied, nutrient availability can be compromised. This perceived variability in content and quality of protein is of concern to soybean processors because of other high quality amino acid sources (e.g., fishmeal, canola meal, and

miscellaneous animal protein sources) that compete with SBM produced in the United States. Thus, an experiment was designed with the objectives: 1) to gain an understanding of the variation encountered in the nutrient content of SBM processed within a single plant over several weeks and 2) to determine the apparent and true amino acid digestibilities in these same SBM samples.

Procedures

Four samples (181 kg each) of soybean meal (SBM) were acquired 15 days apart (d 0, 15, 30 and 45) from a soybean processing plant in northeast Kansas (Bunge Corp. Soybean Processing, Emporia, KS) during a fall harvest season. These SBM samples were compared to an SBM control that originated from the fall harvest in Ohio and a soy protein concentrate (Central Soya, in Decatur, IN). Casein (Carl Ackey, Lewisburg, OH) was used to formulate a low protein diet to allow estimation of endogenous losses and to allow calculation of true digestibility of amino acids. All diets (except the casein-based formulation) were cornstarch-based and formulated to 17% CP, (4.44% CP for the casein diet), .9% Ca, and .75% P (Table 1). Vitamins and minerals were added to meet or exceed NRC (1998) recommendations.

Nine barrows (55 lb initial BW) were fitted surgically with a simple T-cannula

¹This study was done in collaboration with North Carolina State University; University of Illinois; The Ohio State University; and Wageningen Agriculture University, the Netherlands.

²Appreciation is extended to the Illinois Soybean Program Operating Board (ISPOB) for financial assistance.

approximately 6 inches anterior to the ileocecal valve. Following surgery, pigs were housed in steel metabolism crates (4.9 ft × 1.6 ft) in a temperature-controlled (72°F) room during a 10-d recovery period. At the end of the recovery period, the pigs were weighed and assigned randomly to treatments in a 7 × 7 Latin square design (pig and period as blocking criteria).

Feed was provided at 7:00 a.m. and 7:00 p.m. each day using the equation: daily feed allowance = $BW^{.75} \times .09$. Chromic oxide (.5%) was added as an indigestible marker to allow determination of apparent digestibility coefficients. The pigs were allowed 5 d for adjustment to diet followed by 2 d of digesta collection (from 7:00 a.m. to 7:00 p.m.). Collections of digesta were made every 20 to 30 min, emptied into a plastic container, and frozen. Upon completion of the collection period, the samples were thawed and homogenized, and subsamples were re-frozen until they could be lyophilized and ground for laboratory analyses.

Amino acid analyses were performed on the ileal collection for each pig along with the soy samples and diets. Diet and ileal samples were analyzed for dry matter, chromium, ash, crude protein, fat, fiber, and amino acid concentrations. Color of the SBM samples was characterized using Hunter Lab (L^* , a^* , b^*) to give indications of surface lightness, redness, and yellowness, respectively. The soy products also were analyzed for urease activity, protein solubility in a KOH solution, and protein dispersibility in water.

Data from the digestibility experiment were analyzed as a Latin square design using the GLM procedure of SAS. The statistical model included the effects of pig, period, and treatment (protein source). Means were separated using the LSD procedure.

Results and Discussion

Dry matter concentrations for the protein sources (Table 2) were very similar (ranging from 88.5 to 90.2%). Likewise, other proximate components (i.e., N, ether extract,

crude fiber, ash, and nitrogen free extract) and amino acid concentrations were typical for the protein sources and similar among the SBM samples. However, chemical analyses are not good indicators of differences in nutrient digestibility that can result from variation in processing (e.g., over- or under-heating). Instead, soybean processors prefer a urease index between .02 and .2) pH to indicate adequate thermal treatment. For our experiment, urease indexes ranged from .01 to .03) pH, suggesting that heat treatment was adequate to inactivate the protease inhibitors found in raw soybeans.

Another assay that can be used to detect over/underprocessing is color determination using the Hunter miniscan. Our SBM samples had Hunter L^* values ranging from 61.5 to 71.8, a^* values from 4.7 to 5.9, and b^* values from 31.2 to 38.4. The control SBM (from Ohio) had a Hunter L^* value of 71.1, a^* value of 5.0, and b^* value of 31.9. Thus, all of the SBM samples used in our experiment were similar in color, suggesting similar processing conditions.

Endogenous losses of amino acids (Table 3) were determined by feeding pigs a casein-based diet. This allowed calculation of true digestibility of amino acids. For example endogenous lysine losses ranged from .44 to .58 and averaged .51%. The underlying assumption in calculating true digestibility using this procedure is that the protein within the casein was 100% digestible.

For digestibility of nutrients, the soy protein concentrate had lower apparent and true digestibility coefficients for several of the amino acids compared to the SBM treatments (Table 4). This response is difficult to explain, because most known antinutritional factors (e.g., lectins, protease inhibitors, oligosaccharides, and antigenic constituents) in soy protein concentrates supposedly are either removed or inactivated by a hot alcohol wash before toasting or extruding.

As for the SBM treatments, apparent digestibility of DM was greater for the SBM control and the sample collected on d 15 vs the samples collected on d 0 and 45 ($P < .05$).

Apparent digestibility of N was similar among the various SBM samples ($P>.05$) but the SBM control did have greater apparent digestibility of Ile and greater true digestibilities of Ile, Leu, and Val than the SBM collected on d 0 ($P<.05$). Also, the SBM control had greater apparent digestibilities of Ile and Thr and greater true digestibilities of His, Ile, Trp, and Val than the SBM collected on d 30 ($P<.05$). Among the SBM samples collected on d 0, 15, 30, and 45, only one response criterion (true digestibility of Trp for d 0 vs d 30) was different, with values being similar to those reported by the NRC for SBM (47.5% CP). Thus, the differences in digestibilities of

nutrients and amino acids for the SBM samples collected on different dates were inconsistent and small in magnitude.

In conclusion, our results indicate that day of processing at a single crushing plant probably is not a major source of variability in the nutritional value of soybean meal. However, several differences in the apparent and true digestibilities of amino acids did occur among the soybean meal control (from Ohio), the soy protein concentrate, and the soybean meal samples that we collected in Kansas. Those differences suggest that variation (sometimes considerable) in soy products does exist.



Eldo Heller, Breeding Barn Manager.

Table 1. Compositions of Diets

Item, %	Soy Concentrate	SBM Control	Soybean Meals ^a				Casein
			d 0	d 15	d 30	d 45	
Corn starch	46.00	38.10	37.28	37.54	38.31	37.14	61.60
Sucrose	20.00	20.00	20.00	20.00	20.00	20.00	20.00
Soybean meal	—	35.25	36.07	35.81	35.04	36.21	—
Soy protein concentrate	27.00	—	—	—	—	—	—
Casein	—	—	—	—	—	—	5.00
Cellulose fiber	—	—	—	—	—	—	5.00
Corn oil	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Salt	.35	.35	.35	.35	.35	.35	.40
Dicalcium phosphate	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	.45	.45	.45	.45	.45	.45	.60
Vitamins and minerals	.35	.35	.35	.35	.35	.35	.35
Chromic oxide	.50	.50	.50	.50	.50	.50	.50
Potassium carbonate (55% K)	.35	—	—	—	—	—	1.40
Magnesium oxide (58% Mg)	$\frac{3}{4}$	—	—	—	—	—	.15
Calculated Analysis							
CP	17.00	17.00	17.00	17.00	17.00	17.00	4.44
Lysine	1.03	1.05	1.05	1.05	1.05	1.05	.37
Ca	.90	.90	.90	.90	.90	.90	.90
P (total)	.75	.75	.75	.75	.75	.75	.61
Analyzed Values							
CP	16.99	16.29	17.94	17.41	17.42	16.11	5.51
Lysine	1.04	1.07	1.19	1.29	1.04	1.07	.38

^aSoybean meals were acquired from Bunge Corp. Soybean Processing of Emporia, KS.

Table 2. Chemical Analyses of Protein Sources, %

Item	Soy Conc.	SBM Control	Soybean Meals ^a				Casein
			d 0	d 15	d 30	d 45	
Proximate Components ^b							
DM, %	90.2	90.0	88.8	88.7	88.6	88.5	89.9
N, %	68.1	54.4	56.3	56.3	56.3	56.3	98.1
Ether extract, %	.6	2.5	2.0	1.9	1.7	1.9	.2
Crude fiber, %	3.9	3.4	3.9	3.6	3.7	3.6	.1
Ash, %	7.8	7.2	8.2	8.1	8.3	8.3	3.9
Nitrogen free extract, %	9.9	22.9	18.5	19.0	18.7	18.5	0
Urease index, ΔpH	.03	.03	.03	.01	.03	.03	—
Trypsin inhibitor, mg/g	.50	.48	.51	.55	.57	.62	—
Hunter L*	67.2	71.1	61.5	70.8	71.4	71.8	53.8
a*	4.7	5.0	5.9	4.9	4.7	5.0	6.6
b*	36.6	31.9	38.4	32.3	32.1	31.2	38.7
Protein solubility index, %	54.1	79.5	79.7	77.8	79.7	80.7	96.3
Protein dispersability index, %	4.1	28.0	26.4	27.7	33.4	33.8	—
Indispensable amino acid, %							
Arginine	4.68	3.58	3.53	3.59	3.58	3.57	3.03
Histidine	1.74	1.30	1.40	1.37	1.35	1.34	2.43
Isoleucine	2.94	2.17	2.10	2.16	2.22	2.17	4.00
Leucine	4.97	3.69	3.73	3.78	3.79	3.76	7.68
Lysine	4.08	2.99	3.07	3.12	3.13	3.11	6.39
Methionine	.81	.66	.71	.71	.74	.73	2.35
Phenylalanine	3.24	2.44	2.60	2.58	2.55	2.54	4.31
Threonine	2.55	1.87	1.85	1.84	1.85	2.84	3.52
Tryptophan	.83	.61	.79	.74	.76	.77	1.17
Valine	3.15	2.34	2.17	2.25	2.33	2.29	5.24
Total	28.99	21.65	21.95	22.14	22.30	22.12	40.12
Dispensable amino acids, %	30.52	22.66	22.69	23.13	23.34	23.22	42.51

^aSoybean meals were acquired from Bungee Corp. Soybean Processing, Emporia, KS.

^bDry matter basis.

Table 3. Endogenous Losses of Amino Acids in Pigs, g/d^{ab}

Period	Indispensable Amino Acids									
	Arginine	Histidine	Isoleucine	Leucine	Lysine	Methionine	Phenylalanine	Threonine	Tryptophan	Valine
1	.52	.24	.50	.72	.58	.12	.41	.62	.14	.59
2	.72	.20	.42	.62	.44	.11	.35	.63	.13	.52
3	.50	.24	.60	.77	.59	.17	.40	.74	.17	.65
4	1.14	.24	.65	.74	.50	.17	.36	.87	.18	.67
5	.54	.23	.60	.77	.49	.15	.38	.74	.10	.58
6	.56	.29	.84	.92	.52	.17	.46	.92	.19	.84
7	.91	.26	.59	.79	.51	.13	.40	.78	.13	.64
Mean	.70	.24	.60	.76	.52	.15	.39	.76	.15	.64

^aValues were obtained by feeding a purified diet with 5% added casein.

^bValues are reported on a dry matter basis.

Table 4. Apparent and True Digestibilities of Amino Acids in Soybean Protein Meals^a

Item	SBM 47.5% ^c	Soy Conc.	SBM Control	Soybean Meals ^b				SE
				d 0	d 15	d 30	d 45	
DM digestibility	—	80.6 ^{xy}	81.6 ^x	79.4 ^y	81.6 ^x	79.8 ^{xy}	79.2 ^y	.6
N digestibility	—	76.3 ^y	82.1 ^x	79.3 ^{xy}	82.1 ^x	79.8 ^{xy}	81.1 ^x	1.3
Arg digestibility, %								
Apparent	90.0	89.8	92.1	91.0	91.9	91.0	91.5	1.7
True	94.0	93.8 ^y	96.1 ^x	95.0 ^{xy}	95.8 ^x	95.0 ^{xy}	95.4 ^{xy}	.6
His digestibility, %								
Apparent	86.0	83.8 ^z	88.7 ^x	87.8 ^x	88.5 ^x	86.6 ^{xy}	87.4 ^{xy}	.8
True	91.0	87.6 ^z	92.5 ^x	91.3 ^{xy}	92.0 ^{xy}	90.2 ^y	91.0 ^{xy}	.8
Ile digestibility, %								
Apparent	84.0	83.6 ^y	86.6 ^x	84.1 ^y	85.8 ^{xy}	84.3 ^y	84.9 ^{xy}	.8
True	89.0	89.1 ^z	92.3 ^x	89.9 ^{yz}	91.4 ^{xy}	90.0 ^{yz}	90.4 ^{xyz}	.8
Leu digestibility, %								
Apparent	84.0	81.9 ^z	85.0 ^{xy}	83.0 ^{yz}	85.0 ^y	83.2 ^{yz}	83.7 ^{xyz}	.8
True	89.0	86.0 ^z	89.3 ^x	87.0 ^{yz}	89.1 ^{xy}	87.4 ^{xyz}	87.8 ^{xyz}	.8
Lys digestibility, %								
Apparent	85.0	82.9 ^z	87.1 ^{xy}	84.9 ^{yz}	86.7 ^{xy}	85.4 ^{xyz}	86.7 ^{xy}	1.1
True	90.0	86.3 ^y	90.7 ^x	88.3 ^{xy}	90.1 ^x	88.9 ^{xy}	90.0 ^x	1.1
Met digestibility, %								
Apparent	86.0	83.4 ^y	87.0 ^x	86.9 ^x	88.9 ^x	87.3 ^x	87.4 ^x	.7
True	91.0	87.8 ^y	91.8 ^x	91.2 ^x	93.2 ^x	91.4 ^x	91.5 ^x	.8
Phe digestibility, %								
Apparent	84.0	84.9	87.1	86.3	87.4	85.5	86.1	.7
True	89.0	88.1 ^y	90.4 ^x	89.3 ^{xy}	90.5 ^x	88.7 ^{xy}	89.2 ^{xy}	.7
Thr digestibility, %								
Apparent	78.0	74.1 ^z	78.8 ^x	76.0 ^{xyz}	78.0 ^{xy}	75.8 ^{yz}	75.7 ^{yz}	1.0
True	87.0	82.2 ^z	87.2 ^x	84.3 ^{xyz}	86.4 ^{xy}	84.3 ^{xyz}	84.0 ^{yz}	1.1
Trp digestibility, %								
Apparent	81.0	80.8 ^z	84.9 ^y	86.5 ^{xy}	87.9 ^x	84.3 ^y	86.5 ^{xy}	1.0
True	90.0	85.6 ^z	89.9 ^{xy}	90.3 ^{xy}	92.0 ^x	88.4 ^{yz}	90.3 ^{xy}	1.1
Val digestibility, %								
Apparent	81.0	80.5	85.2	82.0	83.8	82.1	82.9	1.0
True	88.0	85.9 ^z	90.8 ^x	87.9 ^{yz}	89.5 ^{xy}	87.8 ^z	88.4 ^{xyz}	1.0
Total indispensable amino acid digestibility, %								
Apparent		82.7	86.3	84.8	86.4	84.5	85.4	1.6
True		87.3 ^y	91.1 ^x	89.3 ^{xy}	90.9 ^x	89.0 ^{xy}	89.7 ^{xy}	1.1

^aTrue digestibilities were calculated using average amino acid values for pigs fed a casein-based diet. ^bSoybean meals were acquired from Bungee Corp. Soybean Processing, Emporia, KS. ^cNational Research Council, 1998. ^{x,y,z}Means in the same row with different superscripts are different (P<.05).