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Abstract

We conducted two experiments to determine the apparent ileal digestibility of amino acids and digestible energy (DE) and metabolizable energy (ME) values for conventionally processed, solvent-extracted soybean meal (SBM) compared to dry-extruded-expelled SBM with or without soy hulls. Apparent ileal digestibility of crude protein and lysine and DE and ME values were greater in either extruded-expelled SBM compared to the conventionally processed SBM. No differences occurred in apparent digestibility of amino acids or energy values between extruded-expelled SBM with hulls and that without hulls. These results suggest that the dry extrusion followed by expeller processing of soybeans results in a SBM with slightly greater digestibility of crude protein and lysine as well as greater DE and ME values con1pared to conventionally processed, solvent-extracted SBM.; Swine Day, Manhattan, KS, November 19, 1998

Keywords

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APPARENT ILEAL DIGESTIBLITY OF AMINO ACIDS AND DIGESTIBLE AND METABOLIZABLE ENERGY VALUES FOR CONVENTIONAL SOYBEAN MEAL OR DRY EXTRUDED-EXPELLED SOYBEAN MEAL FOR SWINE [1]

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Summary

We conducted two experiments to determine the apparent ileal digestibility of amino acids and digestible energy (DE) and metabolizable energy (ME) values for conventionally processed, solvent-extracted soybean meal (SBM) compared to dry-extruded-expelled SBM with or without soy hulls. Apparent ileal digestibility of crude protein and lysine and DE and ME values were greater in either extruded-expelled SBM compared to the conventionally processed SBM. No differences occurred in apparent digestibility of amino acids or energy values between extruded-expelled SBM with hulls and that without hulls. These results suggest that the dry extrusion followed by expeller processing of soybeans results in a SBM with slightly greater digestibility of crude protein and lysine as well as greater DE and ME values compared to conventionally processed, solvent-extracted SBM.

(Key Words: Soybean Meal, Processing, Digestibility, Energy.)

Introduction

Extrusion processing is an effective means of improving the nutritional value of whole soybeans fed to swine. A relatively recent advancement has been the use of an expeller to remove the oil from the soybeans. This results in an extruded-expelled soybean meal (SBM) that contains slightly higher levels of fat than solvent-extracted SBM. This extruded-expelled SBM has potential advantages in swine diets because of the increased energy content and decreased dustiness from the higher fat levels.

Therefore, the objectives of these experiments were to determine the apparent ileal amino acid digestibility and DE and ME values of SBM produced by dry extrusion followed by expelling and compare these values with those of conventionally processed, solvent-extracted SBM.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved protocols used in this experiment. Two experiments were conducted to determine the apparent ileal digestibility of amino acids and DE and ME values for dry-extruded-expelled SBM with and without hulls and conventionally processed, solvent extracted SBM. Extruded-expelled SBM products were processed by the Insta-Pro Express™ extruder/press system, using the Model 2500 Insta-Pro Dry-Extruder and Model 1500 Continuous Horizontal Press. Extruder temperatures and production rates for extruded-expelled SBMs with and without

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hulls were 312 and 316°F and 1,875 and 1925 lb/hr, respectively.

In Exp. 1, six barrows (initially 85 lb) were fitted surgically with a simple T-cannula approximately 15 cm anterior to the ileocecal valve. Pigs were used previously to determine the digestibility of amino acids in different corn varieties but were allowed 15 days of adjustment before the start of this experiment. Pigs were housed in stainless-steel metabolism cages and randomly allotted to one of three dietary treatments in a replicated 3 × 3 Latin square design. Diets were formulated to .80% total lysine using analyzed nutrient compositions of the three SBM sources (Table 1). The diets used in Exp. 1 were cornstarch based and contained either commercially obtained solvent-extracted SBM, extruded-expelled SBM with hulls, or extruded-expelled SBM without hulls (Table 2). All diets were formulated so that each SMB source provided the same amount of total lysine. All diets contained .25% chromic oxide as an indigestible marker.

Each 5-d feeding period consisted of a 3-d acclimation period followed by collection of ileal digesta for 2 days (8 h/d). Feed was divided into two equal meals and fed at 0600 and 1800 each day. All pigs were fed 3.0, 3.2, and 3.4 lb/d during periods 1, 2, and 3, respectively. Daily feed was determined by maintaining intakes of 3.0 to 3.5% of BW. Water was provided twice daily at a rate of 2:1 water:feed (wt:wt). Average weight of the pigs at the end of period 3 was 105 lb.

Ileal digesta was collected between 0600 and 1400 on 2 consecutive days by attaching a latex balloon to the cannula. Digesta in the balloon was collected periodically and stored on ice during the 8-h collection period. At the end of each day's collection, a .5 lb subsample was taken and frozen. The two subsamples from each pig in their respective period were homogenized, freeze-dried, and ground before analysis. All nutrient digestibilities were calculated using chromic oxide as the indigestible marker.

In Exp. 2, six barrows (initially 91 lb) were used to determine DE and ME values for the three SMB sources. Pigs were housed in stainless-steel metabolism cages designed to allow separate collection of urine and feces. Pigs were allotted to one of three experimental treatments in a replicated 3 × 3 Latin square design. The three SBM sources used were from the same batches as those used in Exp.1. Diets (Table 3) were formulated to contain 25% of one of three different SBM sources. Because the corn in each diet also supplied dietary energy, a fourth diet containing all ingredients except SBM was fed at the end of the experiment. The fourth collection period was used to determine the energy value of the corn, so energy values for the SBM could be determined by difference.

The four feeding periods consisted of 3 days of diet acclimation followed by 4 days of total fecal and urine collection. Feces were collected twice daily and pooled for each period. The feces then were mixed, and a representative subsample was freeze-dried and ground for chemical analysis. Ferric oxide (1% of diet) was used as the indigestible marker to identify the beginning and end of each collection period. Urine was collected into plastic bottles containing 25 mL of 6 *N* HCl. Ten percent of each day's output (volume basis) was stored frozen, pooled within a collection period, centrifuged to remove trace amounts of particulate matter, and then analyzed.

Feed was divided into two equal meals and fed at 0600 and 1800 each day. Daily feed intakes were 2.7, 3.2, 3.6, and 4.0 lb/d for periods 1, 2, 3, and 4, respectively, maintaining intakes of 3% of BW. Water was provided twice daily at a rate of 2:1 water:feed (wt:wt). Average weight of the pigs at the end of period 4 was 134 lb.

Data were analyzed using the GLM procedure of SAS with pig as the experimental unit. Data from both trials were analyzed as a replicated 3 × 3 Latin square design in which the model included the effects of treatment, square (replication), period, and 2-way interactions of pig and square.

Results and Discussion

Analyzed nutrient compositions of the three SBM sources suggest that many nutrients are higher in the extruded-expelled sources compared to the conventionally processed SBM (Table 1). However, the extruded-expelled SMB sources were 6 to 7 percentage units higher in DM than the conventionally processed SBM. When the SBM sources are compared on an equal DM basis, their nutrient profiles are very similar.

No differences (P>.14) in apparent ileal digestibility of nutrients occurred among the two extruded-expelled SBMs (Table 4). However, the apparent ileal digestibilities of crude protein (CP), lysine, valine, isoleucine, and some other amino acids were greater (P<.05) for the extruded-expelled products compared to the conventionally processed, solvent-extracted SBM. Digestibility values for the conventionally processed SBM are similar to published data (NRC, 1998).

Energy values for the three SBM products showed the same trend as CP and amino acid digestibility values (Table 5). *No differences* (P>.13) in DE or ME occurred between the two extruded-expelled SBM products. However, the conventionally processed SBM had lower (P<.0001) DE and ME compared to either extruded-expelled product. The DE and ME for the conventionally processed SBM product were similar to published values (1.67 and 1.53 Mcal/lb; respectively) (NRC, 1998).

In conclusion, nutrient composition of extruded-expelled SBM with and without hulls is similar to that of conventionally processed SBM on an equal DM basis. The apparent ileal digestibilities of some nutrients (CP and lysine) are increased with the extrusion, expeller technology compared to solvent-extraction. Thus, the waste should have lower nutrient concentrations when extruded-expelled SBM products are used. The extruded-expelled products also have higher energy values than the conventionally processed SBM.

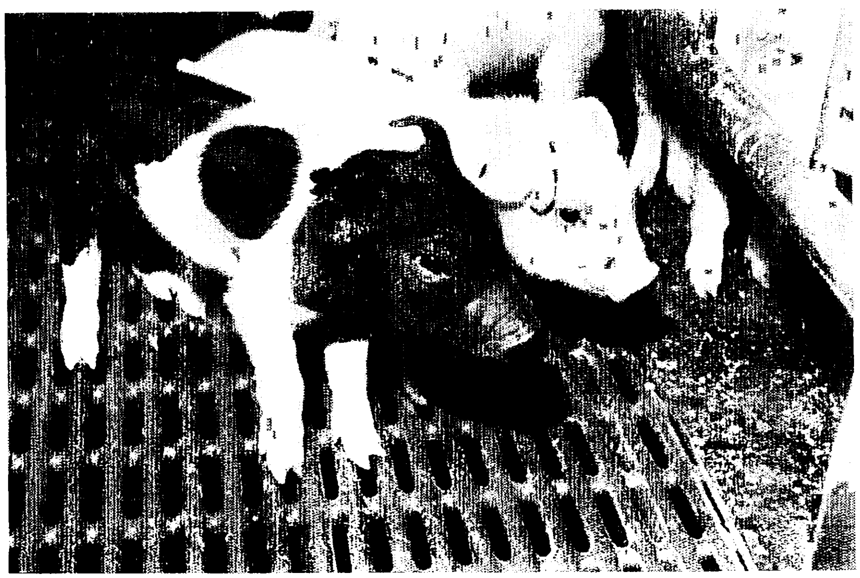

Table 1. Analyzed Nutrient Composition of Soybean Meal Sources[a]

Item	Solvent-Extracted	Dry Extruded-Expelled	
		With hulls	Without hulls
DM, %	88.25	94.59	95.96
CP, %	47.14	47.52	50.47
GE, Mcal/lb	1.93	2.12	2.14
Ash, %	6.76	6.03	6.24
Fat, %	1.14	4.89	5.86
Fiber, %	3.60	4.80	3.30
Urease activity, Δ pH	.03	.03	.03
Free fatty acid, %	9.1	1.7	.90
Peroxide value, meq/kg	21	33	40
Amino acids, %:			
Arginine	3.37	3.85	3.57
Histidine	1.27	1.27	1.35
Isoleucine	2.14	2.08	2.31
Leucine	3.66	3.68	3.89
Lysine	2.97	2.96	3.11
Methionine	.66	.65	.69
Phenylalanine	2.41	2.41	2.58
Threonine	1.83	1.85	1.93
Tryptophan	.68	.73	.72
Valine	2.30	2.24	2.46
Alanine	2.12	2.10	2.21
Aspartic acid	5.29	5.28	5.59
Cysteine	.73	.82	.83
Glutamic acid	8.30	8.19	8.72
Glycine	1.99	1.99	2.07
Proline	2.35	2.32	2.44
Serine	2.10	2.16	2.19
Tyrosine	1.69	1.69	1.78

[a]Values expressed on an as-fed basis.

Table 2. Diet Composition, Exp. 1[a]

		Dry Extruded-Expelled	
Ingredient, %	Solvent-Extracted	With hulls	Without hulls
Corn starch	68.57	69.01	70.13
Soybean meal, 46.5%	27.47	-	-
Extruded-expelled SBM			
with hulls	-	27.03	-
without hulls	-	-	25.91
Monocalcium phosphate	2.29	2.29	2.29
Limestone	.67	.67	.67
Salt	.35	.35	.35
Vitamin premix	.25	.25	.25
Trace mineral premix	.15	.15	.15
Chromic oxide	.25	.25	.25
Calculated analysis, %			
CP	12.65	12.43	12.60
Lysine	.80	.80	.80
Ca	.75	.75	.75
P	.66	.65	.65

[a]Values expressed on an as-fed basis.

Table 3. Diet Composition, Exp. 2[a]

Item, %	Periods 1, 2, and 3	Period 4[b]
Corn	71.59	96.22
Soybean meal[c]	25.00	-
Monocalcium phosphate	1.39	1.81
Limestone	1.07	1.02
Salt	.35	.35
Chromic oxide	.25	.25
Vitamin premix	.20	.20
Trace mineral premix	.15	.15

[a]Values expressed on an as-fed basis.
[b]The corn diet was used to determine the energy value of corn, so energy values of the soybean meal products could be determined by difference.
[c]The source of soybean meal, conventionally processed 46.5% CP soybean meal or extruded-expelled soybean meal with hull or without hulls, to provide three experimental treatments.

Table 4. Apparent Ileal Digestibility (%) of Nutrients in Soybean Meal[a]

	Soybean Meal Processing Technique			
		Dry Extruded-Expelled		
Item	Solvent-extracted	With hulls	Without hulls	SEM
DM	84.79	85.67	85.84	.58
CP	83.22[b]	86.21[c]	85.42[c]	.82
Ash	37.29	36.53	33.30	1.73
Amino Acids				
Arginine	91.39[b]	93.70[c]	93.75[c]	.21
Histidine	88.07	89.42	89.91	.59
Isoleucine	86.95[b]	89.72[c]	89.85[c]	.37
Leucine	85.52[b]	88.48[c]	88.58[c]	.47
Lysine	88.58[b]	90.90[c]	91.08[c]	.51
Methionine	89.10	88.85	88.51	.50
Phenylalanine	86.80[b]	90.01[c]	90.40[c]	.38
Threonine	78.15	79.14	79.79	.96
Tryptophan	86.96	88.38	87.25	.61
Valine	85.23[b]	87.37[c]	87.42[c]	.51
Alanine	82.34[b]	85.05[c]	85.40[c]	.83
Aspartic acid	85.72[b]	88.93[c]	89.22[c]	.51
Cysteine	80.72	81.98	82.65	.95
Glutamic acid	89.85[b]	92.51[c]	92.57[c]	.33
Glycine	75.19	73.35	76.54	1.53
Proline	83.23	81.60	83.29	1.72
Serine	82.65[b]	84.66[c]	84.94[c]	.57
Tyrosine	84.67	86.91	86.65	.72

[a]Values are the means of six pigs (initially 85 lb) used in a replicated 3 × 3 Latin square design.
[b,c]Means within a row with different superscripts differ ($P<.05$).

Table 5. Energy Values of Soybean Meal Sources, Mcal/lb[a]

	Soybean Meal Processing Technique		
		Dry Extruded-Expelled	
Item	Solvent-extracted	With hulls	Without hulls
Digestible energy	1.66[b]	1.87[c]	1.91[c]
Metabolizable energy	1.55[b]	1.76[c]	1.80[c]

[a]Values are the means of six pigs (initially 91 lb) used in a replicated 3 × 3 Latin square design.
[b,c]Means within a row with different superscripts differ ($P<.05$).