EFFECTS OF EXTRUDED-EXPELLED SOYBEAN MEAL AND SOLVENT EXTRACTED SOYBEAN MEAL LEVEL OF GROWTH PERFORMANCE OF WEANLING PIGS[1,2]

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Summary

A total of 350 weanling pigs (initially 15.7 lb) were used to evaluate the effects of soybean meal source and level on growth performance of early weaned pigs. Dietary treatments included a control diet containing no soybean meal, or diets containing 20% or 40% of either solvent extracted soybean meal (SBM) or extruded-expelled soybean meal (EESOY). The SBM and EESOY were analyzed for trypsin inhibitor (0.7 mg TI/g and 1.8 mg TI/g, respectively) to ensure quality, and actual crude protein values (46.9% and 48.3% as-fed, respectively) were used in diet formulation. From d 0 to 14, increasing EESOY decreased ADG and ADFI (linear, *P*<0.01), but improved F/G (linear, *P*<0.05). Increasing SBM decreased ADFI (linear, *P*<0.02), but improved F/G (linear, *P*<0.01). No differences (*P*>0.05) were found between soybean meal sources throughout the trial. The results of this study suggest extruded-expelled soybean meal processed properly and fed in diets immediately after weaning did not improve growth performance of nursery pigs relative to conventional solvent extracted soybean meal. When EESOY or SBM was included at 40% in diets fed immediately after weaning, growth performance of weanling pigs was poorer than if fed at lower levels (20%). Feeding properly processed EESOY resulted in similar growth performance compared to feeding SBM.

(Key Words: Weanling Pigs, Soybean Meal, Performance)

Introduction

The amount of soybean meal in diets fed immediately after weaning is usually limited because of delayed-type hypersensitivity reactions of young pigs to high levels of glycinin and beta conglycinin found in soybean meal. However, it is important to include some soybean meal in the initial diets in order to acclimate pigs to soy protein so that levels of soybean meal can be increased in later diets. Processing methods of soybean meal, such as extruding and expelling, may allow for greater inclusions of soy proteins in the diet without negatively affecting pig performance. Previous research at Kansas State University has

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shown that moist extrusion of soybean meal can result in growth performance comparable to and better than that achieved by feeding highly refined soy products to the early-weaned pig. The dry extrusion-expelling technique (Insta-Pro Express Extruder/Press System, Des Moines, Iowa) results in a soybean meal with higher fat (oil) content than solvent extracted processed soybean meal. The high temperature of the extrusion technology aids in the inactivation of anti-nutritional factors, such as conglycinin and β-conglycinin, which are potentially antigenic with the intestinal lumen.

Previous research has shown that pigs (>25 lb) fed extruded-expelled soybean meal have equal or better growth performance than pigs fed solvent extracted soybean meal.

The objective of studies reported in a previous Kansas State University Swine Day Report (2002) were to evaluate the nutritional value of EESOY relative to SBM. Reports in the 2002 KSU Swine Day showed that pigs fed EESOY performed poorer than pigs fed SBM due to high levels of trypsin inhibitor (>8.2 mg TI/g) in the EESOY. Therefore, the objective of this study was to evaluate the nutritional value of properly processed extruded-expelled soybean meal (<5 mg TI/g) relative to soybean meal in diets fed to pigs immediately after weaning.

Procedures

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

Three hundred and fifty barrows and gilts (initially 15.7 ± 6.0 lb and 21 ± 3 d of age at weaning) were blocked by weight and allotted randomly to one of five dietary treatments which were fed from d 0 to 14 after weaning (Table 1) and a common Phase II diet was fed from d 14 to 21 (Table 2). Each treatment had 14 replications (pens) per treatment and five pigs per pen. Diets were formulated with actual analyzed nutrient soybean meal values. Dietary treatments included a control diet containing no soybean meal, or diets containing 20% or 40% soybean meal or extruded-expelled soybean meal. Soybean meal replaced all or 50% of the spray-dried animal plasma, fishmeal and blood meal in diets containing 20% and 40% soybean meal product. All diets for each experiment were formulated to meet or exceed the nutrient requirement estimates of pigs suggested by the NRC, respectively (1998).

Pigs were housed at the Kansas State University Segregated Early Wean Facility. Each pen was 4 × 4 ft and contained one self feeder and one nipple waterer to allow ad libitum access to feed and water. Room temperature was initially 35ºC then lowered 2ºC each week based on pig comfort. Average daily gain, ADFI, and F/G were determined by weighing pigs and measuring feed disappearance every 7 days.

Data were analyzed using the MIXED procedures of SAS as a randomized complete block design with pen as the experimental unit. Linear and quadratic contrasts were determined for each source of soybean meal and contrasts determined if there were any differences between soybean meal sources.

Results

Crude protein and trypsin inhibitor values for the SBM and EESOY were analyzed prior to the experiment (SBM, 46.9% CP, 0.7 mg TI/g; EESOY, 48.3% CP, 1.8 mg TI/g) to validate adequate processing. From d 0 to 7, increasing extruded-expelled soybean meal decreased (linear, P<0.04) ADG and ADFI (Table 3). Increasing solvent extracted soybean meal decreased (linear, P<0.04) ADFI.

From d 7 to 14 similar results were seen with increasing extruded-expelled soybean meal. As extruded-expelled soybean meal increased, ADG and ADFI decreased (linear, $P<0.03$). For the overall treatment period (d 0 to 14), increasing extruded-expelled soybean meal decreased ADG, ADFI, (linear, $P<0.01$) and improved F/G (linear, $P<0.05$), while increasing solvent extracted soybean meal decreased ADFI (linear, $P<0.02$) and improved F:G (linear, $P<0.01$). For the common period (d 14 to 21), increasing either soybean meal source in the treatment period increased ADG and ADFI (linear, $P<0.01$). For the overall period (d 0 to 21), increasing either soybean meal source improved feed efficiency (linear, $P<0.02$). No differences were observed ($P>0.05$) between growth performance of pigs fed solvent extracted soybean meal or extruded-expelled soybean meal.

Discussion

Results reported of previous trials (Swine Day 2002) suggest that the extruded-expelled soybean meal contained levels of trypsin inhibitor (Exp. 1, 9.3 mg TI/g; Exp. 2, 8.2 mg TI/g) higher than conventional solvent extracted soybean meal (Exp. 1, 1.2 mg TI/g; Exp. 2, 2.0 mg TI/g). This is speculated to be because of the lower moisture level of the whole soybeans used for the extruded-expelled process. The soybeans used in these trials were grown in a relatively dry year and the moisture content of the beans at harvest was lower than average. Moisture needed to be added back to the raw soybeans before processing. For this third experiment, the soybeans used for the extruded-expelled soybean meal were tested for moisture before the raw soybeans were processed to ensure adequate moisture level of the soybeans for processing to help cook the soybeans and deactivate the trypsin inhibitor. The trypsin inhibitor values of the extruded-expelled soybean meal were lowered greatly after the moisture content of the raw soybeans was monitored (1.8 mg TI/g).

Quality control steps of extruded-expelled soybean meal production assure optimum quality of the product. Moisture and temperature are very important to deactivate anti-nutritional factors. Therefore, to reduce the trypsin inhibitor units to an acceptable level with low moisture raw beans, the temperature will need to be increased compared to that of soybeans containing a higher moisture level. Alternatively, moisture could be added to the soybeans. Checking the trypsin inhibitor level of raw soybeans may be useful in determining the proper level of moisture to be added or proper temperature to be used. It is important for EESOY manufacturers to establish a quality control procedure that assures optimum quality of EESOY and proper destruction of anti-nutritional factors.

Previous research at Kansas State University has found dry extruded-expelled soybean meal with or without hulls has greater apparent ileal digestibilities of amino acids and greater digestible and ME than commercially-available, solvent extracted soybean meal. Growth performance of pigs fed dry extruded-expelled soybean meal or solvent extracted soybean meal was similar when diets were formulated on the basis of equal apparent ileal digestible lysine and ME, suggesting that the dry extruder-expeller inactivates the anti-nutritional factors associated with raw soybeans. We found no differences between soybean meal sources when the extruded-expelled soybean meal was adequately processed.

Currently, commercial diets for the early weaned pig contain relatively low levels of soybean meal to minimize the transient hypersensitivity and maximize growth. We had initially hypothesized that the extrusion process may inactivate more of the antigens compared to the solvent extracted soybean meal process.

The results of our experiments are in agreement with previous research suggesting adequate levels of extruded-expelled soybean meal and solvent extracted soybean meal in the weanling pig diet to be approximately 20%. We found that soybean meal source levels of 40% in the diet decreased growth performance of nursery pigs compared to a 20% inclusion rate. Subsequent performance of pigs previously fed 40% soybean meal source had no compensatory growth.

Our results indicate the EESOY was not superior to the solvent extracted soybean meal. Our studies suggest that extruded-expelled soybean meal has similar feeding value compared to solvent extracted soybean meal if the extruded-expelled soybean meal is adequately processed to destroy anti-nutritional factors such as trypsin inhibitor. Increasing levels of either soybean meal source decreased growth performance in weanling pigs immediately after weaning.

In conclusion, extruded-expelled soybean meal production should be monitored closely to ensure destruction of anti-nutritional factors. Pigs fed diets containing properly processed extruded-expelled soybean meal had similar growth rates and feed efficiency compared to pigs fed solvent extracted soybean meal. Therefore, when properly processed, either source of soybean meal is acceptable for early-weaned nursery pig diets. Price and product availability should determine the soybean meal source to be included in nursery diets.

Table 1. Diet Composition (As-fed Basis)[a]

		Soybean meal source			
		Solvent extracted		Extruded-expelled	
Ingredient, %	Control	20%	40%	20%	40%
Corn	50.89	38.75	26.47	40.94	30.85
Soybean meal	-	20.00	40.00	20.00	40.00
Spray-dried whey	22.50	22.50	22.50	22.50	22.50
Fishmeal	8.63	4.94	1.25	4.44	0.25
Spray-dried animal plasma	8.60	4.30	-	4.30	-
Soy oil	3.90	4.73	5.55	2.95	2.00
Spray-dried blood meal	2.50	1.25	-	1.25	-
Medication[b]	1.00	1.00	1.00	1.00	1.00
Monocalcium phosphate, 21% P	-	0.73	1.45	0.78	1.55
Limestone	0.60	0.60	0.60	0.64	0.67
Zinc oxide	0.38	0.38	0.38	0.38	0.38
Salt	0.30	0.30	0.30	0.30	0.30
Vitamin premix	0.25	0.25	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15	0.15	0.15
L-isoleucine	0.20	0.02	-	0.02	-
DL-methionine	0.10	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00	100.00
Calculated Analysis					
Lysine, %	1.55	1.55	1.55	1.55	1.55
Ile:lys ratio, %	60	60	71	60	72
Met Cys:lys ratio, %	58	58	57	58	58
Thr:lys ratio, %	66	66	66	66	66
Trp:lys ratio, %	18	20	21	20	21
Val:lys ratio, %	79	78	77	79	78
ME, kcal/lb	1,581	1,582	1,580	1,583	1582
Protein, %	21.7	23.0	24.5	23.2	24.8
Ca, %	0.87	0.87	0.87	0.87	0.87
P, %	0.72	0.79	0.85	0.79	0.86
Available P, %	0.57	0.57	0.57	0.57	0.57
Lysine:calorie ratio, g/Mcal	4.45	4.45	4.45	4.45	4.45

[a]Diets were formulated on actual analyzed crude protein values of soybean meal. The solvent extracted soybean meal contained 46.9% crude protein and the extruded-expelled soybean meal contained 48.3% crude protein.
[b]Provided 50 g/ton of carbadox.

Table 2. Composition of Common Diet (As-fed Basis)[a]

Ingredient, %	Phase II
Corn	50.04
Soybean meal, 46.5% CP	27.20
Spray-dried whey	10.00
Select menhaden fishmeal	5.00
Soy oil	4.00
Medication[b]	1.00
Monocalcium phosphate, 21% P	0.98
Limestone	0.65
Zinc oxide	0.25
Vitamin premix	0.25
Salt	0.25
Trace mineral premix	0.15
L-lysine HCl	0.15
DL-methionine	0.08
Calculated Analysis	
Lysine, %	1.40
Met:lys ratio, %	32
Met Cys:lys ratio, %	57
Thr:lys ratio, %	61
Trp:lys ratio, %	18
ME, kcal/lb	1,560
CP, %	21.3
Ca, %	0.87
P, %	0.76
Available P, %	0.48

[a]Phase II common diet was fed from d 14 to 21.
[b]Provided 50 g/ton of carbadox.

Table 3. Effects of Extruded-Expelled Soybean Meal and Solvent Extracted Soybean Meal Level on Growth Performance of Weanling Pigs[a]

	Treatments						Probability, P<				
		Soybean meal source					Soybean meal source				
		Solvent extracted		Extruded-expelled			Solvent-extracted		Extruded-expelled		SBM vs.
Item	Control	20%	40%	20%	40%	SE	Linear	Quadratic	Linear	Quadratic	EESOY
Day 0 to 7											
ADG, lb	0.63	0.62	0.62	0.55	0.53	0.04	0.11	0.48	0.04	0.34	0.72
ADFI, lb	0.56	0.52	0.52	0.46	0.44	0.04	0.04	0.74	0.02	0.66	0.81
F/G	0.89	0.84	0.84	0.84	0.85	0.03	0.20	0.43	0.26	0.31	0.99
Day 7 to 14											
ADG, lb	0.72	0.69	0.68	0.69	0.61	0.04	0.57	0.82	0.03	0.71	0.19
ADFI, lb	0.80	0.76	0.75	0.72	0.67	0.04	0.11	0.95	0.01	0.74	0.37
F/G	1.14	1.10	1.11	1.07	1.10	0.03	0.06	0.89	0.31	0.82	0.38
Day 0 to 14[b]											
ADG, lb	0.67	0.66	0.62	0.65	0.57	0.03	0.10	0.71	0.01	0.30	0.20
ADFI, lb	0.68	0.64	0.59	0.63	0.56	0.03	0.02	0.86	0.01	0.61	0.45
F/G	1.02	0.97	0.96	0.98	0.98	0.02	0.01	0.41	0.05	0.26	0.42
Day 14 to 21[c]											
ADG, lb	1.06	1.10	1.12	1.22	1.27	0.04	0.01	0.36	0.01	0.34	0.32
ADFI, lb	1.29	1.29	1.30	1.46	1.46	0.04	0.01	0.05	0.01	0.11	0.87
F/G	1.22	1.18	1.17	1.22	1.17	0.03	0.97	0.27	0.16	0.40	0.20
Day 0 to 21											
ADG, lb	0.80	0.80	0.82	0.81	0.80	0.03	0.49	0.78	0.99	0.81	0.67
ADFI, lb	0.88	0.86	0.88	0.86	0.86	0.03	0.99	0.37	0.45	0.67	0.61
F/G	1.08	1.04	1.04	1.04	1.04	0.01	0.02	0.13	0.01	0.11	0.77

[a]A total of 350 pigs (five pigs per pen and fourteen pens per treatment) with an average initial BW of 15.7 lb.
[b]Treatment diets were fed from d 0 to 14 of the experiment.
[c]Day 14 to 21 pigs were fed common Phase II diet.