EFFECTS OF SOYBEAN MEAL SOURCE AND LEVEL ON GROWTH PERFORMANCE OF WEANLING PIGS

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Summary

A total of 525 weanling pigs (initially 13.0 lb) were used in two experiments to evaluate the effects of soybean meal source and level on growth performance of early weaned pigs. In both experiments, 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). In Exp. 1, diets were formulated with NRC (1998) nutrient values for the solvent extracted soybean meal and previously determined values (1998 KSU Swine Day Report of Progress) for the extruded-expelled soybean meal. In Exp. 1, from d 0 to 7, increasing solvent extracted soybean meal or extruded-expelled soybean meal decreased (linear, $P<0.05$) ADG. Feed efficiency was reduced with an increase of either soybean meal source (SBM quadratic, $P<0.05$; EESoy linear, $P<0.05$). However, the mean ADG and F/G of pigs fed solvent extracted soybean meal were better than the mean of pigs fed extruded-expelled soybean meal. No differences were found in growth performance from d 7 to 14 and 14 to 21. However, from d 0 to 14, F/G became poorer (linear, $P<0.06$) as either soybean meal source increased, and the mean F/G of pigs fed solvent extracted soybean meal was better than those fed extruded-expelled soybean meal. For the overall growth period, d 0 to 21, F/G became poorer (linear, $P<0.04$) as solvent extracted soybean meal increased. After the trial was completed, the soybean meal sources were chemically analyzed and the extruded-expelled soybean meal was found to be lower in crude protein (43.6% vs 46.5%) than what was used in diet formulation. We speculated that the differences in growth performance between the two soybean meal sources could have been a result of the low protein (lysine) concentrations. Therefore, in Exp. 2 diets were formulated with actual analyzed nutrient soybean meal values.

In Exp. 2, from d 0 to 7, increasing either soybean meal source resulted in decreased (linear, $P<0.01$) ADG and ADFI, and reduced (quadratic, $P<0.04$) F/G. The mean ADG, ADFI, and F/G of pigs fed solvent extracted soybean meal were better than the mean of those fed extruded-expelled soybean meal. From d 7 to 14, ADG and F/G improved (linear, $P<0.05$) with increasing solvent extracted soybean meal. Increasing extruded-expelled soybean meal had no affect on ADG or F/G but decreased (linear, $P<0.03$) ADFI. From d 0 to 14, increasing solvent extracted soybean meal decreased (linear, $P<0.02$) ADFI. Increasing extruded-expelled soybean meal decreased ADG, ADFI, and decreased F/G (linear, $P<0.01$). The mean ADG, ADFI, and F/G of pigs fed solvent extracted soybean meal

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was better than the mean of pigs fed extruded-expelled soybean meal. For the overall trial, increasing extruded-expelled soybean meal decreased ADG and ADFI (linear, $P<0.01$) and the mean ADG and ADFI, were less than those fed solvent extracted soybean meal. Because of previous research demonstrating equal or better growth performance of pigs fed extruded-expelled soybean meal, the results of these trials led us to suspect that poor quality extruded-expelled soybean meal was used in this trial. At the conclusion of the study, soybean meal sources from both trials were analyzed for trypsin inhibitor. Results of the trypsin inhibitor assay suggest that the extruded-expelled soybean meal from both experiments was underprocessed, resulting in poor growth performance. In conclusion, trypsin inhibitor values are extremely important in verifying quality of extruded-expelled soybean meal.

(Key Words: Soybean Meal, Weanling Pigs.)

Introduction

Commercial diets for early-weaned pigs contain relatively low levels of soybean meal. Previous research suggests that the amount of soybean meal in diets is 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 soybean meal so its levels 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. This would offer a large economic incentive to the producer. Previous research has shown that pigs (>25 lb) fed extruded-expelled soybean meal have better growth performance than pigs fed solvent extracted soybean meal. Therefore, the objective of this study was to compare the effects of increasing levels of solvent extracted soybean meal and extruded-expelled soybean meal on weanling pig performance.

Procedures

In Exp. 1, a total of 175 pigs (initially 13.1 lb and 21 ± 3 d of age) were used in a 21-d growth assay. There were five pigs per pen and seven pens per treatment. Experimental diets were fed to all pigs from d 0 to 14 after weaning. All diets were corn-soybean meal-based and formulated to 1.50% total lysine, 0.76% Ca, and 0.50% available phosphorus (Table 1). The five dietary treatments included a control containing no soybean meal, diets containing 20% and 40% of either solvent extracted soybean meal or extruded-expelled soybean meal. Pigs were fed the same common diet from d 14 to 21 after weaning.

In Exp. 2, a total of 350 pigs (initially 12.9 lb and 21 ± 3 d of age) were used in a 21-d growth assay. There were five pigs per pen and 14 pens per treatment. Experimental diets were fed to all pigs from d 0 to 14 after weaning. All diets were corn-soybean meal-based and formulated to 1.50% total lysine, 0.76% Ca, and 0.50% available phosphorus (Table 2). The five dietary treatments were identical to Exp. 1, which included a control containing no soybean meal, diets containing 20% and 40% of either solvent extracted soybean meal or extruded-expelled soybean meal. Diets in Exp. 2 were formulated on actual chemical analysis of the solvent extracted and extruded-expelled soybean meal. Pigs were fed the same common diet from d 14 to 21 after weaning. In both experiments, pigs were housed in the Kansas State University Segregated Early Weaning Facility. Each pen was 4 × 4 ft and contained one self-feeder and one nipple waterer to provide ad libitum access to feed and water. 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 differences between soybean meal source.

Results and Discussion

In Exp. 1, from d 0 to 7, increasing solvent extracted soybean meal or extruded-expelled soybean meal decreased (linear, $P<0.05$) ADG (Table 3). Feed efficiency was reduced as either soybean meal source increased (SBM quadratic, $P<0.05$; EESoy linear, $P<0.05$). However, the mean ADG and F/G of pigs fed solvent extracted soybean meal were better than the mean of pigs fed extruded-expelled soybean meal. No differences were found in growth performance from d 7 to 14 and 14 to 21. From d 0 to 14, F/G was reduced (linear, $P<0.06$) as either soybean meal source increased, and the mean F/G of pigs fed solvent extracted soybean meal was better than those fed extruded-expelled soybean meal. For the overall experimental period, d 0 to 21, F/G decreased (linear, $P<0.04$) as solvent extracted soybean meal increased.

In Exp. 2, from d 0 to 7, increasing either soybean meal source resulted in decreased (linear, $P<0.01$) ADG and ADFI, and F/G (quadratic, $P<0.04$) (Table 4). The mean ADG, ADFI, and F/G of pigs fed solvent extracted soybean meal were better than the mean of those fed extruded-expelled soybean meal. From d 7 to 14, ADG and F/G improved (linear, $P<0.05$) with increasing solvent extracted soybean meal. Increasing extruded-expelled soybean meal had no affect on ADG or F/G but decreased (linear, $P<0.03$) ADFI. From d 0 to 14, increasing solvent extracted soybean meal decreased (linear, $P<0.02$) ADFI. Increasing extruded-expelled soybean meal decreased ADG, ADFI, and F/G (linear, $P<0.01$). The mean ADG, ADFI, and F/G of pigs fed solvent extracted soybean meal was better than the mean of pigs fed extruded-expelled soybean meal. For the overall trial, increasing extruded-expelled soybean meal decreased ADG and ADFI (linear, $P<0.01$). The mean ADG and ADFI were less than those fed solvent extracted soybean meal.

Previous research suggests improved growth performance in pigs fed extruded-expelled soybean meal. Results of this trial indicate otherwise. Therefore, samples of the different batches of soybean meal used in both trials were analyzed for trypsin inhibitor, urease, protein solubility (KOH), nitrogen solubility (NSI), and mycotoxins. These tests can identify whether or not soybean meal has been over- or underprocessed. Results of the trypsin inhibitor assay and other tests suggest that the solvent extracted soybean meal for both trials was processed properly. However, the trypsin inhibitor assay results of the extruded expelled soybean meal were above recommended values and indicate that the extruded-expelled soybean meal in both studies was underprocessed. Interestingly, the other analytical procedures would have suggested that the extruded-expelled soybean meal was properly processed. We speculate that there may be factors or conditions in soybean thermal processing that result in some quality indicator tests to be normal but not others. For example, the urease, PSI, and NSI results suggested adequately processed soybean meal but trypsin inhibitor did not.

In conclusion, results of the trypsin inhibitor assay suggest that the extruded-expelled soybean meal from both experiments was undercooked, resulting in poor growth performance.

Trypsin inhibitor values are extremely important in verifying the quality of extruded-expelled soybean meal while other quality tests may not be as accurate in testing soybean meal quality, especially at the mill. Soybean meal processors must ensure soybean meal is adequately processed to a high enough temperature to reduce anti-nutritional factors that result in decreased growth performance.

Table 1. Diet Composition (Exp. 1)[a]

		SBM		EESOY	
Ingredient, %	Control	20%	40%	20%	40%
Corn	52.52	39.80	27.15	41.75	31.05
Soybean meal	-	20.00	40.00	-	-
EESOY	-	-	-	20.00	40.00
Spray-dried whey	22.50	22.50	22.50	22.50	22.50
Spray-dried animal plasma	8.60	4.30	-	4.30	-
Fish meal	7.50	3.95	0.40	3.84	0.18
Blood meal	2.50	1.25	-	1.25	-
Soy oil	3.90	4.80	5.70	2.95	2.00
Monocalcium phosphate, 21% P	-	0.63	1.25	0.63	1.25
Limestone	0.45	0.65	0.85	0.65	0.85
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
Antimicrobial[b]	1.00	1.00	1.00	1.00	1.00
Zinc oxide	0.38	0.38	0.38	0.38	0.38
L-Isoleucine	0.19	-	-	-	-
DL-Methionine	0.08	0.08	0.08	0.08	0.08
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Digestible lysine, %	1.28	1.27	1.27	1.26	1.26
Lysine, %	1.50	1.50	1.50	1.50	1.50
Isoleucine:lysine, %	60	59	59	72	72
Met & Cys:lysine, %	53	54	53	55	53
Threonine:lysine, %	63	62	62	61	62
Tryptophan:lysine, %	18	19	19	20	20
Valine:lysine, %	80	77	77	75	75
ME, kcal/lb	1,584	1,585	1,583	1,585	1,584
Protein, %	21.10	22.40	23.90	22.50	24.10
Ca, %	0.76	0.82	0.89	0.82	0.88
P, %	0.69	0.74	0.79	0.74	0.79
Available P, %	0.54	0.52	0.51	0.52	0.50
Lysine:calorie ratio, g/mcal	4.30	4.29	4.30	4.29	4.30

[a]Values calculated on an as-fed basis. Both protein sources were assumed to contain 46.5% crude protein, but the solvent extracted soybean meal contained 46.7% and the extruded-expelled soybean meal contained 43.6%.
[b]Provided 50g/ton carbadox.

Table 2. Diet Composition (Exp. 2)[a]

		SBM		EESOY	
Ingredient, %	Control	20%	40%	20%	40%
Corn	52.20	39.30	26.40	40.95	29.70
Soybean meal	-	20.00	40.00	-	-
EESOY	-	-	-	20.00	20.00
Spray-dried whey	22.50	22.50	22.50	22.50	22.50
Spray-dried animal plasma	8.60	4.30	-	4.30	-
Fish meal	7.50	4.30	1.10	4.45	1.40
Blood meal	2.50	1.25	-	1.25	-
Soy oil	3.90	4.83	5.75	3.03	2.15
Monocalcium phosphate, 21% P	-	0.63	1.25	0.63	1.25
Limestone	0.45	0.65	0.85	0.65	0.85
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
Antimicrobial[b]	1.00	1.00	1.00	1.00	1.00
Zinc oxide	0.38	0.38	0.38	0.38	0.38
L-Isoleucine	0.19	0.09	-	0.09	-
DL-Methionine	0.08	0.08	0.08	0.08	0.08
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
Digestible lysine, %	1.28	1.27	1.26	1.27	1.25
Lysine, %	1.50	1.50	1.50	1.50	1.50
Isoleucine:lysine, %	59	59	72	59	72
Met & Cys:lysine, %	57	57	56	57	57
Threonine:lysine, %	67	66	66	67	66
Tryptophan:lysine, %	18	20	21	20	21
Valine:lysine, %	80	79	77	79	78
ME, kcal/lb	1,584	1,584	1,584	1,584	1,584
Protein, %	21.10	22.40	23.80	22.50	23.90
Ca, %	0.76	0.84	0.92	0.85	0.94
P, %	0.69	0.75	0.81	0.76	0.83
Available P, %	0.54	0.53	0.52	0.54	0.53
Lysine:calorie ratio, g/mcal	4.30	4.29	4.29	4.30	4.30

[a]Values calculated on an as-fed basis. Diets were formulated on actual analyzed crude protein values of soybean meal. The solvent extracted soybean meal contained 45.3% crude protein and the extruded-expelled soybean meal contained 44.4% crude protein.
[b]Provided 50g/ton carbadox.

Table 3. Effects of Soybean Meal Source and Level on Growth Performance of Weanling Pigs (Exp.1)[a]

Item	Control	SBM 20%	SBM 40%	EESOY 20%	EESOY 40%	SEM	SBM Linear	SBM Quad	EESOY Linear	EESOY Quad	SBM vs. EESOY
D 0 to 7											
ADG, lb	0.48	0.46	0.38	0.43	0.34	0.06	0.05	0.38	0.05	0.69	0.03
ADFI, lb	0.47	0.44	0.37	0.42	0.37	0.06	0.17	0.74	0.15	0.94	0.21
Feed/gain	0.99	0.96	1.12	0.98	1.10	0.04	0.02	0.05	0.05	0.22	<0.01
D 7 to 14											
ADG, lb	0.66	0.64	0.75	0.61	0.62	0.06	0.20	0.24	0.56	0.63	0.20
ADFI, lb	0.65	0.61	0.75	0.64	0.64	0.06	0.17	0.17	0.84	0.96	0.20
Feed/gain	0.98	0.98	1.00	1.05	1.03	0.04	0.73	0.79	0.35	0.31	0.99
D 14 to 21[c]											
ADG, lb	1.11	1.10	1.11	1.09	1.15	0.06	0.95	0.87	0.55	0.57	0.50
ADFI, lb	1.39	1.44	1.47	1.39	1.41	0.06	0.30	0.94	0.84	0.87	0.62
Feed/gain	1.28	1.31	1.33	1.29	1.22	0.04	0.34	0.91	0.28	0.38	0.51
D 0 to 14[b]											
ADG, lb	0.57	0.55	0.55	0.52	0.48	0.05	0.65	0.84	0.11	0.96	0.57
ADFI, lb	0.56	0.53	0.56	0.53	0.50	0.06	0.99	0.53	0.32	0.99	0.98
Feed/gain	0.98	0.97	1.06	1.02	1.06	0.03	0.06	0.11	0.04	0.87	0.02
D 0 to 21											
ADG, lb	0.75	0.73	0.73	0.71	0.70	0.04	0.75	0.81	0.33	0.74	0.91
ADFI, lb	0.84	0.83	0.86	0.82	0.80	0.05	0.63	0.65	0.51	0.95	0.80
Feed/gain	1.08	1.08	1.15	1.08	1.12	0.02	0.04	0.21	0.29	0.69	0.10

[a]A total of 175 pigs (five pigs per pen and seven pens per treatment) with an average initial BW of 13.1 lb.
[b]Treatment diets were fed from d 0 to 14.
[c]D 14 to 21 common SEW diet.

Table 4. Effects of Soybean Meal Source and Level on Growth Performance of Weanling Pigs (Exp. 2)[a]

		SBM		EESOY		SEM	SBM		EESOY		SBM vs. EESOY
Item	Control	20%	40%	20%	40%		Linear	Quad	Linear	Quad	
D 0 to 7											
ADG, lb	0.50	0.47	0.32	0.43	0.26	0.03	<0.01	0.12	<0.01	0.17	<0.01
ADFI, lb	0.48	0.43	0.32	0.41	0.29	0.03	<0.01	0.31	<0.01	0.40	<0.01
Feed/gain	0.96	0.93	1.02	0.97	1.11	0.02	0.08	0.04	<0.01	0.03	<0.01
D 7 to 14											
ADG, lb	0.64	0.66	0.71	0.62	0.57	0.03	0.05	0.75	0.11	0.57	0.98
ADFI, lb	0.65	0.65	0.68	0.64	0.57	0.03	0.40	0.61	0.03	0.35	0.47
Feed/gain	1.02	0.98	0.95	1.03	1.00	0.02	0.03	0.76	0.53	0.56	0.25
D 14 to 21[c]											
ADG, lb	0.97	1.08	1.10	0.99	1.05	0.03	<0.01	0.20	0.06	0.47	0.15
ADFI, lb	1.24	1.31	1.32	1.19	1.19	0.03	0.03	0.29	0.15	0.38	0.89
Feed/gain	1.30	1.23	1.20	1.22	1.14	0.02	<0.01	0.70	<0.01	0.91	0.02
D 0 to 14[b]											
ADG, lb	0.57	0.56	0.52	0.53	0.41	0.03	0.10	0.42	<0.01	0.21	<0.01
ADFI, lb	0.56	0.54	0.50	0.52	0.43	0.03	0.02	0.75	<0.01	0.26	<0.01
Feed/gain	0.99	0.95	0.98	1.00	1.06	0.02	0.76	0.11	<0.01	0.26	0.01
D 0 to 21											
ADG, lb	0.70	0.74	0.71	0.68	0.63	0.03	0.72	0.19	<0.01	0.53	0.04
ADFI, lb	0.79	0.80	0.77	0.75	0.68	0.02	0.42	0.44	<0.01	0.65	0.01
Feed/gain	1.09	1.05	1.05	1.07	1.08	0.02	0.08	0.13	0.77	0.40	0.47

[a]A total of 350 pigs (five pigs per pen and fourteen pens per treatment) with an average initial BW of 12.9 lb.
[b]Treatment diets were fed from d 0 to 14.
[c]D 14 to 21 common SEW diet.

Table 5. Soybean Meal Quality Analysis[a]

Lab Analysis	Soybean Meal Source			
	SBM 1[h]	SBM 2[i]	EESOY 1[j]	EESOY 2[k]
Crude protein[b]	46.7	45.3	43.6	44.4
Trypsin inhibitor, mgTI/g[c]	1.2	2.0	9.3	8.2
Urease[d]	0.02	0.02	0.04	0.03
Protein solubility index (KOH)[e]	78.9	81.6	83.2	83.1
Nitrogen solubility index (NSI)[f]	11.4	19.5	21.0	17.7
Mycotoxin[g]	----	Negative	----	Negative

[a]Urease, PSI, TI, and NSI results are reported on average from two different labs (KSU Swine Labs, Manhattan, KS and Woodson-Tenent, Des Moines, IA).
[b]Crude protein is on an as-fed basis.
[c]Trypsin inhibitor is a heat liable anti-nutritional factor (TI values of 1 to 4 mgTI/g of soybean meal are adequately processed).
[d]Urease is useful to determine if soybean meal has been heated enough to reduce anti-nutritional factors sufficiently (low urease value 0 to .2 is optimal value).
[e]KOH protein solubility index detects excessive heating or over-processing of soybean meal (decrease from 71 to 66 has shown a decreased pig performance).
[f]NSI is also a measure of protein solubility in water, but less sensitive than KOH (values of 12.5 have shown over-processing, 25.1 adequately processed, and 27.8 under-processed).
[g]Mycotoxins may cause reduced growth and feed efficiency.
[h]Soybean meal Exp. 1.
iSoybean meal Exp. 2.
[j]Extruded-expelled soybean meal Exp. 1.
[k]Extruded-expelled soybean meal Exp. 2.