

The Effects of Soybean Hulls on Nursery Pig Growth Performance

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Summary

Two experiments were conducted to evaluate the effects of soybean hulls on growth performance of nursery pigs. In both experiments, pens of pigs were balanced by initial BW and randomly allotted to 1 of 5 dietary treatments with 6 replications per treatment. In Exp. 1, a total of 210 nursery pigs (PIC, 337 × 1050, initially 14.7 lb and 28 d of age) were used in a 34-d experiment. Diets contained increasing amounts of soybean hulls (0, 5, 10, 15, and 20%) and were not balanced for energy. Overall (d 0 to 34), pigs fed increasing soybean hulls had decreased ADG (linear, $P < 0.01$) and poorer F/G (linear, $P < 0.001$), with no change in ADFI ($P > 0.23$). Despite the linear response, the greatest decreases in pig performance were observed as soybean hulls were added at 10% or greater of the diet; those fed only 5% of the diet were similar to control pigs.

In Exp. 2, 210 nursery pigs (PIC, 337 × 1050, initially 29.9 lb) were used in a 20-d study. Pigs were fed a common diet for 14 d after weaning. The 5 corn-soybean meal-based diets were arranged in a $2 \times 2 + 1$ factorial, including a corn-soybean meal control diet without soybean hulls and diets containing 10 or 20% soybean hulls either balanced on an NE basis or not. The diets balanced for NE contained 3.6 and 7.15% added fat (soybean oil) in the 10 and 20% soybean hull diets to achieve the same NE value as the control diet.

Overall (d 0 to 20), pigs fed increasing soybean hulls had decreased ADG (linear, $P < 0.01$) regardless of formulation method; however, pigs fed increasing amounts of soybean hulls without added fat were similar in ADFI but had poorer F/G (linear, $P < 0.001$). Pigs fed diets containing soybean hulls balanced for NE had decreased ADFI ($P < 0.001$) but improved F/G ($P < 0.001$) compared with pigs fed soybean hulls with no added fat, resulting in F/G similar to the control-fed pigs.

In summary, soybean hulls can be included in nursery pig diets up to 5% with no negative effects on ADG, ADFI, and F/G. Higher amounts, up to 20% soybean hulls, can be included in nursery pig diets with F/G similar to pigs fed corn-soybean diets if diets are formulated on an NE basis, but there are reductions in ADFI and ADG.

Key words: NE, nursery pig, soybean hulls

Introduction

Soybean hulls are a readily available co-product of the solvent extraction of whole soybeans that could be used in swine diets across the Midwest, but because of soybean hulls' low energy value (corn NE = 1,202 kcal/lb; soybean hulls NE = 455 kcal/lb;

INRA 2004¹) and a lack of research, few swine producers use soybean hulls in nursery pig diets. When including soybean hulls in corn-soybean meal-based diets, the energy content will decrease unless diets are balanced for energy by including added fat.

Due to limited research on added soybean hulls in nursery diets, the first objective of these two studies was to evaluate the effects of increasing soybean hulls (0 to 20%) on nursery pig performance. Our second objective was to determine whether balancing diets on an NE basis by adding dietary fat influenced the pigs' response to soybean hulls.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. Both studies were conducted at the K-State Swine Teaching and Research Center in Manhattan, KS.

Soybean hull samples were collected and submitted to Ward Laboratories, Inc. (Kearney, NE) for analysis of DM, CP, ADF, NDF, crude fiber, Ca, and P (Table 1). Bulk density of the soybean hulls (Table 1) and complete diets were also determined (Tables 2 and 3).

In Exp. 1, a total of 210 pigs (PIC 327 × 1050, initially 14.7 lb and 28 d of age) were used. Pigs were allotted to pens by initial BW, and pens were assigned to 1 of 5 treatments in a completely randomized design with 7 pigs per pen and 6 replications per treatment. Experimental diets contained increasing amounts of soybean hulls: 0, 5, 10, 15, or 20% and were not balanced to a constant NE (Table 2). Pig weight and feed disappearance were measured on d 0, 7, 13, 20, 27, and 34 of the trial to determine ADG, ADFI, and F/G. All diets were fed in meal form and were prepared at the K-State Animal Science Feed Mill in Manhattan, KS.

In Exp. 2, a total of 210 pigs (PIC 327 × 1050, initially 29.9 lb) were used in a 20-d growth trial to determine the effects of increasing dietary soybean hulls with or without a constant NE level on nursery pig performance. All pigs were initially fed a starter diet followed by a Phase 2 diet for 14 d after weaning. Pigs were allotted to pens by initial BW, and pens were assigned to 1 of 5 treatments in a completely randomized design with 7 pigs per pen and 6 replications per treatment. The 5 treatment diets included a control diet without soybean hulls and diets containing 10% or 20% soybean hulls either balanced on an NE-basis or not. The diets balanced for NE contained 3.6 and 7.15% added soybean oil in the 10 and 20% soybean hull diets to achieve the same NE as the control diet (Table 3). Pig weight and feed disappearance were measured on d 0, 6, 13, and 20 of the trial to determine ADG, ADFI, and F/G. All diets were fed in meal form and were prepared at the K-State Animal Science Feed Mill.

In both studies, each pen contained a 4-hole, dry self-feeder and a nipple waterer to provide ad libitum access to feed and water. Pens had wire-mesh floors and allowed approximately 3 ft²/pig.

¹ INRA (Institut National de la Recherche Agronomique). 2004. Tables of composition and nutritional value of feed materials, Sauvant, D., J-M. Perez, and G. Tran, eds. Wageningen Academic Publishers, The Netherlands and INRA, Paris, France.

Data were analyzed as a completely randomized design using the PROC MIXED procedure of SAS (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. In Exp. 1, contrasts were used to compare linear and quadratic effects of increasing soybean hulls. Contrasts in Exp. 2 were used to compare linear and quadratic effects of increasing soybean hulls with and without balancing for NE. In addition, diet formulation method and soybean hull level effects were also tested, along with interactions between soybean hulls and diet formulation method. Results were considered significant at $P \leq 0.05$ and a trend at $P \leq 0.10$.

Results and Discussion

In Exp. 1, increasing soybean hulls resulted in higher fiber and NDF and lower energy and decreased bulk densities compared with the corn-soybean meal control diet (Table 2). For every dietary period, pigs fed increasing soybean hulls had decreased (linear, $P < 0.01$) ADG and poorer (linear, $P < 0.001$) F/G, with no change ($P > 0.21$) in ADFI. Despite the linear response for ADG and F/G, much of this effect was observed in pigs fed 10% soybean hulls or greater (Table 4). Although F/G became worse, increasing soybean hulls in the diet improved (linear, $P < 0.02$) caloric efficiency on an NE basis. Nursery pigs will attempt to consume feed to meet an energy requirement. Because of the low bulk density and potential for increased gut fill caused by high amounts of soybean hulls, pigs in this experiment were unable to maintain energy intake on lower-energy diets containing more than 5% soybean hulls.

Based on the results in Exp. 1, 5% soybean hulls could be used with no negative effects on growth performance, but using more than 5% resulted in poorer F/G and ADG. Therefore, the objective of Exp. 2 was to determine if balancing diets containing soybean hulls on an NE basis with added fat could restore performance similar to corn-soybean diets.

Overall (d 0 to 20), pigs fed increasing soybean hulls had decreased ADG (linear, $P < 0.003$), whether or not diets were formulated to a constant NE. When diets were not balanced for NE (no added fat), ADFI did not change, but poorer (linear, $P < 0.0001$) F/G and caloric efficiency on an NE basis ($P < 0.05$) were observed. When adding fat to diets containing soybean hulls to increase NE, F/G was similar to pigs fed the control diet and improved F/G ($P < 0.0001$) compared with pigs fed diets not balanced for NE. Overall, increasing soybean hulls decreased (linearly, $P < 0.0002$) ADFI. The fact that pigs fed diets balanced on a NE basis were identical to the control-fed pigs in F/G suggests that the NE value used for the soybean hulls in this study was appropriate.

In conclusion, soybean hulls are a low-energy, low bulk density ingredient that can be used in nursery pig diets at 5% with no negative effects on growth performance. Conversely, high amounts (greater than 5%) of soybean hulls can restrict performance, probably because of increased fiber and low diet bulk density. Formulating diets on an NE basis by adding fat can result in similar F/G but still fail to maintain ADG and ADFI. These studies suggest that more research is needed to understand how low-energy ingredients such as soybean hulls can potentially affect gut fill, feed intake, and growth.

Table 1. Chemical analysis soybean hulls (as-fed basis)

Item	Exp. 1	Exp. 2
DM, %	91.9	90.6
CP, %	11.2 (11.1) ¹	10.2 (11.1)
ADF, %	44.0	42.0
NDF, %	59.0	56.2
Crude fiber, %	34.2 (33.3)	33.3 (33.3)
Ca, %	0.64 (0.52)	0.65 (0.52)
P, %	0.11 (0.15)	0.11 (0.15)
Bulk density, lb/bu	27.9	34.5

¹ Values in parentheses indicate those used in diet formulation.

Table 2. Diet composition (Exp. 1, as-fed basis)

Item	Soybean hulls, %	Phase 1 ¹					Phase 2 ²				
		0	5	10	15	20	0	5	10	15	20
Ingredient											
Corn		54.70	50.10	45.50	40.90	36.29	63.75	59.07	54.39	49.71	45.04
Soybean meal, 46.5% CP		29.40	29.06	28.71	28.36	28.02	32.79	32.53	32.26	31.99	31.72
Soybean hulls		--	5.00	10.00	15.00	20.00	--	5.00	10.00	15.00	20
Select menhaden fish meal		3.00	3.00	3.00	3.00	3.00	--	--	--	--	--
Spray-dried whey		10.00	10.00	10.00	10.00	10.00	--	--	--	--	--
Monocalcium P, 21% P		0.65	0.65	0.65	0.65	0.65	1.05	1.05	1.05	1.05	1.05
Limestone		0.88	0.81	0.75	0.69	0.63	0.95	0.89	0.83	0.77	0.71
Salt		0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Trace mineral premix		0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
L-lysine HCl		0.248	0.243	0.238	0.233	0.228	0.330	0.323	0.315	0.308	0.300
L-threonine		0.120	0.130	0.140	0.150	0.160	0.130	0.138	0.145	0.153	0.160
L-tryptophan		0.130	0.135	0.140	0.145	0.150	0.125	0.130	0.135	0.140	0.145
Phytase 600 ³		0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125
Total		100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

continued

Table 2. Diet composition (Exp. 1, as-fed basis)

Item	Soybean hulls, %	Phase 1 ¹					Phase 2 ²				
		0	5	10	15	20	0	5	10	15	20
Calculated analysis											
Standardized ileal digestible (SID) amino acids, %											
Lysine		1.32	1.32	1.32	1.32	1.32	1.28	1.28	1.28	1.28	1.28
Isoleucine:lysine		62	62	62	62	62	61	61	61	61	61
Leucine:lysine		127	125	124	122	121	129	127	126	124	123
Methionine:lysine		34	34	35	35	35	33	34	34	34	34
Met & Cys:lysine		58	58	58	58	58	58	58	58	58	57
Threonine:lysine		65	65	65	65	65	63	63	63	63	63
Tryptophan:lysine		18	18	18	17	17	17	18	18	18	18
Valine:lysine		68	68	67	67	66	68	68	67	67	66
Total lysine, %		1.46	1.47	1.48	1.49	1.50	1.42	1.43	1.44	1.45	1.46
ME, kcal/lb		1,500	1,455	1,410	1,365	1,320	1,503	1,458	1,413	1,368	1,323
SID lysine:ME, g/Mcal		3.99	4.12	4.25	4.39	4.54	3.86	3.98	4.11	4.24	4.39
CP, %		21.8	21.8	21.8	21.8	21.9	21.1	21.2	21.2	21.3	21.3
Crude fiber,%		2.4	3.9	5.5	7.0	8.6	2.7	4.2	5.8	7.3	8.9
ADF ⁴		3.1	5.0	6.9	8.7	10.6	3.6	5.4	7.3	9.2	11.1
NDF ⁴		7.9	10.2	12.6	14.9	17.3	9.0	11.4	13.7	16.1	18.4
Ca, %		0.80	0.80	0.80	0.80	0.80	0.69	0.69	0.69	0.69	0.69
P, %		0.66	0.65	0.64	0.63	0.62	0.63	0.62	0.61	0.60	0.60
Available P, %		0.48	0.48	0.48	0.48	0.48	0.42	0.42	0.42	0.42	0.42
Bulk density, lb/bu ⁵		62.9	59.7	55.5	52.5	51.2	62.3	60.0	55.8	56.0	51.7

¹Phase 1 diets were fed from d 0 to 13.²Phase 2 diets were fed from d 13 to 34.³Phyzyme 600 (Danisco, Animal Nutrition, St. Louis, MO) provided 231 phytase units (FTU)/lb, with a release of 0.10% available P.⁴Soybean hulls ADF and NDF values are from INRA (Institut National de la Recherche Agronomique), 2004. All other values taken from NRC, 1998.⁵Diet samples collected from the top of each feeder during each phase.

Table 3. Diet composition (Exp. 2, as-fed basis)

Item	Soybean hulls, %	0	10	20	10	20
	NE, kcal/lb:	1,073	1,001	930	1,073	1,073
Ingredient						
Corn		63.75	54.39	45.03	50.49	37.29
Soybean meal, 46.5% CP		32.79	32.26	31.72	32.55	32.30
Soybean hulls		--	10.00	20.00	10.00	20.00
Soybean oil		--	--	--	3.60	7.15
Monocalcium P, 21% P		1.05	1.05	1.05	1.05	1.05
Limestone		0.95	0.83	0.71	0.83	0.71
Salt		0.35	0.35	0.35	0.35	0.35
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-lysine HCl		0.330	0.315	0.300	0.315	0.300
DL-methionine		0.130	0.150	0.170	0.155	0.180
L-threonine		0.125	0.135	0.145	0.135	0.145
Phytase 600 ¹		0.125	0.125	0.125	0.125	0.125
Total		100.0	100.0	100.0	100.0	100.0

continued

Table 3. Diet composition (Exp. 2, as-fed basis)

	Soybean hulls, %	0	10	20	10	20
Item	NE, kcal/lb:	1,073	1,001	930	1,073	1,073
Calculated analysis						
Standardized ileal digestible (SID) amino acids, %						
Lysine		1.28	1.28	1.28	1.28	1.28
Isoleucine:lysine		61	61	61	61	60
Leucine:lysine		129	126	123	124	119
Methionine:lysine		33	34	35	34	35
Met & Cys:lysine		58	58	58	58	58
Threonine:lysine		63	63	63	63	63
Tryptophan:lysine		17	18	18	17	17
Valine:lysine		68	67	66	67	65
Total lysine, %		1.42	1.44	1.46	1.44	1.46
ME, kcal/lb		1,503	1,413	1,323	1,495	1,485
NE, kcal/lb		1,073	1,001	930	1,073	1,073
SID lysine:ME, g/Mcal		3.86	4.11	4.39	3.88	3.91
CP, %		21.1	21.2	21.3	21.0	20.9
Crude fiber,%		2.7	5.8	5.7	8.9	8.7
ADF ²		3.6	7.3	7.2	11.1	10.9
NDF ²		9.0	13.7	13.4	18.4	17.7
Ca, %		0.69	0.69	0.69	0.69	0.69
P, %		0.63	0.61	0.60	0.60	0.58
Available P, %		0.42	0.42	0.42	0.42	0.42
Bulk density, lb/bu ³		62.5	57.7	53.2	54.2	50.4

¹ Phyzyme 600 (Danisco, Animal Nutrition, St. Louis, MO), providing 231 phytase units (FTU)/lb, with release of 0.10% available P.

² Soybean hulls ADF and NDF values are from INRA (Institut National de la Recherche Agronomique), 2004. All other values taken from NRC, 1998.

³ Diet samples collected from the top of each feeder during each phase.

Table 4. The effects of soybean hulls in nursery diets on nursery pig performance (Exp. 1)¹

Item	Soybean hulls, %					SEM	Probability, <i>P</i> <	
	0	5	10	15	20		Linear	Quadratic
d 0 to 13								
ADG, lb	0.48	0.46	0.44	0.41	0.39	0.026	0.01	0.79
ADFI, lb	0.72	0.71	0.76	0.71	0.66	0.030	0.21	0.16
F/G	1.49	1.52	1.70	1.73	1.71	0.062	0.01	0.27
Caloric efficiency²								
ME	2,264	2,263	2,468	2,453	2,375	91.9	0.17	0.29
NE	1,646	1,627	1,759	1,728	1,654	65.0	0.58	0.27
d 13 to 34								
ADG, lb	1.28	1.28	1.26	1.23	1.12	0.032	0.01	0.07
ADFI, lb	1.98	1.96	2.02	2.01	1.87	0.051	0.30	0.10
F/G	1.55	1.53	1.61	1.63	1.66	0.024	0.01	0.62
Caloric efficiency								
ME	2,328	2,247	2,308	2,289	2,272	34.2	0.52	0.70
NE	1,662	1,586	1,610	1,577	1,547	23.6	0.004	0.68
d 0 to 34								
ADG, lb	0.97	0.97	0.95	0.91	0.84	0.024	0.01	0.11
ADFI, lb	1.50	1.48	1.54	1.51	1.41	0.041	0.23	0.10
F/G	1.54	1.53	1.62	1.65	1.67	0.024	0.0001	0.88
Caloric efficiency								
ME	2,315	2,247	2,331	2,314	2,284	34.0	0.96	0.85
NE	1,658	1,592	1,633	1,600	1,561	23.5	0.02	0.84
BW, lb								
d 0	14.62	14.60	14.85	14.60	14.62	0.13	1.00	0.38
d 13	20.86	20.62	20.59	20.17	19.61	0.37	0.02	0.47
d 34	47.67	47.55	47.02	46.02	43.22	0.87	0.01	0.09

¹ A total of 210 nursery pigs (PIC 337 × 1050, initially 14.7 lb) were used in a 34-d study with 7 pigs per pen and 6 replications per treatment.

² Caloric efficiency is expressed as kcal/lb gain.

Table 5. The effects of soybean hulls and diet NE on nursery pig performance¹

Item	NE, kcal/lb:	Soybean hulls, %					SEM ²	Soybean hulls ³		Soybean hulls + oil ⁴		NE effect
		0	10	20	10	20		Linear	Quadratic	Linear	Quadratic	
d 0 to 20												
ADG, lb		1.50	1.46	1.38	1.48	1.40	0.021	0.0004	0.39	0.003	0.28	0.32
ADFI, lb		2.36	2.45	2.41	2.31	2.22	0.038	0.33	0.21	0.02	0.68	0.0002
F/G		1.57	1.67	1.75	1.56	1.58	0.019	0.0001	0.61	0.62	0.49	0.0001
Caloric efficiency ⁵												
ME		2,365	2,402	2,393	2,364	2,419	28.6	0.49	0.52	0.19	0.43	0.96
NE		1,687	1,676	1,629	1,673	1,698	20.2	0.05	0.48	0.70	0.43	0.11
BW, lb												
d 0		29.9	29.9	29.9	29.9	29.8	5.65	0.54	0.70	0.58	0.81	0.84
d 20		59.9	59.2	57.4	59.5	57.9	8.54	0.57	0.42	0.74	1.00	0.81

¹ A total of 210 nursery pigs (PIC 337 × 1050, initially 29.9) were used in a 20-d study with 7 pigs per pen and 6 replications per treatment.

² Soybean hulls × NE interaction, $P > 0.09$.

³ Comparisons of 0, 10, and 20% added soybean hulls without constant NE value.

⁴ Comparison of 0, 10, and 20% with constant NE value.

⁵ Caloric efficiency is expressed as kcal/lb gain.