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Effects of PurePro Soy on Growth Performance and Fecal Dry Matter of Nursery Pigs

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Summary

A total of 360 barrows (DNA 200 × 400; initially 12.3 ± 0.05 lb) were used in a 37-d study to determine the effects of a refined soy protein concentrate (PurePro Soy, Bunge; Chesterfield, MO) on nursery-pig growth performance and fecal dry matter (DM). Pens of pigs were randomly allotted to one of six dietary treatments in a generalized randomized block design with BW as a blocking factor. There were six replications for each treatment within pens of light pigs (initially 11.0 ± 0.02 lb) and six replications for each treatment within pens of heavy pigs (initially 13.7 ± 0.02 lb). There were five pigs per pen and 12 pens per treatment. Diets were corn-soybean meal-based with increasing PurePro Soy (0, 4.25, 8.5, 12.75, and 17%) replacing SBM in the diet. A sixth diet served as a positive control containing 8.5% enzymatically treated SBM (HP 300, Hamlet Protein; Findlay, OH) also replacing SBM in the diet. Treatment diets were fed in two phases from d 0 to 9 (phase 1) and d 9 to 23 (phase 2) followed by a common diet from d 23 to 37 (phase 3). On d 9 and 23, fecal samples were collected from the same three randomly selected pigs in each pen to determine fecal DM. There were no interactions of treatment and BW block, therefore interpretation is focused on the main effect of treatment. During the experimental period (d 0 to 23), ADG and F/G improved (quadratic, $P < 0.05$) as PurePro Soy increased with the greatest improvement in ADG and F/G when PurePro Soy increased from 0 to 8.5%. Pigs fed 8.5% PurePro Soy or 8.5% HP 300 had similar performance. Additionally, ADFI increased (linear, $P = 0.019$) as PurePro Soy increased. Overall (d 0 to 37), increasing PurePro Soy improved (quadratic, $P = 0.014$) ADG and tended to worsen (linear, $P = 0.087$) F/G and increase ADFI (quadratic, $P = 0.080$) with the greatest response at 8.5%. For fecal DM, increasing PurePro Soy increased (linear, $P = 0.035$) fecal DM on d 9, and pigs fed 8.5% PurePro Soy had greater ($P = 0.011$) fecal DM than those fed 8.5% HP 300. In summary, replacing SBM with 8.5% PurePro Soy improved nursery pig growth performance and fecal DM.

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Introduction

Weaning is a stressful period for pigs as they adjust to a new diet and environment. Because of this, low feed intake and diarrhea can result, which can lead to an increase in morbidity and mortality. Soybean meal (SBM) is the main source of protein for pigs, but it needs to be introduced slowly because of its anti-nutritional factors, such as trypsin inhibitors, antigens, and indigestible oligosaccharides. Newly weaned pigs can develop a hypersensitivity to SBM[3] and are challenged by the complex carbohydrates (stachyose, raffinose) and storage proteins (glycinin, beta-conglycinin) in SBM. It has been demonstrated that further processed soy products can be more tolerable for weanling pigs when compared to conventional SBM.[4] PurePro Soy is a refined soy protein concentrate with lower stachyose (1.4%) and raffinose (0.2%), as well as lower glycinin and beta-conglycinin, (< 5 and 2 ppm, respectively). With reduced anti-nutritional factors, increased quantities of processed soy protein may be included in starter diets for pigs as replacement for other specialty protein sources. Therefore, the objective of this study was to evaluate the effect of inclusion level of PurePro Soy on nursery pig growth performance and fecal dry matter.

Materials and Methods

Animals and diets

The protocol used in this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. This study was conducted at the Kansas State University Segregated Early Weaning facility in Manhattan, KS. The facility has two identical barns that are completely enclosed, environmentally controlled, and mechanically ventilated. Each pen contained a 4-hole, dry self-feeder and a cup waterer for ad libitum access to feed and water. Pens (4 × 4 ft) had metal tri-bar floors and allowed approximately 2.7 ft^2/pig.

A total of 360 barrows (DNA 200 × 400; initially 12.3 ± 0.05 lb) were used in a 37-d growth trial. Pigs were weaned at approximately 21 d of age and blocked by initial weight. Treatments were assigned in a generalized randomized block design. Pigs were blocked into light (initially 11.0 ± 0.02 lb) and heavy groups (initially 13.7 ± 0.02 lb). There were five pigs per pen, and within each block, there were six pens per treatment (three pens per weight group in each barn) for a total of 12 replications per treatment (six per barn). Pens of pigs were randomly allotted to one of six dietary treatments. Diets were corn-soybean meal-based and consisted of increasing PurePro Soy (0, 4.25, 8.5, 12.75, and 17%) replacing SBM in the diet with the diet containing 17% PurePro Soy replacing 100% of the SBM (Table 1). A sixth diet served as a positive control containing 8.5% enzymatically treated SBM (HP 300, Hamlet Protein; Findlay, OH) also replacing SBM in the diet. All diets were formulated to the same SID Lys level and were similar in energy content with SBM NE considered to be 100% of corn NE. Dietary additions of feed-grade AA were adjusted to meet or exceed AA requirements in relation to Lys for Ile, Met and Cys, Thr, Trp, and Val. Pigs were fed treatment diets in two phases with phase 1 from d 0 to 9, followed by phase 2 from d 9 to 23. Subse-

[3] Li, D. F., J. L. Nelssen, P. G. Reddy, F. Blecha, J. D. Hancock, G. L. Allee, R. D. Goodband, and R. D. Klemm 1990. Transient hypersensitivity to soybean meal in the early-weaned pig. *J. Anim. Sci. 68:1790-1799.*

[4] N. A. Lenehan, J. M. DeRouchey, R. D. Goodband, M. D. Tokach, S. S. Dritz, J. L. Nelssen, C. N. Groesbeck, K. R. Lawrence 2007. Evaluation of soy protein concentrates in nursery pig diets. *J. Anim. Sci. 85(11):3013-3021.*

quently, all pigs were fed a common corn-soybean meal-based diet without specialty soy protein sources until d 37 of the trial. Treatment diets were manufactured at the Kansas State University O.H. Kruse Feed Technology Innovation Center in Manhattan, KS and fed in pellet form for phase 1 and meal form in phases 2 and 3. Pig weights and feed disappearance were measured on d 0, 9, 16, 23, 30, and 37 to determine ADG, ADFI, and feed efficiency (F/G). Feces were collected on d 9 and 23 from the same three randomly selected pigs in each pen for fecal dry matter (DM) analysis. Fecal samples were dried at 131°F (55°C) in a forced air oven for 48 h, and the ratio of dried to wet fecal weight determined the fecal dry matter. Fecal samples were analyzed separately for each pig, and the average of the three samples from each pen was then used for statistical analysis.

Statistical analysis

Data were analyzed as a generalized randomized block design as a one-way ANOVA using the lmer function from the lme4 package in R Studio (Version 3.5.2, R Core Team. Vienna, Austria) with pen serving as the experimental unit, and dietary treatment, weight block, and the associated interaction as fixed effects. Barn was included in the model as a random effect. Linear and quadratic contrasts were tested within increasing levels of PurePro Soy, excluding HP 300. The effect of HP 300 was tested by a pairwise comparison with the 8.5% PurePro Soy. Fecal DM samples were analyzed using the fixed effects of day, treatment, block, and the associated interactions accounting for repeated measures over time. When treatment was a significant source of variation, differences were determined by pairwise comparison using the Tukey-Kramer multiplicity adjustment to control for Type I Error. Results were considered significant with $P \leq 0.05$ and were considered marginally significant with $P \leq 0.10$.

Results and Discussion

Growth performance

There were no interactions of treatment and BW block, therefore interpretation is focused on the main effect of treatment. From d 0 to 9 (phase 1), d 9 BW tended to increase (quadratic, $P = 0.052$) with an increase in PurePro Soy, and a tendency for improvement in ADG (quadratic, $P = 0.077$) was observed as PurePro Soy increased to 4.25% (Table 2). Additionally, as PurePro Soy increased, feed efficiency was improved (quadratic, $P = 0.029$) with the greatest improvement at the 8.5% inclusion level. When comparing 8.5% PurePro Soy to the 8.5% HP 300 inclusion level, there was a tendency for improvement in feed efficiency with PurePro Soy ($P = 0.065$).

From d 9 to 23 (phase 2), d 23 BW increased up to 8.5% and decreased as the inclusion level reached 17% (quadratic, $P = 0.030$). There was a tendency for increased ADG (quadratic, $P = 0.072$) with increasing PurePro Soy with maximal performance observed at 8.5% of the diet. Additionally, as PurePro Soy increased up to 12.75%, ADFI increased (linear, $P = 0.024$). This resulted in poorer feed efficiency as PurePro Soy increased up to 17% (linear, $P = 0.003$).

For the experimental period (d 0 to 23), as PurePro Soy increased, ADFI increased (linear, $P = 0.019$) and ADG and F/G improved (quadratic, $P < 0.030$) with maximum response at the 8.5% inclusion rate.

In the common period (phase 3), no differences ($P > 0.10$) in ADG, ADFI, or F/G were observed due to the inclusion rate of PurePro Soy in the previous diets. However, d 37 BW increased (quadratic, $P = 0.035$) as PurePro Soy increased up to an inclusion rate of 8.5%.

Overall (d 0 to 37), increasing PurePro Soy increased ADG (quadratic, $P = 0.014$) with the peak at 8.5% of the diet and a tendency for poorer (linear, $P = 0.087$) F/G. Additionally, ADFI tended to increase up to 8.5% of PurePro Soy in the diet (quadratic, $P = 0.080$).

The intermediate levels of PurePro Soy improved performance quadratically compared to the lowest and highest inclusion levels. Decreased performance at an inclusion level of 0% may be due to hypersensitivity of the soybean meal as ADFI was lowest for this diet. Performance was also decreased at the highest inclusion of 17%, which may possibly be due to decreased palatability from the PurePro Soy as ADFI was also low for pigs fed this diet. However, it also may be caused by a deficiency of nonessential amino acids resulting from the lower dietary CP as PurePro Soy replaced all the SBM in the diet. The reduction in performance at high inclusions of a specialty soy product agrees with results of Jones et al. (2017), who found that pigs fed the high (20%) inclusion level of HP 300[5] had decreased growth performance compared to the intermediate inclusion rate (13.33%). Pigs fed the diets containing 8.5% HP 300 had similar performance throughout the study compared to pigs fed the diets containing 8.5% PurePro Soy.

Fecal dry matter analysis

Increasing PurePro Soy increased fecal DM on d 9 (linear, $P = 0.035$). Additionally, a protein source response was observed ($P = 0.011$) where pigs fed 8.5% PurePro Soy had greater fecal DM than pigs fed 8.5% HP 300. There were no differences in fecal DM on d 23.

In conclusion, replacing SBM with 8.5% PurePro Soy in phase 1 and 2 diets improved pig growth performance and fecal DM and resulted in similar performance and improved fecal DM compared to pigs fed 8.5% HP 300.

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Brand names appearing in this publication are for product identification purposes only. No endorsement is intended, nor is criticism implied of similar products not mentioned. Persons using such products assume responsibility for their use in accordance with current label directions of the manufacturer.

[5] Jones, A. M., DeRouchey, J. M., Fitzner, G., Woodworth, J. C., Tokach, M. D., Goodband, R. D., and Dritz, S.S. 2017. Effects of Feeding Increasing Levels of HP 300 on Nursery Pig Performance. Kansas Agricultural Experiment Station Research Reports: Vol. 3: Iss. 7. https://doi.org/10.4148/2378-5977.7474.

Table 1. Diet Composition (as-fed basis)[1]

	Phase 1						Phase 2						Phase 3
Protein source:	PurePro Soy					HP 300[2]	PurePro Soy					HP 300[2]	
Inclusion, %:	**0**	**4.25**	**8.50**	**12.75**	**17.00**	**8.50**	**0**	**4.25**	**8.50**	**12.75**	**17.00**	**8.50**	**Common**
Ingredient, %													
Corn	43.02	46.20	49.41	52.63	55.88	44.55	56.13	59.32	62.53	65.74	68.95	57.61	68.06
Soybean meal (47% CP)	30.00	22.51	15.02	7.52	---	19.98	29.99	22.50	15.00	7.51	---	20.01	28.12
PurePro Soy	---	4.25	8.50	12.75	17.00	---	---	4.25	8.50	12.75	17.00	---	---
Enzymatically treated SBM[2]	---	---	---	---	---	8.50	---	---	---	---	---	8.50	---
Whey powder	22.50	22.50	22.50	22.50	22.50	22.50	10.00	10.00	10.00	10.00	10.00	10.00	---
Soybean oil	1.00	1.00	1.00	1.00	1.00	1.00	---	---	---	---	---	---	---
Calcium carbonate	0.65	0.65	0.65	0.65	0.65	0.65	0.70	0.70	0.70	0.70	0.70	0.70	0.75
Monocalcium P (21% P)	0.68	0.73	0.75	0.78	0.80	0.70	0.75	0.80	0.83	0.85	0.88	0.75	0.85
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.55	0.55	0.55	0.55	0.55	0.55	0.60
L-Lys-HCl	0.39	0.39	0.39	0.39	0.39	0.39	0.50	0.50	0.50	0.50	0.50	0.50	0.55
DL-Met	0.22	0.22	0.22	0.22	0.22	0.22	0.23	0.23	0.23	0.23	0.23	0.23	0.21
L-Thr	0.18	0.19	0.19	0.20	0.20	0.18	0.24	0.24	0.24	0.25	0.25	0.24	0.23
L-Trp	0.03	0.04	0.05	0.05	0.06	0.03	0.05	0.06	0.07	0.07	0.08	0.05	0.05
L-Val	0.12	0.12	0.11	0.11	0.10	0.09	0.15	0.15	0.15	0.14	0.14	0.15	0.16
Zinc oxide	0.39	0.39	0.39	0.39	0.39	0.39	0.25	0.25	0.25	0.25	0.25	0.25	---
Vitamin premix	0.25	0.25	0.25	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	0.15	0.15	0.15
Choline chloride	0.05	0.05	0.05	0.05	0.05	0.05	---	---	---	---	---	---	---
Phytase[3]	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.03
Total	100	100	100	100	100	100	100	100	100	100	100	100	100

Continued

Table 1. Diet Composition (as-fed basis)[1]

	Phase 1						Phase 2						Phase 3
Protein source:	PurePro Soy					HP 300[2]	PurePro Soy					HP 300[2]	
Inclusion, %:	**0**	**4.25**	**8.50**	**12.75**	**17.00**	**8.50**	**0**	**4.25**	**8.50**	**12.75**	**17.00**	**8.50**	**Common**
Calculated analysis													
SID AA, %													
Lys, %	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.30
Ile:Lys	59	59	59	59	59	61	55	55	55	55	55	57	53
Leu:Lys	114	115	116	117	117	116	112	113	114	115	115	114	113
Met:Lys	37	37	37	37	38	36	37	37	38	38	38	37	36
Met and Cys:Lys	58	58	58	58	58	58	58	58	58	58	58	58	57
Thr:Lys	65	65	65	65	65	65	65	65	65	65	65	65	63
Trp:Lys	20.0	20.1	20.2	20.2	20.1	20.0	20.1	20.0	20.3	20.3	20.2	20.1	19.3
Val:Lys	70	70	70	70	70	70	70	70	70	70	70	72	70
His:Lys	35	34	34	33	33	35	35	34	34	34	33	35	35
NE, kcal/lb	1,182	1,181	1,181	1,181	1,181	1,175	1,156	1,156	1,156	1,156	1,156	1,151	1,111
SID Lys:NE, g/Mcal	5.18	5.18	5.18	5.18	5.18	5.21	5.29	5.29	5.29	5.29	5.29	5.33	5.31
CP, %	20.8	20.5	20.2	19.8	19.4	21.0	20.6	20.3	20.0	19.6	19.3	20.9	20.0
Ca, %	0.69	0.69	0.69	0.69	0.68	0.69	0.65	0.65	0.65	0.65	0.64	0.65	0.61
STTD P, %	0.55	0.55	0.55	0.55	0.55	0.56	0.50	0.50	0.50	0.50	0.50	0.50	0.43
Ca:P	1.11	1.11	1.11	1.11	1.12	1.11	1.10	1.10	1.11	1.11	1.12	1.10	1.08
Na, %	0.36	0.36	0.36	0.35	0.35	0.36	0.35	0.34	0.34	0.34	0.33	0.34	0.28
Cl, %	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.60	0.51

[1] Phase 1 diets were fed from d 0 to 9 (12 to 15 lb). Phase 2 diets were fed from d 9 to 23 (15 to 28 lb). Phase 3 was fed to pigs from d 23 to 37 (28 to 45 lb).
[2] HP 300 (Hamlet Protein, Findlay, OH).
[3] Ronozyme HiPhos (DSM, Parsippany, NJ) included at 1,250 FTU/kg provided an estimated release of 0.14% STTD P.

Table 2. Effect of increasing PurePro Soy on growth performance and fecal DM of nursery pigs[1,2]

Protein source:	PurePro Soy					HP 300[3]		*P* =		
Inclusion, %:	0	4.25	8.50	12.75	17.00	8.50	SEM	Linear[4]	Quadratic[4]	Protein Source[5]
BW, lb										
d 0	12.4	12.3	12.4	12.3	12.3	12.3	0.04	0.417	0.568	0.559
d 9	14.5	15.0	15.0	15.0	15.0	14.7	0.15	0.078	0.052	0.143
d 23	27.4	28.1	28.4	28.2	27.7	28.1	0.48	0.546	0.030	0.529
d 37	44.8	45.0	45.7	45.2	44.1	45.7	0.76	0.454	0.035	0.968
Phase 1 (d 0 to 9)										
ADG, lb	0.25	0.30	0.30	0.29	0.30	0.27	0.016	0.055	0.077	0.176
ADFI, lb	0.31	0.33	0.31	0.35	0.34	0.31	0.018	0.158	0.866	0.842
G:F	0.79	0.91	0.97	0.84	0.88	0.86	0.042	0.451	0.029	0.065
F/G[6]	1.29	1.13	1.06	1.24	1.16	1.17	0.054	----	----	----
Phase 2 (d 9 to 23)										
ADG, lb	0.91	0.94	0.95	0.94	0.91	0.95	0.032	0.936	0.072	0.990
ADFI, lb	1.18	1.23	1.23	1.26	1.25	1.22	0.037	0.024	0.254	0.620
G:F	0.77	0.76	0.77	0.75	0.73	0.79	0.011	0.003	0.199	0.467
F/G[6]	1.30	1.32	1.30	1.35	1.38	1.28	0.020	----	----	----
Experimental period (d 0 to 23)										
ADG, lb	0.65	0.69	0.70	0.68	0.67	0.69	0.021	0.365	0.030	0.601
ADFI, lb	0.83	0.88	0.87	0.90	0.89	0.86	0.025	0.019	0.300	0.647
G:F	0.78	0.78	0.80	0.76	0.75	0.80	0.010	0.018	0.024	0.893
F/G[6]	1.29	1.28	1.26	1.33	1.34	1.26	0.017	----	----	----
Common period (d 23 to 37)										
ADG, lb	1.22	1.21	1.23	1.22	1.17	1.25	0.025	0.180	0.173	0.582
ADFI, lb	1.80	1.80	1.83	1.80	1.74	1.82	0.056	0.270	0.106	0.765
G:F	0.68	0.67	0.68	0.67	0.67	0.69	0.013	0.556	0.894	0.251
F/G[6]	1.48	1.49	1.48	1.49	1.50	1.45	0.030	----	----	----
Overall (d 0 to 37)										
ADG, lb	0.86	0.88	0.90	0.88	0.86	0.90	0.019	0.960	0.014	0.881
ADFI, lb	1.19	1.23	1.24	1.24	1.21	1.22	0.034	0.309	0.080	0.573
G:F	0.72	0.72	0.73	0.71	0.71	0.74	0.008	0.087	0.225	0.506
F/G[6]	1.39	1.39	1.37	1.41	1.42	1.36	0.017	----	----	----
Fecal DM, %										
d 9	22.7	23.5	24.8	25.6	24.5	21.7	1.36	0.035	0.177	0.011
d 23	23.9	23.2	25.1	24.8	25.2	23.3	1.36	0.128	0.999	0.145

[1] A total of 360 barrows (initially 12.3 ± 0.05 lb) were used with five pigs per pen and 12 replicates per treatment.
[2] No meaningful interactions of treatment and BW block.
[3] HP 300 (Hamlet Protein, Findlay, OH).
[4] Comparing the main effects of PurePro Soy inclusion excluding HP 300.
[5] Comparing 8.5% PurePro Soy and 8.5% HP 300.
[6] F/G was calculated taking the inverse of G:F. *P*-values are the same as reported for G:F.