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Evaluating the Effects of Startup Soybean Meal on Nursery Pig Growth Performance, Fecal Dry Matter, and Apparent Total Tract Digestibility of Crude Protein

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Summary

A total of 300 pigs (241 × 600, DNA; initially 11.8 ± 0.01 lb) were used in a 38-d growth study. Pens were randomly allotted to one of five dietary treatments in a generalized randomized complete block design with five pigs per pen and 12 replicate pens per treatment. Two batches of soybean meal were sourced from the same processing plant. The first batch was obtained from the initial truckload from the startup phase of the plant. Approximately four hours later, a second batch was sourced when the soybean meal processing had stabilized. To assess the nutritional quality of soybean meal, protein solubility in potassium hydroxide (KOH) and trypsin inhibitor units (TIU) were measured on both sources. The startup soybean meal had a KOH solubility of 68.9% and a TIU of 6.34 ± 0.12 TIU/mg seed powder, while the normal soybean meal had a KOH solubility of 82.1% and a TIU of 7.12 ± 0.54 TIU/mg seed powder. The two different soybean meal sources were blended to create a titration of startup soybean meal in the diet. Startup soybean meal replaced 0, 25, 50, 75, and 100% of the normal soybean meal to form the dietary treatments. The nutritional composition of both soybean meal sources was considered the same and thus the startup soybean meal replaced the normal soybean meal on an equal weight basis without other changes to the formulation. All diets were provided in mash form, with dietary treatments fed throughout all three dietary phases. From d 0 to 10, increasing the startup soybean meal led to a marginal decrease (linear, $P < 0.10$) in ADG and d 10 BW and poorer (linear, $P = 0.041$) F/G. From d 10 to 22, increasing startup soybean meal decreased ADG and d 22 BW (linear, $P < 0.05$), with a marginal worsening (linear, $P = 0.067$) of F/G. However, no differences were observed for any growth performance criteria from d 22 to 38 and for the overall nursery period. On d 10 and 22, fecal DM decreased (d 10, linear, $P = 0.053$; d 22, linear, $P = 0.045$) as startup soybean meal increased in the diet. The apparent total tract digestibility (ATTD) of DM tended to decrease (linear, $P = 0.095$) as startup soybean meal increased in the diet, but there was no evidence of a

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difference in ATTD of CP. In conclusion, the quality of startup soybean meal can affect the performance of nursery pigs, specifically during the first three weeks after weaning, suggesting that pigs may be particularly sensitive to soybean meal quality during that phase of growth. However, pigs adjusted to the startup soybean meal toward the end of the nursery period, leading to no differences in overall growth.

Introduction

The conventional processing of soybeans into soybean meal includes multiple stages such as dehulling, solvent extraction, and heat treatment to eliminate anti-nutritional factors. A soybean crush plant's startup phase is when the plant reinitiates its processing after a pause in operations. This is a critical phase in manufacturing because the soybean meal processed during startup may differ in quality from meal produced under normal operations. However, to the authors' knowledge, there is currently no research evaluating the differences in composition of soybean meal produced during the startup phase of production compared to soybean meal produced under stabilized conditions. Therefore, the objective of this study was to investigate the effects of increasing the startup soybean meal in nursery pig diets on growth performance, fecal dry matter (DM), and apparent tract digestibility (ATTD) of crude protein (CP).

Materials and Methods

The protocol for this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The study was conducted at the Kansas State University Swine Teaching and Research Center in Manhattan, KS. Each pen contained a four-hole, dry self-feeder and nipple waterer for *ad libitum* access to feed and water throughout the duration of the study.

A total of 300 pigs (241 × 600, DNA, initially 11.8 ± 0.01 lb) were weaned at approximately 19 d of age and randomly assigned to pens with five pigs per pen. Pens were then randomly allotted to one of five dietary treatments in a generalized randomized complete block design with 12 replicate pens per treatment. Dietary treatments included increasing levels of startup soybean meal replacing 0, 25, 50, 75, and 100% of normal soybean meal in the complete diet.

All soybean meal was sourced from the same soybean processing facility. The first batch was obtained from the initial truckload from the startup phase of the plant. Approximately four hours later, a second batch was sourced when the soybean meal processing had stabilized. To assess the nutritional quality of both soybean meal sources, protein solubility in potassium hydroxide (KOH) was measured at the Kansas State University Swine Nutrition Laboratory and trypsin inhibitor units (TIU) were measured following procedures outlined by Kim and Krishnan (2023).[3] Diets were manufactured at O.H. Kruse Feed Technology Innovation Center at Kansas State University, Manhattan, KS. The two different soybean meal sources were blended to create a titration of startup soybean meal in the diet. The nutritional composition of both soybean meal sources was considered the same, and thus the startup soybean meal replaced the normal soybean meal on an equal weight basis without other changes to the formulation (Table 1).

[3] Kim, S., and H. B. Krishnan. 2023. A fast and cost-effective procedure for reliable measurement of trypsin inhibitor activity in soy and soy products. Methods Enzymol. 680:195–213. doi:10.1016/bs.mie.2022.08.016.

Pig weights and feed disappearance were measured on d 0, 10, 17, 22, 31, and 38 to determine ADG, ADFI, and F/G. All diets were fed in meal form in three phases: phase 1 from weaning to d 10, phase 2 from d 10 to 22, and phase 3 from d 22 to 38. Feces were collected on d 10 and d 22 from three pigs per pen to determine percentage fecal DM. Additionally, titanium dioxide was included in phase 2 diets as an indigestible marker to determine ATTD of DM and CP from samples collected on d 22.

Digestibility analysis

At the conclusion of the study, fecal samples were dried at 130°F for 48 h. The loss of weight was used to calculate percentage fecal DM. Following fecal DM determination, both ground feed and fecal samples were dried in a 275°F forced-air drying oven for 2 h to determine percentage DM of the samples used for titanium analysis. Titanium dioxide concentration in both dried feed and fecal samples was determined utilizing procedures outlined by Leone (1973).[4] For CP analysis, both feed and fecal samples were analyzed in duplicate for N content at the Kansas State University Swine Laboratory. The ATTD of DM and CP was determined using the index method (Adeola, 2001).[5]

Statistical analysis

Data were analyzed as a generalized randomized complete block design for a one-way ANOVA using the GLIMMIX procedure of SAS v. 9.4 (SAS Institute, Inc., Cary, NC). Pen was considered the experimental unit, room served as a random effect, and both treatment and block served as fixed effects. Linear and quadratic contrasts were used to test for the main effects of increasing startup soybean meal. Similarly, contrasts were used to test for the main effects of treatment, day, and interaction between treatment and day on fecal DM. Results were considered significant with $P \leq 0.05$ and marginally significant with $P \leq 0.10$.

Results and Discussion

For the analysis of each soybean meal source, the startup soybean meal had a KOH solubility of 68.9% and a TIU of 6.34 ± 0.12 TIU/mg of seed powder, while the normal soybean meal had a KOH solubility of 82.1% and a TIU of 7.12 ± 0.54 TIU/mg of seed powder.

From d 0 to 10, increasing the startup soybean meal led to a marginal decrease in ADG and d 10 BW (linear, $P < 0.10$) and poorer (linear, $P = 0.041$) F/G (Table 2). From d 10 to 22, increasing startup soybean meal decreased ADG and d 22 BW (linear, $P < 0.05$), with a marginal worsening (linear, $P = 0.067$) in F/G. However, no effects were observed for any growth performance criteria from d 22 to 38 and for the overall nursery period.

There was no evidence ($P = 0.892$) of an interaction between treatment and day for fecal DM. On d 10 and 22, fecal DM decreased (d 10, linear, $P = 0.053$; d 22, linear, $P = 0.045$) as startup soybean meal increased. There was no evidence for a main effect of day ($P = 0.204$) with pigs exhibiting fecal DM of approximately 20% for both sampling timepoints.

[4] Leone, J. L. 1973. Collaborative study of the quantitative determination of titanium dioxide in cheese. AOAC. 56(3):535.

[5] Adeola, O. 2001. Digestion and balance techniques in pigs. pp. 903. Swine Nutrition, 2nd ed. A. J. Lewis and L. L. Southern ed. CRC Press, Washington, DC.

The ATTD of DM tended to decrease (linear, $P = 0.095$) as startup soybean meal increased in the diet. However, there was no evidence of a difference in ATTD of CP.

In summary, the quality of startup soybean meal can affect the performance of nursery pigs, specifically during the first three weeks after weaning, suggesting that pigs may be particularly sensitive to soybean meal quality during that phase of growth. However, pigs adjusted to the startup soybean meal toward the end of the nursery period, leading to no differences in overall growth.

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

Item	Phase 1	Phase 2	Phase 3
Ingredients, %			
Corn	48.18	54.06	65.55
Soybean meal[2]	19.66	28.46	30.54
Spray-dried whey	10.00	---	---
Whey permeate, 80% lactose	10.00	10.00	---
Enzymatically treated soybean meal[3]	5.75	2.50	---
Spray-dried bovine plasma	2.50	---	---
Monocalcium P, 21% P	1.15	1.40	0.95
Calcium carbonate	0.58	0.65	0.85
Zinc oxide	0.40	0.25	---
Salt	0.40	0.50	0.60
Vitamin premix	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15
Phytase[4]	0.08	0.08	0.08
L-Lys-HCL	0.40	0.52	0.48
DL-Met	0.21	0.24	0.20
L-Thr	0.18	0.25	0.22
L-Trp	0.02	0.04	0.04
L-Val	0.10	0.15	0.12
L-Ile	---	0.02	---
Titanium dioxide	---	0.50	---
Total	100	100	100

continued

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

Item	Phase 1	Phase 2	Phase 3
Calculated analysis			
SID amino acids, %			
Lys	1.35	1.35	1.35
Ile:Lys	56	56	56
Leu:Lys	114	109	115
Met:Lys	35	38	36
Met and Cys:Lys	58	58	58
Thr:Lys	64	64	63
Trp:Lys	19.2	19.3	19.3
Val:Lys	70	70	70
Total Lys, %	1.50	1.49	1.50
NE, kcal/lb	1,128	1,103	1,097
SID Lys:NE, g/Mcal	5.43	5.55	5.58
CP, %	20.7	20.7	21.3
Ca, %	0.70	0.72	0.71
P, %	0.69	0.70	0.61
STTD P, %	0.60	0.58	0.48

[1]Phase 1 diets were fed from 11.8 lb to 14.4 lb, phase 2 diets were fed from 14.4 lb to 24.7 lb, and phase 3 diets were fed from 24.7 lb to 44.7 lb.
[2]All soybean meal was sourced from the same soybean crush plant. The first batch was obtained from the initial truckload from the startup phase of the plant. Approximately four hours later, a second batch was sourced when the soybean meal processing had stabilized. The nutritional composition of both soybean meal sources was considered the same, and thus the startup soybean meal replaced the normal soybean meal on an equal weight basis without other changes to the formulation.
[3]HP 300, Hamlet Protein, Findlay, OH.
[4]Ronozyme HiPhos 2700 GT, DSM Nutritional Products, Parsippany, NJ was included at 2,000 FTU/kg to provide an estimated release of 0.12% STTD P for all diets.

Table 2. Effects of increasing startup soybean meal on nursery pig performance, fecal dry matter (DM), and apparent total tract digestibility (ATTD) of crude protein (CP) and DM[1]

	Startup soybean meal, %[2]						*P* =	
	0	25	50	75	100	SEM	Linear	Quadratic
BW, lb								
d 0	11.8	11.8	11.8	11.8	11.8	0.01	0.658	0.723
d 10	14.7	14.4	14.3	14.3	14.2	0.22	0.096	0.583
d 22	25.7	24.7	24.7	24.6	24.0	0.40	0.012	0.712
d 38	45.9	44.6	45.2	43.9	43.7	0.94	0.091	0.949
d 0 to 10 (Phase 1)								
ADG, lb	0.29	0.27	0.25	0.26	0.24	0.021	0.097	0.593
ADFI, lb	0.32	0.32	0.30	0.31	0.30	0.021	0.493	0.855
F/G	1.09	1.20	1.26	1.27	1.28	0.067	0.041	0.346
d 10 to 22 (Phase 2)								
ADG, lb	1.00	0.93	0.94	0.94	0.89	0.028	0.021	0.878
ADFI, lb	1.36	1.35	1.32	1.35	1.29	0.047	0.232	0.691
F/G	1.37	1.46	1.41	1.45	1.45	0.038	0.067	0.354
d 22 to 38 (Phase 3)								
ADG, lb	1.19	1.15	1.15	1.15	1.19	0.031	0.996	0.155
ADFI, lb	1.72	1.70	1.67	1.70	1.72	0.043	0.897	0.397
F/G	1.44	1.47	1.46	1.49	1.44	0.025	0.818	0.240
d 0 to 38 (Overall)								
ADG, lb	0.90	0.85	0.85	0.85	0.85	0.021	0.175	0.238
ADFI, lb	1.25	1.23	1.20	1.23	1.22	0.032	0.605	0.618
F/G	1.39	1.44	1.42	1.45	1.43	0.022	0.105	0.109
Fecal DM, %[3]								
d 10	22.72	23.37	21.95	19.85	21.33	1.070	0.053	0.793
d 22	20.78	20.97	19.72	19.07	19.19	0.853	0.045	0.869
ATTD, %[4]								
DM	83.81	82.96	83.58	81.44	82.87	0.957	0.095	0.455
CP	74.07	73.93	74.78	74.12	74.47	1.777	0.798	0.906

[1]A total of 300 weanling pigs (241 × 600, DNA; initially 11.8 ± 0.01 lb), approximately 19 days of age, were used in a 38-d experiment with five pigs per pen and 12 pens per treatment.

[2]All soybean meal was sourced from the same soybean crush plant. The first batch was obtained from the initial truckload from the startup phase of the plant. Approximately four hours later, a second batch was sourced when the soybean meal processing had stabilized.

[3]Feces from three pigs from each pen were pooled, weighed, and dried to measure fecal DM. Treatment × day, $P = 0.892$; Treatment, $P = 0.040$; Day, $P = 0.204$.

[4]Both ground feed and fecal samples were dried in a 275°F forced-air drying oven for 2 h to determine DM percentage of the samples used for titanium determination. Titanium dioxide concentration in both dried feed and fecal samples were analyzed in duplicate.