Use of Specialty Soy Products to Replace Poultry Meal and Spray-Dried Blood Plasma in Diets Provided to Nursery Pigs Housed in Commercial Conditions

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Summary

A total of 2,260 pigs (PIC TR4 × [Fast LW × PIC L02]; initially 14.8 lb) were used to evaluate a specialty soy protein source as an alternative to poultry meal and spray-dried blood plasma on nursery pig performance in a commercial environment. At weaning, pigs were allotted to 1 of 5 dietary treatments based on initial weight in two research nurseries. In the first facility there were 20 pigs per pen and 10 pens per treatment. In the second facility, there were 21 pigs per pen and 12 replications per treatment for a total of 22 replications per treatment. Dietary treatments included a control diet containing 9.5% poultry meal (AV-E Digest, XFE Products, Des Moines, IA) and 4.13 (phase 1) or 2.75% (phase 2) spray-dried blood plasma (Appetein, APC Inc., Ankeny, IA). The four additional diets were set up in a 2 × 2 factorial with a novel soy protein concentrate (AX3 Digest; Protekta; Plainfield, IN) or fermented soybean meal (MEPro; Prairie Aquatech; Brookings, SD) replacing poultry meal or poultry meal and spray-dried blood plasma in the control diet. Pigs were fed experimental diets during phase 1 (d 0 to 7) and phase 2 (d 7 to 21). Following phase 2, pigs were fed a common diet for an additional 21 d (d 21 to 42). During the experimental period (d 0 to 21), pigs fed the novel soy protein concentrate had improved ($P < 0.001$) F/G with no differences in ADG or ADFI compared to pigs fed fermented soybean meal. During the experimental period (d 0 to 21) and overall (d 0 to 42), pigs fed soy protein as a replacement to poultry meal had increased ($P \leq 0.016$) ADG and ADFI compared to pigs fed the control diet. During the experimental period (d 0 to 21), pigs fed soy protein as a replacement to spray-dried blood plasma had improved ($P = 0.044$) F/G compared to pigs fed soy protein without replacing spray-dried blood plasma, with no differences in ADG or ADFI. In summary, utilizing a specialty soy protein source as a replacement for poultry meal improved growth performance. Replacing poultry meal and spray-dried blood plasma with soy protein improved feed efficiency when treatment diets were fed, but not overall. In addition, the novel soy protein concentrate improved feed efficiency

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compared to fermented soybean meal during the experimental period with no effect on ADG or ADFI.

Introduction

Low feed intake is common in nursery pigs during the first few weeks after weaning, ultimately limiting their growth. Although soybean meal is the predominant protein source used in nursery pig diets, it contains antinutritional factors that cause a hypersensitive immune response in the gastrointestinal tract.[3] As a result, soybean meal's antinutritional factors limit the inclusion rate in diets immediately after weaning. Thus, other protein sources that are high quality, cost-effective, and contain minimal anti-nutritional factors are used to meet the amino acid requirements of the pig.

Spray-dried blood plasma is used in nursery pig diets because of its high amino acid digestibility and presence of gamma immunoglobulins to promote growth, immune status, and gut health.[4] Spray-dried blood plasma has been shown to increase nursery pig performance, but its inclusion in diets is often expensive relative to vegetable protein sources.[5] Poultry meal is another protein source that is used because of its similarities in AA content to other specialty protein sources such as fish meal.[6] However, the source and quality of poultry meal can lead to inconsistencies regarding nursery pig performance.[7]

Fermented soybean meal is a soybean meal-based product that is further processed to optimize protein and amino acids while significantly reducing potential anti-nutritional factors. It has been used as an alternative to fish meal and other protein sources in nursery diets. Soy protein concentrate is another alternative protein source that can be used due to its high AA digestibility and minimal content of anti-nutritional factors. Recently, a novel soy protein concentrate has entered the market with a low acid-binding capacity relative to soybean meal and other soy protein sources. Ingredients with low acid-binding capacity can maintain a low stomach pH, which may improve nursery pig health status and growth performance. However, little data are available to determine the new product's effects in comparison to other soy specialty protein sources, or its quality as a replacement for other specialty protein products. Therefore, the objective of this study was to evaluate a novel soy protein concentrate and fermented soybean meal as a replacement to poultry meal or spray-dried blood plasma in nursery pig diets under commercial conditions.

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[4] Balan, P., M. Staincliffe, and P.J. Moughan. 2021. Effects of spray-dried animal plasma on the growth performance of weaned piglets-a review. J. Anim. Physiol. Anim. Nutr. 105:699-714. doi:10.1111/jpn.13435.

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[6] Keegan, T. P., J. M. DeRouchey, J. L. Nelssen, M. D. Tokach, R. D. Goodband, and S. S. Dritz. 2004. The effects of poultry meal source and ash level on nursery pig performance. Journal of Animal Science.

[7] Rojas, O. J., and H. H. Stein. 2015. Effects of replacing fish, chicken, or poultry by-product meal with fermented soybean meal in diets fed to weanling pigs. Rev. Colomb. Cienc. Pecu. 28:22-41.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted at two commercial research sites owned and operated by New Fashion Pork in Jackson, MN. All diets were manufactured at the New Fashion Pork feed mill located in Estherville, IA.

Animals and diets

A total of 2,260 pigs (PIC TR4 × [Fast LW × PIC L02]; initially 14.8 lb) were used in a 42-d study across two facilities. In the first facility, there were 20 pigs per pen and 10 replications per treatment spread across two rooms. In the second facility, there were 21 pigs per pen and 12 replications per treatment. In total, there were 22 replications per treatment. Pens were randomly assigned to treatment and blocked based on initial body weight. Dietary treatments included a control diet containing 9.5% poultry meal (AV-E Digest, XFE Products, Des Moines, IA) and 4.13 (phase 1) or 2.75% (phase 2) spray-dried blood plasma (Appetein, APC Inc., Ankeny, IA). The four additional diets were set up in a 2 × 2 factorial with a novel soy protein concentrate (AX3 Digest; Protekta; Plainfield, IN) or fermented soybean meal (MEPro; Prairie Aquatech; Brookings, SD) replacing poultry meal or poultry meal and spray-dried blood plasma in the control diet. Protein sources were added to the diet to maintain a similar level of soybean meal and balanced for SID amino acids by using feed-grade amino acids. Thus, soy protein sources were added at 6 and 13 (phase 1) or 10.75% (phase 2) of the diet to replace poultry meal or poultry meal and spray-dried blood plasma, respectively. Dietary treatment structure allowed the opportunity to compare each protein source to the other, the soy protein sources as a replacement to poultry meal, and the soy protein sources as a replacement to spray-dried blood plasma. Diets were formulated to contain 1.36% (phase 1) and 1.42% (phase 2) SID Lys and met or exceeded other nutrient requirement estimates established by the NRC.[8] Treatment diets were fed for 7 d in phase 1 (d 0 to 7) and 14 d in phase 2 (d 7 to 21). Following phase 2, all pigs were fed a common diet for an additional 21 d (d 21 to 42). Pens of pigs were weighed, and feed disappearance was calculated weekly from d 7 to 42 to determine ADG, ADFI, and F/G.

Statistical analysis

Data were analyzed as a randomized complete block design using the RStudio environment (Version 1.3.1093, RStudio, Inc., Boston, MA) using R programming language [Version 4.0.2 (2020-06-22), R Core Team, R Foundation for Statistical Computing, Vienna, Austria] with body weight serving as the blocking factor and pen as the experimental unit. Block was included in the model as a random effect. Interactive and main effects of soy protein source, replacement of poultry meal, and replacement of spray-dried blood plasma were tested using the lmer function. Differences between treatments were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

Throughout the study, there were no soy source × specialty protein replacement strategy interactions for any response criteria ($P > 0.10$).

[8] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

When comparing soy protein sources, in phase 1 (d 0 to 7), pigs fed fermented soybean meal tended to have increased ($P = 0.063$) ADFI compared to pigs fed the novel soy protein concentrate. In phase 2 (d 7 to 21) and the full experimental period (d 0 to 21), pigs fed the novel soy protein concentrate had improved ($P < 0.001$) F/G compared to pigs fed fermented soybean meal. In the common period (d 21 to 42), pigs previously fed fermented soybean meal tended to have improved ($P = 0.079$) F/G compared to pigs previously fed soy protein concentrate. Overall (d 0 to 42), there were no differences ($P > 0.10$) between pigs fed novel soy protein concentrate or fermented soybean meal for BW, ADG, ADFI, or F/G.

For the comparison of soy protein sources replacing poultry meal, in phase 1 (d 0 to 7) pigs fed diets containing the soy protein sources as a replacement to poultry meal had improved ($P \leq 0.016$) BW, ADG, ADFI, and F/G. In phase 2 (d 7 to 21) and the experimental period (d 0 to 21), pigs fed the soy protein sources as a replacement to poultry meal had increased ($P < 0.001$) BW, ADG, and ADFI with no differences in F/G. In the common period, pigs previously fed soy protein sources as a replacement to poultry meal had increased ($P = 0.044$) ADFI; however, pigs previously fed the control diet had improved ($P = 0.002$) F/G compared to pigs previously fed soy protein sources replacing poultry meal. Overall (d 0 to 42), pigs fed the soy protein sources as a replacement to poultry meal had increased ($P \leq 0.028$) BW, ADG, and ADFI; however, pigs fed the control diet had improved ($P = 0.029$) F/G compared to pigs fed diets when soy protein sources replaced poultry meal.

For the comparison of soy protein sources replacing spray-dried blood plasma, in phase 1 (d 0 to 7), pigs fed diets containing soy protein sources as a replacement to spray-dried blood plasma tended to have increased ($P \leq 0.075$) BW and ADG and improved ($P = 0.020$) F/G. In the experimental period (d 0 to 21), pigs that were fed soy protein sources as a replacement to spray-dried blood plasma tended to have increased ($P = 0.097$) ADG and improved ($P = 0.044$) F/G. In the common period (d 21 to 42) and overall (d 0 to 42), there were no differences ($P > 0.10$) for pigs fed soy protein sources as a replacement to spray-dried blood plasma. Overall (d 0 to 42), there were no differences ($P > 0.10$) in removals and mortalities between dietary treatments.

In summary, the results of this experiment indicate that utilizing a novel soy protein concentrate or fermented soybean meal as a replacement to poultry meal improved growth performance in nursery pigs. Continued replacement of poultry meal and spray-dried blood plasma yielded an additional improvement in feed efficiency. The results of this study also indicate that the novel soy protein concentrate improved feed efficiency during the experimental period compared to fermented soybean meal. Additional research is warranted to determine if improved nutrient utilization of the novel soy protein concentrate can be attributed to its low acid-binding capacity properties or some other mechanism.

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

		Novel soy protein concentrate[2]		Fermented soybean meal[3]	
Item	**Control**	**Replacing poultry meal**	**Replacing poultry meal and blood plasma**	**Replacing poultry meal**	**Replacing poultry meal and blood plasma**
Ingredients, %					
Corn	44.10	46.34	43.36	46.17	42.96
Soybean meal, 46.8% CP	18.59	18.58	18.54	18.74	18.87
Cereal blend	13.10	13.10	13.10	13.10	13.10
Poultry meal[4]	9.50	---	---	---	---
Novel soy protein concentrate[2]	---	6.00	13.00	---	---
Fermented soybean meal[3]	---	---	---	6.00	13.00
Spray-dried blood plasma[5]	4.13	4.13	---	4.13	---
Oat groats	3.75	3.75	3.75	3.75	3.75
Milk, lactose	1.38	1.38	1.38	1.38	1.38
Fat blend	2.00	2.00	2.00	2.00	2.00
Beef tallow	0.50	0.50	0.50	0.50	0.50
Limestone	0.38	0.60	0.33	0.68	0.53
Dicalcium phosphate, 19% P	0.23	1.05	1.40	0.95	1.15
Salt	---	0.25	0.45	0.33	0.63
L-Lys	0.42	0.42	0.42	0.42	0.42
DL-Met	0.20	0.21	0.22	0.20	0.20
L-Thr	0.26	0.27	0.26	0.26	0.25
L-Trp	0.08	0.07	0.07	0.06	0.05
L-Val	0.11	0.10	0.06	0.10	0.05
L-Ile	0.11	0.09	---	0.08	---
Copper chloride	0.04	0.04	0.04	0.04	0.04
Choline chloride	0.03	0.03	0.03	0.03	0.03
Zinc oxide	0.30	0.30	0.30	0.30	0.30
Vitamin E	0.05	0.05	0.05	0.05	0.05
Vitamin-trace mineral premix[6]	0.25	0.25	0.25	0.25	0.25
Benzoic acid	0.50	0.50	0.50	0.50	0.50
Manganese	0.02	0.02	0.02	0.02	0.02
Total	100	100	100	100	100

continued

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

Item	Control	Novel soy protein concentrate[2]: Replacing poultry meal	Novel soy protein concentrate[2]: Replacing poultry meal and blood plasma	Fermented soybean meal[3]: Replacing poultry meal	Fermented soybean meal[3]: Replacing poultry meal and blood plasma
SID amino acids, %					
Lys	1.36	1.36	1.36	1.36	1.36
Ile:Lys	59	59	61	60	63
Leu:Lys	105	108	113	109	114
Met:Lys	33	33	36	33	35
Met and Cys:Lys	56	56	56	56	56
Thr:Lys	66	66	66	66	66
Trp:Lys	22.2	22.2	22.3	22.1	22.2
Val:Lys	70	70	70	70	70
His:Lys	34	35	36	35	36
Total Lys, %	1.55	1.52	1.51	1.52	1.52
NE NRC,[7] kcal/lb	1,057	1,093	1,080	1,089	1,071
SID Lys:NE, g/Mcal	5.84	5.65	5.71	5.67	5.76
CP, %	22.0	21.3	22.6	21.5	23.0
Ca, %	0.59	0.59	0.59	0.59	0.59
P, %	0.55	0.58	0.62	0.55	0.59
STTD P, %	0.43	0.43	0.43	0.43	0.43

[1] Phase 1 diets were fed from approximately 14.8 to 15.5 lb.
[2] AX3 Digest; Protekta, Plainfield, IN.
[3] MEPro; Prairie Aquatech, Brookings, SD.
[4] AV-E Digest; XFE Products, Des Moines, IA.
[5] Appetein; APC Inc., Ankeny, IA.
[6] Vitamin-trace mineral premix contained Optiphos PLUS (Huvepharma Inc., Peachtree City, GA) which provided an estimated release of 0.12% STTD P with 1,426 FTU/lb.
[7] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

Table 2. Phase 2 diet composition (as-fed basis)[1]

Item	Control	Novel soy protein concentrate[2]		Fermented soybean meal[3]	
		Replacing poultry meal	Replacing poultry meal and blood plasma	Replacing poultry meal	Replacing poultry meal and blood plasma
Ingredients, %					
Corn	52.72	54.96	53.03	54.77	52.71
Soybean meal, 46.8% CP	22.76	22.76	22.60	22.91	22.87
Cereal blend	5.00	5.00	5.00	5.00	5.00
Poultry meal[4]	9.50	---	---	---	---
Soy protein concentrate[2]	---	6.00	10.75	---	---
Fermented soybean meal[3]	---	---	---	6.00	10.75
Spray-dried blood plasma[5]	2.75	2.75	---	2.75	---
Milk, lactose	1.38	1.38	1.38	1.38	1.38
Fat blend	2.00	2.00	2.00	2.00	2.00
Beef tallow	0.50	0.50	0.50	0.50	0.50
Limestone	0.53	0.75	0.55	0.83	0.70
Dicalcium phosphate, 19% P	0.23	1.05	1.30	0.95	1.10
Salt	0.18	0.43	0.58	0.50	0.70
L-Lys	0.49	0.49	0.49	0.49	0.49
DL-Met	0.24	0.25	0.24	0.25	0.24
L-Thr	0.27	0.27	0.26	0.27	0.25
L-Trp	0.09	0.08	0.08	0.07	0.07
L-Val	0.16	0.16	0.13	0.16	0.13
L-Ile	0.10	0.07	---	0.07	---
Copper chloride	0.04	0.04	0.04	0.04	0.04
Choline chloride	0.03	0.03	0.03	0.03	0.03
Zinc oxide	0.28	0.28	0.28	0.28	0.28
Vitamin E	0.01	0.01	0.01	0.01	0.01
Vitamin-trace mineral premix[6]	0.25	0.25	0.25	0.25	0.25
Benzoic acid	0.50	0.50	0.50	0.50	0.50
Manganese	0.02	0.02	0.02	0.02	0.02
Total	100	100	100	100	100

continued

Table 2. Phase 2 diet composition (as-fed basis)[1]

		Novel soy protein concentrate[2]		Fermented soybean meal[3]	
Item	Control	Replacing poultry meal	Replacing poultry meal and blood plasma	Replacing poultry meal	Replacing poultry meal and blood plasma
SID amino acids, %					
Lys	1.42	1.42	1.42	1.42	1.42
Ile:Lys	58	57	58	59	60
Leu:Lys	103	106	109	107	110
Met:Lys	36	35	36	35	36
Met and Cys:Lys	56	56	56	56	56
Thr:Lys	66	66	66	66	66
Trp:Lys	22.3	22.3	22.3	22.2	22.4
Val:Lys	71	71	71	71	71
His:Lys	33	34	34	34	34
Total Lys, %	1.61	1.58	1.57	1.58	1.58
NE NRC,[7] kcal/lb	1,095	1,131	1,122	1,127	1,115
SID Lys:NE, g/Mcal	5.88	5.70	5.74	5.72	5.77
CP, %	22.6	22.0	22.8	22.2	23.1
Ca, %	0.64	0.64	0.64	0.64	0.64
P, %	0.56	0.58	0.61	0.55	0.56
STTD P, %	0.43	0.43	0.43	0.43	0.43

[1] Phase 2 diets were fed from approximately 15.5 to 25.4 lb.
[2] AX3 Digest; Protekta, Plainfield, IN.
[3] MEPro; Prairie Aquatech, Brookings, SD.
[4] AV-E Digest; XFE Products, Des Moines, IA.
[5] Appetein; APC Inc., Ankeny, IA.
[6] Vitamin-trace mineral premix contained Optiphos PLUS (Huvepharma Inc., Peachtree City, GA) which provided an estimated release of 0.12% STTD P with 1,426 FTU/lb.
[7] National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. https://doi.org/10.17226/13298.

Table 3. Specialty soy protein products to replace poultry meal and blood plasma on nursery diets in commercial conditions[1]

		Novel soy protein concentrate[2]		Fermented soybean meal[3]			P^4 =		
Item	Control	Replacing poultry meal	Replacing poultry meal and blood plasma	Replacing poultry meal	Replacing poultry meal and blood plasma	SEM	Soy protein source[5]	Replacing poultry meal with soy source[6]	Replacing blood plasma with soy source[7]
BW, lb									
d 0	14.8	14.8	14.8	14.8	14.8	0.13	0.954	0.796	0.819
d 7	15.1	15.4	15.5	15.5	15.6	0.14	0.503	0.001	0.071
d 21	24.1	25.6	25.8	25.1	25.6	0.28	0.210	<0.001	0.130
d 42	45.3	46.7	47.1	46.4	46.8	0.67	0.548	0.028	0.392
Phase 1 (d 0 to 7)									
ADG, lb	0.05	0.09	0.11	0.10	0.12	0.011	0.477	<0.001	0.075
ADFI, lb	0.14	0.20	0.18	0.20	0.22	0.010	0.063	<0.001	0.789
F/G[8]	3.29	2.16	1.68	2.25	1.82	---	0.515	0.016	0.020
G:F	0.30	0.46	0.60	0.44	0.55	0.051	0.515	0.016	0.020
Phase 2 (d 7 to 21)									
ADG, lb	0.63	0.71	0.72	0.68	0.71	0.013	0.098	<0.001	0.251
ADFI, lb	0.77	0.86	0.85	0.84	0.87	0.014	0.846	<0.001	0.332
F/G[8]	1.23	1.20	1.19	1.23	1.24	---	<0.001	0.495	0.529
G:F	0.81	0.83	0.84	0.81	0.81	0.008	<0.001	0.495	0.529
Experimental period (d 0 to 21)									
ADG, lb	0.43	0.50	0.51	0.49	0.51	0.010	0.229	<0.001	0.097
ADFI, lb	0.56	0.63	0.63	0.63	0.65	0.011	0.439	<0.001	0.341
F/G[8]	1.30	1.26	1.22	1.29	1.29	---	<0.001	0.162	0.044
G:F	0.77	0.79	0.82	0.78	0.78	0.008	<0.001	0.162	0.044

continued

Table 3. Specialty soy protein products to replace poultry meal and blood plasma on nursery diets in commercial conditions[1]

		Novel soy protein concentrate[2]		Fermented soybean meal[3]			P[4] =		
Item	Control	Replacing poultry meal	Replacing poultry meal and blood plasma	Replacing poultry meal	Replacing poultry meal and blood plasma	SEM	Soy protein source[5]	Replacing poultry meal with soy source[6]	Replacing blood plasma with soy source[7]
Common period (d 21 to 42)									
ADG, lb	1.00	0.98	1.01	1.01	1.01	0.027	0.370	0.964	0.428
ADFI, lb	1.47	1.53	1.56	1.52	1.55	0.031	0.838	0.044	0.236
F/G[8]	1.48	1.56	1.55	1.51	1.54	---	0.079	0.002	0.735
G:F	0.68	0.64	0.65	0.66	0.65	0.009	0.079	0.002	0.735
Overall (d 0 to 42)									
ADG, lb	0.71	0.74	0.76	0.74	0.75	0.015	0.890	0.016	0.135
ADFI, lb	1.01	1.07	1.08	1.07	1.10	0.018	0.834	0.001	0.181
F/G[8]	1.42	1.46	1.43	1.44	1.45	---	0.874	0.029	0.630
G:F	0.70	0.69	0.70	0.70	0.69	0.007	0.874	0.029	0.630
Rem+Mort,[9] %	5.6	5.1	4.0	4.0	3.1	1.08	0.416	0.349	0.333

[1] A total of 2,260 pigs (initially 14.8 ± 0.59 lb) across two facilities were used in a 42-d nursery trial. A total of 5 dietary treatments were utilized with two different specialty soy protein sources replacing poultry meal or poultry meal and spray-dried blood plasma. In the first facility, there were 20 pigs per pen and 10 pens per treatment spread across two barns. In the second facility, there were 21 pigs per pen and 12 replications per treatment. In total, there were 22 replications per treatment.

[2] AX3 Digest; Protekta, Plainfield, IN.

[3] MEPro; Prairie Aquatech, Brookings, SD.

[4] There were no soy protein source × poultry meal and spray-dried blood plasma replacement interactions observed ($P > 0.05$) throughout the duration of the study.

[5] Compares the average of pigs fed diets containing novel soy protein concentrate to those fed diets containing fermented soybean meal.

[6] Compares the control to the average of each poultry meal replacement diet.

[7] Compares the average of diets with soy protein sources replacing poultry meal to the average of diets with soy protein sources replacing poultry meal and spray-dried blood plasma.

[8] Feed efficiency was calculated from G:F by taking the inverse, therefore the P-values are the same and there are no reported SEM.

[9] Percentage of pigs removed from trial as removal or mortality.