Evaluation of Fermented Soybean Meal Sources in Diets for Nursery Pigs[1]

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Summary

A total of 296 mixed-sex pigs (PIC 327 × 1050; 14.5 ± 3.0 lb BW and 21 d of age) were used in a 31-d experiment evaluating the effect of further processing methods for soybean meal on weanling pig growth performance. There were 11 replicate pens per treatment with 6 or 7 pigs per pen. At weaning, pigs were allotted to pens by initial weight to 1 of 4 treatments in a completely randomized design. Experimental treatments were: (1) negative control (NC: no specialty protein sources), (2) fermented soybean meal processing method 1 (FSBM 1), (3) fermented soybean meal processing method 2 (FSBM 2), and (4) enzymatically treated soybean meal (ETS). The specialty soybean meal protein sources were included in Phase 1 (d 0 to 7) and Phase 2 (d 7 to 20) diets at 5%, and diets were formulated to the same standardized ileal digestible (SID) amino acid level. All pigs were subsequently fed a common diet during Phase 3 (d 20 to 31). Phase 1 and 2 diets were fed in pellet form, whereas the Phase 3 common diet was fed in meal form. Nutrient analyses of specialty soybean meal ingredients were conducted and generally matched those used for diet formulation. From d 0 to 7, pigs fed FSBM 2 had increased ($P < 0.05$) ADG and BW compared with pigs fed ETS, whereas those fed NC and FSBM 1 were intermediate. No other differences were observed between treatments for growth or BW during the experimental period, common period, or overall. In summary, further processed soybean meal sources did not improve nursery pig growth compared with traditional soybean meal.

Key words: fermented soybean meal, nursery pig, protein sources

Introduction

Newly weaned pigs have limited ability to utilize plant protein sources because of their relatively immature digestive systems. This is why specialty animal protein sources are frequently used in diets as a source of readily available protein and amino acids; however, the high cost associated with the animal by-products creates a need for an economical plant-derived specialty protein source.

Traditional soybean meal contains high levels of intact proteins, which are not readily available to pigs' immature digestive system. Research has indicated that pigs fed fermented rather than solvent-extracted soybean meal have improved nutrient digestibility. Soybean meal fermented in the presence of *Aspergillus oryzae* and *Bacillus subtilis* (FSBM) may be used in diets fed to weanling pigs in place of specialty animal proteins without negatively affecting ME or NE of the diet or the standardized ileal digestibility

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(SID) of amino acids (Rojas and Stein, 2013[3]; Cervantes-Pahm 2010[4]). The fermentation process is thought to reduce trypsin inhibitors and some oligosaccharides that have been shown to decrease pig performance, but most research has indicated that soy proteins cannot fully replace animal protein sources postweaning and maintain equal pig growth performance (Jones et al., 2008[5]). Consequently, the objective of this study was to determine the impact of partially replacing conventional soybean meal with fermented or enzymatically treated soybean meal on nursery pig growth performance.

Procedures

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

A total of 296 mixed-sex pigs (PIC 327 × 1050; 14.5 ± 3.0 lb BW and 21 d of age) were used in a 31-d experiment. There were 11 replicate pens per treatment with 6 or 7 pigs per pen. At weaning, pigs were allotted to pens by initial weight to 1 of 4 dietary treatments in a completely randomized design. Each pen (4 ft × 5 ft) contained a 4-hole, dry self-feeder and a nipple waterer to provide ad libitum access to feed and water.

The four dietary treatments were: (1) negative control (NC: no specialty protein sources), (2) fermented soybean meal processing method 1 (FSBM 1), (3) fermented soybean meal processing method 2 (FSBM 2), and (4) enzymatically treated soybean meal (ETS). Both FSBM products were manufactured using solid-state fermentation. FSBM processing methods differed from a previous experiment (see "Effects of PepSoyGen Processing Method on Nursery Pig Growth Performance," p. 27) because separate patented bacteria strains were utilized in the fermentation process. FSBM 1, FSBM 2, and ETS were included at 5% in the treatment diets. Nutrient profiles and SID amino acid digestibility coefficients for FSBM 1 and FSBM 2 were provided by the manufacturer. The SID amino acid coefficients for ETS were from NRC (2012[6]).

A three-phase diet (Table 1) series was used with treatment diets fed during Phase 1 (d 0 to 7) and Phase 2 (d 7 to 20), and a common diet was fed during Phase 3 (d 20 to 31). All diets were manufactured at the K-State O.H. Kruse Feed Technology Innovation Center. Phases 1 and 2 were fed in pelleted form, whereas the common diet was provided in meal form. Experimental protein sources were provided by Nutraferma (North Sioux City, SD) and shipped to Kansas State University prior to diet manufacturing. All specialty proteins were analyzed for amino acid profile and proximate analysis (Table 2) at the University of Missouri Agricultural Experiment Station Chemical Laboratories (Columbia, MO). Diet samples were collected from the feeders for each dietary phase and sent for proximate analysis (Table 3) at Ward Laboratories, Inc.

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[3] Rojas, O.J., and H.H. Stein. 2013. Concentration of digestible, metabolizable, and net energy and digestibility of energy and nutrients in fermented soybean meal, conventional soybean meal, and fish meal fed to weanling pigs. J. Anim. Sci. 91:4397–4405.
[4] Cervantes-Pahm, S.K., and H.H. Stein. 2010. Ileal digestibility of amino acids in conventional, fermented and enzyme-treated soybean meal and in soy protein isolate, fish meal, and casein fed to weanling pigs. J. Anim. Sci. 88:2674–2683.
[5] Jones et al., Swine Day 2008. Report of Progress 1001, pp. 52–61.
[6] NRC, 2012. Nutrient Requirements of Swine, 11th ed. Natl. Acad. Press, Washington, DC.

(Kearney, NE). Average daily gain, ADFI, and F/G were calculated by weighing pigs and determining feed disappearance on d 0, 7, 14, 20, and 31 (Table 4).

Results were analyzed as a completely randomized design. One replicate pen from the NC treatment was determined to be an outlier (F/G > 2 SD from the mean) on d 7, and this data point was therefore removed from the dataset. Treatment means were analyzed using the LSMEANS statement with pen as the experimental unit. Least squares means were calculated for each independent variable, and means were considered significant at $P < 0.05$ and tendencies at $0.05 < P < 0.10$.

Results and Discussion

Nutrient analyses (Table 3) of experimental diets generally matched formulated levels for CP and amino acids. Given the similar nutrient content between FSBM 1 and FSBM 2, it is unlikely that any growth performance differences observed between processing methods are due to differences in essential amino acid concentrations.

For Phase 1 (d 0 to 7), pigs fed FSBM 2 had improved ($P < 0.05$; Table 4) ADG compared with ETS, whereas pigs fed the NC and FSBM 1 diets were intermediate. No differences in ADFI or feed efficiency were detected across treatments. Accordingly, pigs fed FSBM 2 were heavier ($P < 0.05$) than those fed ETS at d 7. During Phase 2 (d 7 to 20) and the common diet period (d 20 to 31), no growth performance differences were observed between treatment, and pig weights were similar on d 14, 20, and 31. Overall (d 0 to 31), there were no significant differences between treatments for ADG, ADFI, or feed efficiency.

Although the greater ADG seen for FSBM 2 compared with ETS in Phase 1 appears promising within treatments containing specialty proteins, the lack of a response in Phase 2 and overall appears to indicate a limited impact of processing method on overall nursery performance. Moreover, in the present study, pigs fed a negative control diet without specialty proteins performed similarly to those fed diets containing various further-processed soybean meal products. Many studies have demonstrated growth benefits when incorporating high-quality animal protein sources in early nursery diets. This benefit is thought to be the result of reducing the amount of soybean meal that may contain less digestible nutrients or anti-nutritional factors for the young pig; however, the present study failed to indicate any benefit of additional soybean meal processing to improve performance compared with pigs fed diets containing traditional soybean meal. Nevertheless, the postweaning period remains challenging for the young pig and warrants further investigation of plant-based protein source alternatives.

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

	Phase 1				Phase 2				Phase 3
Item	NC[2]	FSBM 1[3]	FSBM 2[3]	ETS[4]	NC[2]	FSBM 1[3]	FSBM 2[3]	ETS[4]	Common
Ingredient, %									
Corn	30.10	34.73	34.70	34.70	42.26	46.92	46.89	46.87	60.88
Soybean meal, 46.5%	38.50	28.50	28.50	28.50	40.92	30.89	30.92	30.90	34.20
Spray dried whey	25.00	25.00	25.00	25.00	10.00	10.00	10.00	10.00	-
Choice white grease	3.00	3.00	3.00	3.00	3.00	3.00	3.00	3.00	1.00
Monocalcium phosphate	1.23	1.28	1.30	1.30	1.55	1.60	1.60	1.65	1.50
Limestone, ground	0.85	0.85	0.85	0.85	0.93	0.95	0.95	0.93	1.13
Sodium chloride	0.30	0.30	0.30	0.30	0.35	0.35	0.35	0.35	0.35
L-lysine HCl	0.09	0.24	0.23	0.24	0.14	0.30	0.29	0.29	0.30
DL-methionine	0.13	0.18	0.18	0.18	0.13	0.18	0.18	0.18	0.14
L-threonine	0.04	0.09	0.10	0.10	0.07	0.13	0.14	0.14	0.11
L-valine	-	0.04	0.04	0.04	-	0.04	0.04	0.04	-
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Zinc oxide	0.40	0.40	0.40	0.40	0.26	0.26	0.26	0.26	-
FSBM 1	-	5.00	-	-	-	5.00	-	-	-
FSBM 2	-	-	5.00	-	-	-	5.00	-	-
ETS	-	-	-	5.00	-	-	-	5.00	-
Total	100	100	100	100	100	100	100	100	100
Calculated composition									
Standardized ileal digestible (SID) amino acids, %									
Lysine	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.35	1.25
Isoleucine:lysine	71	65	65	65	69	63	63	63	63
Methionine:lysine	33	35	35	35	33	35	35	35	34
Met & Cys:lysine	58	58	58	58	58	58	58	58	58
Threonine:lysine	64	64	64	64	64	64	64	64	62
Tryptophan:lysine	21.8	19.1	19.7	19.5	21.1	18.5	19.0	18.9	18.8
Valine:lysine	73	70	70	70	73	70	70	70	68
Total lysine, %	1.50	1.50	1.50	1.49	1.51	1.51	1.51	1.51	1.40
ME, kcal/lb	1,542	1,552	1,546	1,546	1,535	1,545	1,539	1,539	1,496
SID lysine:ME, g/Mcal	3.97	3.95	3.96	3.96	3.99	3.96	3.98	3.98	3.79
CP, %	23.9	22.5	22.5	22.5	24.4	23.0	23.0	23.0	21.8
Ca, %	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.80	0.78
P, %	0.79	0.78	0.78	0.78	0.80	0.79	0.79	0.80	0.72
Available P, %	0.50	0.51	0.51	0.51	0.48	0.49	0.49	0.49	0.40

[1] Experimental diets were fed in two phases with a common Phase 3 diet. Phase 1 (d 0 to 7) and Phase 2 (d 7 to 20) diets were fed in pelleted form, whereas Phase 3 (d 21 to 31) diets were in meal form.
[2] Negative control (NC) diet formulated without the addition of specialty proteins.
[3] Fermented soybean meal (FSBM) produced using 1 of 2 proprietary processing methods.
[4] Enzymatically treated soybean meal (ETS).

Table 2. Nutrient analysis of basal ingredients (as-fed basis)[1]

Item	FSBM 1[2]	FSBM 2[2]	ETS[3]
Crude protein, %	52.57 (54.07)[4]	53.95 (54.07)	51.09 (54.07)
Amino acid content, %			
Lysine	3.25 (3.20)	3.19 (3.36)	3.07 (3.10)
Isoleucine	2.41 (2.21)	2.43 (2.16)	2.31 (2.16)
Leucine	4.19 (5.42)	4.18 (5.42)	3.91 (5.42)
Methionine	0.73 (0.71)	0.72 (0.67)	0.67 (0.67)
Cysteine	0.74 (0.97)	0.78 (0.74)	0.70 (0.74)
Threonine	2.13 (2.15)	2.01 (1.85)	1.91 (1.85)
Tryptophan	0.73 (0.49)	0.69 (0.65)	0.70 (0.65)
Valine	2.50 (2.32)	2.52 (2.27)	2.41 (2.27)

[1] Samples were analyzed at the University of Missouri Agricultural Experiment Station Chemical Laboratories in Columbia, MO.
[2] Fermented soybean meal (Nutraferma) produced using 1 of 2 proprietary processing methods.
[3] Enzymatically treated soybean meal (ETS).
[4] Values in parentheses indicate those used for diet formulation.

Table 3. Nutrient analysis of experimental diets (as-fed basis)[1]

	Phase 1				Phase 2				Phase 3
Ingredient, %	Negative control	FSBM 1[2]	FSBM 2[2]	ETS[3]	Negative control	FSBM 1[2]	FSBM 2[2]	ETS[3]	Common
CP	24.0	22.9	22.7	22.5	24.4	23.3	22.9	23.5	22.0
Ca	0.85	0.87	0.84	0.79	0.79	0.84	0.90	0.79	0.69
P	0.76	0.75	0.76	0.75	0.73	0.74	0.77	0.77	0.58
Ash	7.06	6.98	6.85	6.81	6.35	6.28	6.42	6.26	5.01

[1] Samples were analyzed at Ward Laboratories, Inc. (Kearney, NE).
[2] Fermented soybean meal (Nutraferma, North Sioux City, SD) produced using 1 of 2 proprietary processing methods.
[3] Enzymatically treated soybean meal (ETS).

Table 4. Effects of soybean meal further processing method on nursery pig growth performance[1,2]

Item	Negative control	FSBM 1[3]	FSBM 2[3]	ETS[4]	SEM	Probability, $P<$
Phase 1 (d 0 to 7)						
ADG, lb	0.17[ab]	0.16[ab]	0.21[b]	0.14[a]	0.018	0.073
ADFI, lb	0.38	0.36	0.36	0.31	0.033	0.315
F/G[5]	2.31	2.30	1.75	2.59	1.123	0.417
Phase 2 (d 7 to 20)						
ADG, lb	0.84	0.85	0.83	0.88	0.025	0.425
ADFI, lb	1.11	1.10	1.09	1.10	0.031	0.969
F/G	1.32	1.28	1.32	1.23	0.041	0.155
Experimental period (d 0 to 20)						
ADG, lb	0.61	0.61	0.61	0.62	0.020	0.914
ADFI, lb	0.86	0.84	0.84	0.82	0.026	0.822
F/G	1.41	1.37	1.36	1.31	0.050	0.167
Common period (d 20 to 31)						
ADG, lb	1.12	1.06	1.12	1.07	0.063	0.301
ADFI, lb	1.81	1.75	1.77	1.77	0.085	0.838
F/G	1.61	1.66	1.58	1.65	0.028	0.159
Overall (d 0 to 31)						
ADG, lb	0.79	0.77	0.80	0.79	0.022	0.811
ADFI, lb	1.19	1.16	1.17	1.16	0.042	0.761
F/G	1.51	1.51	1.47	1.48	0.027	0.456
Pig BW, lb						
d 0	14.4	14.3	14.3	14.1	0.39	0.315
d 7	15.5[ab]	15.5[ab]	15.8[b]	15.1[a]	0.44	0.104
d 14	20.4	20.6	20.8	20.4	0.58	0.748
d 20	26.6	26.8	26.7	26.8	0.44	0.995
d 31	38.9	38.4	39.0	38.5	1.02	0.871

[1] A total of 296 barrows and gilts (PIC 327 × 1050; initially 14.5 ± 3.0 lb and 21 d of age) were used in a 31-d experiment with 11 replicate pens per treatment and 6 or 7 pigs per pen.
[2] Treatment diets were fed in two phases. Phase 1 (d 0 to 7) and Phase 2 (d 7 to 20) diets were fed in pelleted form, whereas diets were in meal form during Phase 3 (d 20 to 31).
[3] Fermented soybean meal 1 (FSBM 1) and fermented soybean meal 2 (FSBM 2) were incorporated at 5% into Phase 1 and 2 diets.
[4] Enzymatically treated soybean meal incorporated at 5% into Phase 1 and 2 diets.
[5] For feed efficiency from d 0 to 7, one outlier pen was removed from the dataset.
[a,b] Within a row, means without a common superscript differ, $P < 0.05$.