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Ethan B. Stas
Kansas State University, Manhattan, ebstas@ksu.edu

Mike D. Tokach
Kansas State University, Manhattan, mtokach@k-state.edu

Joel M. DeRouchey
Kansas State University, Manhattan, jderouch@k-state.edu

See next page for additional authors

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Evaluation of Anchovy Fish Meal with or without Added Fish Solubles Compared to Other Specialty Protein Sources on Nursery Pig Performance[1]

Ethan B. Stas, Mike D. Tokach, Joel M. DeRouchey, Jason C. Woodworth, Robert D. Goodband, and Jordan T. Gebhardt[2]

Summary

A total of 2,172 pigs (L337 × 1050 PIC; initially 11.4 lb) were used to evaluate anchovy fish meal with or without added anchovy fish solubles compared to other specialty protein sources on nursery pig performance in a commercial environment. At weaning, pigs were randomly allotted to 1 of 6 dietary treatments containing 6 different specialty protein sources added on an SID Lys basis. Dietary treatments consisted of diets with: 1) 7.0% enzymatically treated soybean meal (HP 300; Hamlet Protein; Findlay, OH); 2) 3.5% spray-dried bovine plasma (APC Inc, Ankeny, IA); 3) 5.0% microbially enhanced soybean meal (MEPro, Prairie Aquatech, Brookings, SD); 4) 5.2% microbially enhanced soybean meal with added anchovy fish solubles (TASA, Lima, Peru); 5) 4.85% anchovy fish meal (TASA Prime, TASA, Lima, Peru); and 6) 5.1% anchovy fish meal with added fish solubles (TASA Swine, TASA, Lima, Peru). Pigs were fed experimental diets in phases 1 and 2 based on feed budget with phase 1 fed at 5 lb/pig and phase 2 fed at 12 lb/pig. Experimental diets were fed for approximately 21 d after weaning and then all pigs were fed a common corn-soybean meal-based diet until the completion of the study. During the experimental period (d 0 to 21), pigs fed bovine plasma or anchovy fish meal had increased ($P < 0.05$) ADG compared to pigs fed anchovy fish meal with solubles, with pigs fed other treatments intermediate. Pigs fed bovine plasma had improved ($P < 0.05$) F/G compared to pigs fed anchovy fish meal with solubles, with pigs fed other treatments intermediate. Overall (d 0 to 42), a tendency was observed ($P = 0.061$) with pigs fed anchovy fish meal having numerically greater ADG compared to those fed the other treatments. On a per pig placed basis, there was a significant treatment effect ($P = 0.032$) where pigs fed anchovy fish meal had numerically higher ADG compared to the other treatments without significant mean separation. In conclusion, results of this trial indicated that anchovy fish meal as the sole specialty protein source can be utilized in nursery pig diets, but added fish solubles in combination with fish meal requires further investigation.

[1] Appreciation is expressed to TASA (Lima, Peru) for partial financial support of this trial and to New Horizon Farms (Pipestone, MN) for technical support and expertise in conducting this trial.

[2] Department of Diagnostic Medicine/Pathobiology, College of Veterinary Medicine, Kansas State University.

Introduction

Low feed intake is a common issue for newly weaned pigs that can lead to weight loss, morbidity, and mortality. Soybean meal is the predominant protein source used in nursery pig diets but contains antinutritional factors that limit its concentration in diets fed immediately after weaning. Therefore, highly palatable and nutrient dense vegetable or animal proteins are added to nursery diets to meet the pig's amino acid (AA) requirement, encourage feed intake, and promote growth. Fish meal has highly digestible AA, vitamins and minerals, and omega 3 fatty acids, making it a high-quality protein source.

Microbially enhanced or enzymatically treated soybean meal is often used to replace fish meal to lower diet cost. A high-quality fish meal or fish solubles produced from whole fish rather than fish by-products may improve pig performance more than other protein sources, but data are not available to confirm this hypothesis. Therefore, the objective of this study was to evaluate the influence of anchovy fish meal and fish solubles compared to other common specialty protein sources on nursery pig performance in a commercial environment.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocols used in this experiment. The experiment was conducted at a commercial research site owned and operated by New Horizon Farms in Pipestone, MN. Phase 1 diets were manufactured at Hubbard Feeds in Mankato, MN. Phase 2 and 3 diets were manufactured at the New Horizon feed mill located in Pipestone, MN. A sample of anchovy fish meal and fish solubles were submitted for analysis of total volatile nitrogen (TVN) and biogenic amines (Table 3; New Jersey Feed Laboratory, Inc., Trenton, NJ).

Animals and diets

A total of 2,172 pigs (L337 × 1050 PIC; initially 11.4 lb) were used in a 42-d study with 25 or 27 pigs per pen and 14 replications per treatment. Pens were randomly assigned to treatment based on initial body weight and weaning date. Dietary treatments consisted of diets with: 1) 7.0% enzymatically treated soybean meal (HP 300; Hamlet Protein; Findlay, OH); 2) 3.5% spray-dried bovine plasma (APC Inc, Ankeny, IA); 3) 5.0% microbially enhanced soybean meal (MEPro, Prairie Aquatech, Brookings, SD); 4) 5.2% microbially enhanced soybean meal with added anchovy fish solubles (TASA, Lima, Peru); 5) 4.85% anchovy fish meal (TASA Prime, TASA, Lima, Peru); and 6) 5.1% anchovy fish meal with added fish solubles. Anchovy fish solubles were added at 6.5% of microbially enhanced soybean meal and anchovy fish meal for diets 4 and 6, respectively (Tables 1 and 2). All specialty protein sources were added on an SID Lys basis, allowing for similar levels of conventional soybean meal in all diets. Experimental diets were fed in two phases and by feed budget with phase 1 fed at 5 lb/pig and phase 2 fed at 12 lb/pig. Phase 1 diets were pelleted, and phase 2 diets were in meal form. Diets were formulated to contain 1.40 and 1.35% SID Lys for phases 1 and 2, respectively, and met or exceeded other nutrient requirement estimates established by the NRC.[3] Experimental diets were fed for approximately 21 d after weaning. Following experimental diets, all pigs were fed a common corn-soybean meal-based diet until the

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

completion of the study. Pens of pigs were weighed, and feed disappearance was calculated weekly to determine ADG, ADFI, and F/G. Overall growth performance was also calculated on a per pig placed basis by calculating BW, ADG, ADFI, and F/G based on the initial inventory.

Statistical analysis

Data were analyzed as a randomized complete block design for a one-way ANOVA 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 and weaning date serving as the blocking factor and pen as the experimental unit. Block was included in the model as a random effect. Differences between treatments were considered significant at $P \leq 0.05$ and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

Anchovy fish meal was found to contain 128 and 609 ppm of total volatile nitrogen (TVN) and histamine, respectively. Anchovy fish solubles were found to contain 219 and 2,690 ppm of TVN and histamine, respectively. A TVN value of less than 150 ppm is considered an indication of good quality.[4] A histamine level of 1,000 ppm or above indicates poor quality, while a histamine level of 500 ppm or less indicates high quality.[5]

From d 0 to 7 there were no differences between treatments ($P > 0.10$; Table 3). From d 7 to 21, pigs fed anchovy fish meal had increased ($P < 0.05$) ADG compared to pigs fed anchovy fish meal with solubles, with those fed the other treatments intermediate. Pigs fed diets containing microbially enhanced soybean meal or anchovy fish meal had increased ($P < 0.05$) ADFI compared to pigs fed anchovy fish meal with solubles, with those fed other treatments intermediate.

In the overall experimental period (d 0 to 21), pigs fed spray-dried bovine plasma or anchovy fish meal had increased ($P < 0.05$) ADG compared to pigs fed anchovy fish meal with solubles, with pigs fed other treatments intermediate. Pigs fed microbially enhanced soybean meal or anchovy fish meal had increased ($P < 0.05$) ADFI compared to pigs fed anchovy fish meal, with solubles with other treatments intermediate. Pigs fed spray-dried bovine plasma had improved ($P < 0.05$) F/G compared to those fed anchovy fish meal with solubles, with pigs fed the other treatments intermediate. In the common period (d 21 to 42), there were no differences between treatments ($P > 0.10$).

Overall (d 0 to 42), there was a tendency for a treatment effect ($P = 0.061$) for ADG without mean separation; however, pigs fed anchovy fish meal did have numerically greater ADG. Overall (d 0 to 42) on a per pig placed basis, there was a tendency for a treatment effect ($P = 0.058$) for BW and a significant treatment effect ($P = 0.032$) for ADG without significant mean separation. However, pigs fed anchovy fish meal did have numerically greater BW and ADG. Pigs fed anchovy fish meal had increased

[4] Jones, A. M., F. Wu, J. C. Woodworth, M. D. Tokach, R. D. Goodband, J. M. DeRouchey, and S. S. Dritz. 2018. Evaluating the effects of fish meal source and level on growth performance of nursery pigs. Transl. Anim. Sci. 2018.2:144-155. doi:10.1093/tas/txy010.

[5] FAO. 2018. Histamine in Salmonids. Joint Food and Agriculture Organization of the United Nations and World Health Organization. Date accessed. May 6, 2022. Retrieved from: https://www.fao.org/3/CA1207EN/ca1207en.pdf.

($P < 0.05$) ADFI compared to pigs fed anchovy fish meal with solubles, with those fed other treatments intermediate.

In conclusion, the results of this study indicated that feeding pigs anchovy fish meal with solubles decreased growth performance compared to feeding pigs other protein sources. Reasons for decreased performance remain unclear but may be associated with the higher histamine content of the fish solubles used in combination with fish meal. Anchovy fish meal without added solubles improved gain during the experimental period, and microbially enhanced soybean meal with fish solubles was comparable with microbially enhanced soybean meal. Ultimately, anchovy fish meal without the added solubles can be fed as the sole specialty protein source to nursery pigs without impacting growth performance, but feeding pigs the added fish solubles in combination with fish meal requires further investigation.

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

Item	Enzymatically treated SBM[2]	Bovine plasma[2]	Microbially enhanced SBM[2]	Microbially enhanced SBM with solubles[2]	Anchovy fish meal[2]	Anchovy fish meal with solubles[2]
Ingredients, %						
Corn	38.11	41.89	40.01	39.80	41.00	40.76
Soybean meal, 46.5% CP[3]	23.70	23.70	23.70	23.70	23.70	23.70
Whey powder	25.00	25.00	25.00	25.00	25.00	25.00
Enzymatically treated soybean meal	7.00	---	---	---	---	---
Microbially enhanced soybean meal	---	---	5.00	---	---	---
Microbially enhanced soybean meal with solubles	---	---	---	5.21	---	---
Anchovy fish meal	---	---	---	---	4.85	---
Anchovy fish meal with solubles	---	---	---	---	---	5.05
Spray-dried bovine plasma	---	3.50	---	---	---	---
Soybean oil	3.00	3.00	3.00	3.00	3.00	3.00
Limestone	0.81	0.83	0.76	0.76	0.51	0.53
Monocalcium phosphate, 21% P	0.65	0.55	0.78	0.78	0.18	0.20
Salt	0.33	0.13	0.35	0.35	0.30	0.30
L-Lys-HCl	0.35	0.35	0.35	0.35	0.35	0.35
DL-Met	0.23	0.21	0.23	0.23	0.21	0.21
L-Thr	0.15	0.15	0.15	0.15	0.18	0.18
L-Trp	0.02	0.02	0.02	0.02	0.02	0.02
L-Val	0.08	0.10	0.08	0.08	0.13	0.13
Zinc oxide	0.39	0.39	0.39	0.39	0.39	0.39
Vitamin premix	0.05	0.05	0.05	0.05	0.05	0.05
Trace mineral premix	0.08	0.08	0.08	0.08	0.08	0.08
Inorganic selenium	0.05	0.05	0.05	0.05	0.05	0.05
Phytase[4]	0.02	0.02	0.02	0.02	0.02	0.02
Total	100	100	100	100	100	100

continued

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

Item	Enzymatically treated SBM[2]	Bovine plasma[2]	Microbially enhanced SBM[2]	Microbially enhanced SBM with solubles[2]	Anchovy fish meal[2]	Anchovy fish meal with solubles[2]
SID amino acids, %						
Lys	1.40	1.40	1.40	1.40	1.40	1.40
Ile:Lys	62	56	62	61	58	58
Leu:Lys	116	114	119	118	111	111
Met:Lys	36	34	36	36	38	38
Met and Cys:Lys	58	58	58	58	58	58
Thr:Lys	64	64	64	64	64	64
Trp:Lys	19.5	19.3	19.3	19.2	19.3	19.3
Val:Lys	70	70	70	70	70	70
His:Lys	35	35	36	36	35	35
Total Lys, %	1.53	1.54	1.54	1.54	1.55	1.54
NE NRC, kcal/lb	1,189	1,196	1,191	1,191	1,198	1,197
SID Lys:NE, g/Mcal	5.36	5.33	5.35	5.35	5.32	5.32
CP, %	21.9	21.0	21.8	21.8	21.6	21.6
Ca, %	0.76	0.74	0.75	0.75	0.75	0.75
P, %	0.64	0.61	0.63	0.63	0.63	0.63
STTD P, %	0.53	0.53	0.53	0.53	0.53	0.53

[1] Phase 1 diets were fed at 5 lb/pig.

[2] 1) HP 300; Hamlet Protein, Findlay, OH. 2) Spray-dried bovine plasma; APC Corp, Ankeny, IA. 3) ME-PRO; Prairie Aquatech, Brookings, SD. 4) ME-PRO with fish solubles; Prairie Aquatech, Brookings, SD; TASA, Lima, Peru. 5) TASA Prime meal; TASA, Lima, Peru. 6) TASA Swine; TASA, Lima, Peru.

[3] CP = crude protein.

[4] Quantum Blue 5G (ABVista; Plantation, FL) provided an estimated release of 0.12% STTD P with 341 FTU/lb.

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

Item	Enzymatically treated SBM[2]	Bovine plasma[2]	Microbially enhanced SBM[2]	Microbially enhanced SBM with solubles[2]	Anchovy fish meal[2]	Anchovy fish meal with solubles[2]
Ingredients, %						
Corn	53.54	57.32	55.39	55.18	56.41	56.18
Soybean meal, 46.5% CP[3]	24.75	24.75	24.75	24.75	24.75	24.75
Whey powder	10.00	10.00	10.00	10.00	10.00	10.00
Enzymatically treated soybean meal	7.00	---	---	---	---	---
Microbially enhanced soybean meal	---	---	5.00	---	---	---
Microbially enhanced soybean meal with solubles	---	---	---	5.21	---	---
Anchovy fish meal	---	---	---	---	4.85	---
Anchovy fish meal with solubles	---	---	---	---	---	5.05
Spray-dried bovine plasma	---	3.50	---	---	---	---
Choice white grease	1.00	1.00	1.00	1.00	1.00	1.00
Limestone	0.91	0.93	0.88	0.86	0.61	0.63
Monocalcium phosphate, 21% P	0.90	0.80	1.03	1.03	0.40	0.45
Salt	0.55	0.35	0.55	0.55	0.53	0.53
L-Lys-HCl	0.38	0.38	0.38	0.38	0.38	0.38
DL-Met	0.20	0.18	0.20	0.20	0.19	0.19
L-Thr	0.19	0.19	0.19	0.19	0.22	0.22
L-Trp	0.02	0.02	0.03	0.03	0.03	0.03
L-Val	0.06	0.09	0.07	0.07	0.11	0.11
Zinc oxide	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin-trace mineral premix	0.20	0.20	0.20	0.20	0.20	0.20
Phytase[4]	0.06	0.06	0.06	0.06	0.06	0.06
Total	100	100	100	100	100	100

continued

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

Item	Enzymatically treated SBM[2]	Bovine plasma[2]	Microbially enhanced SBM[2]	Microbially enhanced SBM with solubles[2]	Anchovy fish meal[2]	Anchovy fish meal with solubles[2]
SID amino acids, %						
Lys	1.35	1.35	1.35	1.35	1.35	1.35
Ile:Lys	62	55	61	61	58	58
Leu:Lys	120	119	123	123	116	115
Met:Lys	36	33	36	36	38	38
Met and Cys:Lys	58	58	58	58	58	58
Thr:Lys	63	63	63	63	63	63
Trp:Lys	19.4	19.3	19.2	19.2	19.3	19.2
Val:Lys	70	70	70	70	70	70
His:Lys	37	37	38	38	38	38
Total Lys, %	1.49	1.50	1.50	1.50	1.50	1.50
NE NRC, kcal/lb	1,131	1,137	1,133	1,132	1,139	1,139
SID Lys:NE, g/Mcal	5.41	5.39	5.40	5.40	5.37	5.38
CP, %	22.0	21.1	21.9	21.9	21.7	21.7
Ca, %	0.76	0.73	0.76	0.75	0.74	0.75
P, %	0.63	0.61	0.63	0.63	0.62	0.63
STTD P, %	0.51	0.51	0.51	0.51	0.51	0.51

[1] Phase 2 diets were fed at 12 lb/pig.

[2] 1) HP 300; Hamlet Protein, Findlay, OH. 2) Spray-dried bovine plasma; APC Corp, Ankeny, IA. 3) ME-PRO; Prairie Aquatech, Brookings, SD. 4) ME-PRO with fish solubles; Prairie Aquatech, Brookings, SD; TASA, Lima, Peru. 5) TASA Prime meal; TASA, Lima, Peru. 6) TASA Swine; TASA, Lima, Peru.

[3] CP = crude protein.

[4] Optiphos 2000 (Huvepharma; Peachtree City, GA) provided an estimated release of 0.12% STTD P with 545 FTU/lb.

Table 3. Effects of anchovy fish meal with or without added fish solubles compared to other specialty protein sources on nursery pig performance[1]

	Protein source							
	Enzymatically treated SBM[2]	Bovine plasma[2]	Microbially enhanced SBM[2]	Microbially enhanced SBM with solubles[2]	Anchovy fish meal[2]	Anchovy fish meal with solubles[2]	SEM	*P* =
BW, lb								
d 0	11.4	11.4	11.5	11.5	11.4	11.5	0.52	0.984
d 7	12.7	12.9	12.8	12.9	12.7	12.7	0.48	0.936
d 21	21.3	21.8	21.8	21.8	22.0	20.8	0.80	0.132
d 42	42.6	43.0	42.7	43.6	44.1	42.4	1.47	0.469
d 42 per pig placed[3]	33.3	35.5	34.7	35.3	36.3	33.2	1.71	0.058
Day 0 to 7								
ADG, lb	0.19	0.21	0.18	0.19	0.19	0.17	0.032	0.397
ADFI, lb	0.48	0.48	0.47	0.46	0.47	0.46	0.020	0.510
G:F	0.36	0.42	0.38	0.41	0.39	0.36	0.066	0.486
F/G[4]	2.76	2.36	2.65	2.46	2.56	2.79	---	0.486
Day 7 to 21								
ADG, lb	0.56[ab]	0.59[ab]	0.60[ab]	0.59[ab]	0.62[a]	0.53[b]	0.028	0.016
ADFI, lb	0.89[ab]	0.89[ab]	0.96[a]	0.93[ab]	0.94[a]	0.86[b]	0.029	0.004
G:F	0.63	0.66	0.62	0.63	0.65	0.62	0.018	0.289
F/G[4]	1.58	1.52	1.61	1.58	1.54	1.62	---	0.289
Day 0 to 21 (experimental period)								
ADG, lb	0.42[ab]	0.45[a]	0.45[ab]	0.44[ab]	0.46[a]	0.40[b]	0.024	0.004
ADFI, lb	0.74[ab]	0.74[ab]	0.78[a]	0.76[ab]	0.77[a]	0.72[b]	0.022	0.008
G:F	0.57[ab]	0.60[a]	0.57[ab]	0.58[ab]	0.59[ab]	0.56[b]	0.020	0.012
F/G[4]	1.77	1.66	1.76	1.72	1.69	1.80	---	0.012
Day 21 to 42 (common period)								
ADG, lb	0.98	1.00	0.97	1.00	1.03	0.99	0.040	0.342
ADFI, lb	1.46	1.47	1.45	1.48	1.52	1.43	0.056	0.342
G:F	0.67	0.68	0.67	0.67	0.68	0.69	0.008	0.275
F/G[4]	1.49	1.48	1.50	1.48	1.47	1.45	---	0.275

continued

Table 3. Effects of anchovy fish meal with or without added fish solubles compared to other specialty protein sources on nursery pig performance[1]

	Protein source							
	Enzymatically treated SBM[2]	Bovine plasma[2]	Microbially enhanced SBM[2]	Microbially enhanced SBM with solubles[2]	Anchovy fish meal[2]	Anchovy fish meal with solubles[2]	SEM	*P* =
Day 0 to 42 (overall)								
ADG, lb	0.68	0.71	0.69	0.71	0.73	0.68	0.026	0.061
ADFI, lb	1.07	1.09	1.09	1.10	1.12	1.05	0.032	0.135
G:F	0.63	0.65	0.63	0.64	0.65	0.64	0.010	0.160
F/G[4]	1.58	1.54	1.59	1.56	1.54	1.56	---	0.160
Day 0 to 42 (overall) per pig placed								
ADG, lb[5]	0.56	0.61	0.59	0.60	0.63	0.55	0.038	0.032
ADFI, lb[6]	0.93[ab]	0.95[ab]	0.95[ab]	0.95[ab]	0.99[a]	0.89[b]	0.037	0.053
G:F	0.59	0.64	0.62	0.63	0.62	0.60	0.032	0.186
F/G[4]	1.69	1.57	1.62	1.59	1.60	1.66	---	0.186
Day 0 to 42 (overall)								
Removals, %[7]	16.0	11.6	13.8	14.9	13.8	11.9	2.83	0.860
Mortality, %[8]	6.4	3.0	4.4	3.6	3.6	7.4	1.96	0.535
Total mortality, %[9]	11.9	8.3	9.9	8.0	8.6	14.9	---	---
Total rem and mort, %	22.4	14.6	18.2	18.5	17.4	19.3	2.88	0.545

[1] A total of 2,172 pigs (initial BW of 11.4 ± 1.37 lb) were used in a 42-d nursery trial. There were 25 or 27 pigs per pen and 14 replications per treatment. Experimental diets were fed in 2 phases for approximately 21 d. Pigs received a feed budget of 5 and 12 lb/pig for phases 1 and 2, respectively. Following phase 2, all pigs were placed on a common diet for the remainder of the trial.

[2] 1) HP 300; Hamlet Protein, Findlay, OH. 2) Spray-dried bovine plasma; APC Corp, Ankeny, IA. 3) ME-PRO; Prairie Aquatech, Brookings, SD. 4) ME-PRO with fish solubles; Prairie Aquatech, Brookings, SD; TASA, Lima, Peru. 5) TASA Prime meal; TASA, Lima, Peru. 6) TASA Swine; TASA, Lima, Peru.

[3] BW per pig placed = final ending weight ÷ number of pigs placed.

[4] F/G was calculated by taking the inverse of G:F. Statistics were not run on F/G therefore no SEM is reported and *P*-values are the same as reported for G:F.

[5] ADG per pig placed = (final ending weight – initial weight) ÷ (Pigs initially placed × days of trial).

[6] ADFI per pig placed = (total feed intake) ÷ (Pigs initially placed × days of trial).

[7] Percentage of pigs that were removed into a hospital pen.

[8] Percentage of pigs that died/euthanized in original pen.

[9] Percentage of pigs that died/euthanized in original pen or hospital pen after removed. Removed pigs were only followed according to treatment and not pen originally removed from; therefore, no SEM or *P*-values are reported.