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The authors appreciate TASA (Lima, Peru) for partial financial support of this trial.

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Ethan B. Stas, Joel M. DeRouchey, Mike D. Tokach, Jason C. Woodworth, Robert D. Goodband, and Jordan T. Gebhardt²

Summary

A total of 1,134 pigs (L337 × 1050 PIC; initially 10.4 lb) were used to evaluate anchovy fish meal with or without added fish solubles on nursery pig performance in a commercial environment. At weaning, pigs were allotted to 1 of 3 dietary treatments containing three different specialty protein sources added on an SID Lys basis. Dietary treatments consisted of a control diet containing enzymatically treated soybean meal at 7.0% of the diet, a diet containing 5.1% anchovy fish meal, and a diet containing 5.33% anchovy fish meal with added anchovy fish solubles. 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. Following experimental diets, all pigs were fed a common corn-soybean meal-based diet until the completion of the study. There were no differences in growth performance throughout the experimental period (d 0 to 21). During the common period (d 21 to 42), pigs previously fed anchovy fish meal with added fish solubles had improved ($P < 0.05$) feed efficiency compared to pigs fed the control diet, with those fed anchovy fish meal alone intermediate. Overall (d 0 to 42), there was a tendency was observed ($P = 0.070$) where pigs fed anchovy fish meal with added fish solubles had numerically better feed efficiency compared to the other treatments. In conclusion, feeding pigs anchovy fish meal alone resulted in no differences in growth compared to pigs fed diets with enzymatically treated soybean meal, but utilizing anchovy fish meal with added anchovy fish solubles in early nursery diets improved feed efficiency late in the nursery period.

Introduction

Nursery pigs have low feed intake during the first few weeks after weaning which limits their growth. Although soybean meal is the predominant protein source used in nursery pig diets, it contains antinutritional factors that limit the inclusion rate in diets immediately after weaning. Thus, other protein sources are used to meet the amino acid requirements of the pig. These protein sources must be highly digestible and palatable to encourage feed intake. Ideally, they will also provide other benefits, such as improving the omega 6:omega 3 fatty acid ratio or providing other immunological benefits.

¹ The authors appreciate TASA (Lima, Peru) for partial financial support of this trial.

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Traditionally, fish meal has been known as a highly palatable and digestible ingredient for nursery pig diets. In recent years, it has often been replaced with fermented or enzymatically hydrolyzed soybean products to reduce cost or because of variation in quality of fish meal sources. High quality fish meal or additives that provide some of the benefits of fish meal may impact the feed intake and pig performance more than other protein sources, but little data are available to determine the full extent of impact on growth performance. Therefore, the objective of this study is to evaluate anchovy fish meal with or without fish solubles on nursery pig performance in a commercial environment.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The experiment was conducted at a commercial research site owned and operated by New Horizon Farms in Pipestone, MN.³ 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.

Animals and diets

A total of 1,134 pigs (L337 × 1050 PIC; initially 10.4 lb) were used in a 42-d study with 27 pigs per pen and 14 replications per treatment. Pens were randomly assigned to treatment based initial body weight and weaning date. Dietary treatments consisted of 1) control diet containing 7.0% enzymatically treated soybean meal (HP 300; Hamlet Protein; Findlay, OH); 2) diet with 5.1% anchovy fish meal (TASA Prime; TASA; Lima, Peru); and 3) diet with 5.33% anchovy fish meal with added anchovy fish solubles (Tables 1 and 2; TASA Swine; TASA; Lima, Peru). Anchovy fish solubles were added at 7.0% of anchovy fish meal. All three protein sources were included 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 1.35% SID Lys and met or exceeded other nutrient requirement estimates established by the NRC.⁴ Experimental diets were fed for approximately 21 d after weaning. Following experimental diets, all pigs were placed on a common corn-soybean meal-based diet until the completion of the study. Pens of pigs were weighed, and feed disappearance was calculated weekly from d 7 to 42 to determine ADG, ADFI, and F/G.

Economic analysis

For the economic analysis, total feed cost per pig, feed cost per lb of gain, revenue, and income over feed cost (IOFC) were calculated for high and low ingredient prices and market pig price. Feed cost per pig placed was determined by multiplying total feed intake by diet cost. Feed cost per lb of gain was calculated by dividing the total feed cost per pig by the total weight gained. Revenue per pig placed was determined by multiplying total gain by the dressing percentage (0.75) multiplied by carcass price to convert to a live price. Income over feed cost was calculated using revenue per pig placed minus feed cost per pig placed. For high ingredient price scenarios, the following prices were used: corn \$6.00/bushel (\$214/ton); soybean meal = \$400/ton; L-Lys HCl = \$0.80/

³ The authors appreciate New Horizon Farms (Pipestone, MN) for providing technical support and expertise in conducting this trial.

⁴ National Research Council. 2012. Nutrient Requirements of Swine: Eleventh Revised Edition. Washington, DC: The National Academies Press. <https://doi.org/10.17226/13298>.

lb; liquid Lys = \$0.80/lb; DL-Met = \$2.50/lb; L-Thr = \$1.20/lb; Thr Pro = \$0.80/lb; L-Trp = \$5.00/lb; L-Val = \$4.00/lb; enzymatically treated soybean meal = \$0.50/lb; fish meal = \$0.78/lb; fish meal with solubles = \$0.83/lb. For low ingredient price scenarios, the following prices were used: corn = \$3.00/bushel (\$107/ton); soybean meal = \$300/ton; L-Lys HCl = \$0.65/lb; liquid Lys = \$0.80/lb; DL-Met = \$1.70/lb; L-Thr = \$0.85/lb; Thr Pro = \$0.80/lb; L-Trp = \$3.00/lb; L-Val = \$2.50/lb; enzymatically treated soybean meal = \$0.50/lb; fish meal = \$0.78/lb; fish meal with solubles = \$0.83/lb.

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 factors 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

No in-feed medication was provided to the pigs during any of the feeding phases. However, due to health challenges throughout the study, all pigs were administered water medications at various time points during the study (Table 3).

During the experimental period (d 0 to 21), there were no significant differences in growth performance between treatments ($P > 0.10$; Table 4). During the common period (d 21 to 42), pigs previously fed anchovy fish meal with added fish solubles had improved ($P < 0.05$) feed efficiency compared to pigs previously fed the control diet, with pigs fed anchovy fish meal without solubles intermediate. Overall (d 0 to 42), there was a tendency was observed ($P = 0.070$) in which pigs fed anchovy fish meal with added fish solubles had numerically better feed efficiency compared to the other treatments. There were no differences between treatments for overall growth performance on a per pig placed basis, for removal and mortalities, or for economics ($P > 0.10$).

In conclusion, feeding pigs anchovy fish meal with or without added anchovy fish solubles resulted in no differences in growth performance during the experimental period compared with enzymatically treated soybean meal. However, feeding pigs anchovy fish meal with added fish solubles improved feed efficiency when pigs were placed on a common diet. Anchovy fish meal with added fish solubles also numerically improved the feed efficiency overall. In addition, with the current ingredient prices, fish meal with or without added solubles did not affect any economic criteria. This study suggests that anchovy fish meal with or without added fish solubles can be considered a suitable replacement for enzymatically treated soybean meal in early nursery diets.

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

Item	Control	Fish meal	Fish meal with solubles
Ingredients, %			
Corn	40.23	42.93	42.68
Soybean meal, 46.8% CP ²	23.50	23.50	23.50
Granular whey permeate ³	20.00	20.00	20.00
Enzymatically treated soybean meal ⁴	7.00	---	---
Anchovy fish meal ⁵	---	5.10	---
Anchovy fish meal with solubles ⁶	---	---	5.33
Microbially enhanced soybean meal ⁷	2.50	2.50	2.50
Soybean oil	3.00	3.00	3.00
Limestone	0.78	0.48	0.48
Monocalcium phosphate, 21.5% P	1.20	0.70	0.73
Salt	0.30	0.25	0.25
L-Lys	0.38	0.38	0.38
DL-Met	0.24	0.22	0.22
L-Thr	0.20	0.23	0.23
L-Trp	0.02	0.03	0.03
L-Val	0.08	0.13	0.13
Zinc oxide	0.39	0.39	0.39
Vitamin premix	0.05	0.05	0.05
Trace mineral premix	0.08	0.08	0.08
Inorganic Se	0.05	0.05	0.05
Phytase ⁸	0.02	0.02	0.02
Total	100	100	100

continued

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

Item	Control	Fish meal	Fish meal with solubles
SID amino acids, %			
Lys	1.35	1.35	1.35
Ile:Lys	61	57	57
Leu:Lys	115	111	111
Met:Lys	38	39	39
Met and Cys:Lys	58	58	58
Thr:Lys	65	66	66
Trp:Lys	20.3	20.3	20.3
Val:Lys	70	71	71
His:Lys	36	37	37
Total Lys, %	1.49	1.51	1.51
NE, kcal/lb	1,201	1,210	1,209
SID Lys:NE, g/Mcal	5.10	5.06	5.06
CP, %	21.5	21.4	21.4
Ca, %	0.69	0.68	0.68
P, %	0.66	0.66	0.66
STTD P, %	0.54	0.54	0.54

¹Phase 1 diets were fed at 5 lb/pig.

²CP = crude protein.

³Dairylac 80, International Ingredients Corporation; Fenton, MO.

⁴HP 300; Hamlet Protein; Findlay, OH.

⁵TASA Prime; TASA; Lima, Peru.

⁶TASA Swine; TASA; Lima, Peru. Anchovy fish solubles were added at 7% of the anchovy fish meal.

⁷MEPro; Prairie Aquatech; Brookings, SD.

⁸Quantum Blue 5G (ABVista, Plantation, FL) which provided an estimated release of 0.12% STTD P with 341 FTU/lb.

Table 2. Phase 2 and 3 diet composition (as-fed basis)¹

Item	Control	Fish meal	Fish meal with solubles	Common phase 3 diet²
Ingredients, %				
Corn	54.55	57.19	57.19	57.45
Soybean meal, 46.8% CP ³	25.00	25.00	25.00	29.05
Dried distillers grains	---	---	---	10.00
Granular whey permeate ⁴	8.25	8.25	8.25	---
Enzymatically treated soybean meal ⁵	7.00	---	---	---
Anchovy fish meal ⁶	---	5.10	---	---
Anchovy fish meal with solubles ⁷	---	---	5.33	---
Choice white grease	1.00	1.00	1.00	---
Limestone	0.80	0.48	0.48	1.22
Monocalcium phosphate, 21.5% P	1.18	0.65	0.65	0.50
Salt	0.68	0.50	0.50	0.60
Liquid Lys, 55% ⁸	0.65	0.65	0.65	0.68
DL-Met	0.22	0.21	0.21	0.12
Thr Pro	0.25	0.28	0.28	0.18
L-Trp	0.04	0.05	0.05	0.03
L-Val	0.10	0.15	0.15	---
Zinc oxide	0.25	0.25	0.25	---
Vitamin-trace mineral premix	0.20	0.20	0.20	0.11
Phytase ⁹	0.05	0.05	0.05	0.03
Copper chloride	---	---	---	0.03
Total	100	100	100	100

continued

Table 2. Phase 2 and 3 diet composition (as-fed basis)¹

Item	Control	Fish meal	Fish meal with solubles	Common phase 3 diet ²
SID amino acids, %				
Lys	1.35	1.35	1.35	1.30
Ile:Lys	58	54	54	60
Leu:Lys	115	111	111	131
Met:Lys	37	39	39	33
Met and Cys:Lys	58	59	59	56
Thr:Lys	63	64	64	65
Trp:Lys	20.2	20.4	20.4	19.2
Val:Lys	70	71	71	66
His:Lys	36	36	36	40
Total Lys, %	1.49	1.50	1.50	1.47
NE, kcal/lb	1,136	1,144	1,144	1,091
SID Lys:NE, g/Mcal	5.39	5.06	5.06	5.41
CP, %	21.4	21.2	21.2	22.3
Ca, %	0.67	0.67	0.67	0.70
P, %	0.65	0.65	0.65	0.53
STTD P, %	0.52	0.52	0.52	0.39

¹Phase 2 diets were fed at 12 lb/pig.

²Following experimental diets, all pigs were placed on a common phase 3 diet for the remainder of the trial.

³CP = crude protein.

⁴Dairylac 80, International Ingredients Corporation; Fenton, MO.

⁵HP 300; Hamlet Protein; Findlay, OH.

⁶TASA Prime; TASA; Lima, Peru.

⁷TASA Swine; TASA; Lima, Peru. Anchovy fish solubles were added at 7% of the anchovy fish meal.

⁸CJ America; Los Angeles, CA.

⁹Optiphos Plus 2500 G (Huvepharma Inc.; Peachtree City, GA) which provided an estimated release of 0.13% STTD P with 567 FTU/lb.

Table 3. Water medication administration¹

Medication	Days of administration	Amount administered/pig
<i>Escherichia coli</i> vaccine	0	1 mL
Buffered electrolytes ²	0 to 10	0.30 oz
Amoxicillin ³	3 to 10	0.40 g
Gentamicin ⁴	3 to 10	0.24 g
Penicillin ⁵	11 to 28	0.07 oz
Aspirin ⁶	11 to 35	0.21 oz

¹Water medications were administered to all pigs.

²Sky-Lytes; Skylar Nutrition; Rushville, IL.

³Veterinary Pharmaceutical Solutions; St. Peter, MN.

⁴Gen-Gard; Huvepharma; Peachtree City, GA.

⁵R-Pen; Huvepharma; Peachtree City, GA.

⁶Oral-Pro; Aurora Pharmaceutical; Northfield, MN.

Table 4. Effects of anchovy fish meal with or without added fish solubles on nursery pig performance¹

	Control ²	Fish meal ³	Fish meal with solubles ⁴	SEM	P =
BW, lb					
d 0	10.4	10.4	10.4	0.37	0.983
d 7	10.7	10.8	10.7	0.41	0.554
d 21	17.8	17.8	17.7	0.67	0.953
d 42	33.3	33.4	33.4	1.19	0.999
d 42 per pig placed ⁵	25.9	26.9	26.2	1.51	0.837
Day 0 to 7					
ADG, lb	0.04	0.06	0.04	0.012	0.218
ADFI, lb	0.30	0.29	0.28	0.009	0.343
G:F	0.13	0.19	0.14	0.038	0.238
F/G ⁶	7.63	5.21	7.19	---	0.238
Day 7 to 21					
ADG, lb	0.47	0.46	0.46	0.025	0.887
ADFI, lb	0.69	0.68	0.65	0.020	0.211
G:F	0.68	0.68	0.71	0.024	0.401
F/G ⁶	1.47	1.48	1.42	---	0.401
Day 0 to 21					
ADG, lb	0.31	0.32	0.31	0.019	0.793
ADFI, lb	0.54	0.54	0.52	0.014	0.114
G:F	0.56	0.58	0.59	0.026	0.471
F/G ⁶	1.77	1.72	1.70	---	0.471
Day 21 to 42					
ADG, lb	0.71	0.72	0.73	0.030	0.716
ADFI, lb	1.11	1.11	1.09	0.038	0.803
G:F	0.64 ^b	0.65 ^{ab}	0.67 ^a	0.011	0.031
F/G ⁶	1.57 ^b	1.55 ^{ab}	1.49 ^a	---	0.031
Day 0 to 42 (overall)					
ADG, lb	0.50	0.50	0.50	0.024	0.929
ADFI, lb	0.81	0.81	0.78	0.024	0.344
G:F	0.61	0.62	0.64	0.014	0.070
F/G ⁶	1.64	1.61	1.56	---	0.070

continued

Table 4. Effects of anchovy fish meal with or without added fish solubles on nursery pig performance¹

	Control ²	Fish meal ³	Fish meal with solubles ⁴	SEM	<i>P</i> =
Day 0 to 42 (overall) per pig placed					
ADG, lb	0.39	0.39	0.38	0.030	0.832
ADFI, lb	0.72	0.70	0.67	0.029	0.461
G:F	0.53	0.55	0.56	0.024	0.230
F/G ⁶	1.90	1.83	1.79	---	0.230
Day 0 to 42 (overall)					
Removals, % ¹⁰	16.4	15.1	16.1	2.74	0.899
Mortality, % ¹¹	4.2	3.4	5.0	2.52	0.664
Total mortality, % ¹²	10.8	7.9	8.5	2.50	0.703
Total rem and mort, %	20.6	18.5	21.2	2.44	0.703
Economics, \$/pig placed					
Low price scenario ¹³					
Feed cost	5.89	6.10	5.87	0.237	0.520
Feed cost/lb of gain ¹⁴	0.42	0.39	0.39	0.023	0.305
Revenue ¹⁵	6.97	7.29	7.14	0.563	0.832
IOFC ¹⁶	1.08	1.19	1.26	0.347	0.856
High price scenario ¹⁷					
Feed cost	6.76	7.00	6.78	0.237	0.465
Feed cost/lb of gain ¹⁴	0.48	0.45	0.45	0.029	0.351
Revenue ¹⁸	10.23	10.69	10.47	0.825	0.832
IOFC ¹⁶	3.47	3.69	3.69	0.606	0.903

¹ A total of 1,134 pigs (initial BW of 10.4 ± 0.37 lb) were used in a 42-d nursery trial. There was a total of 3 dietary treatments consisting of a control diet, an anchovy fish meal diet, and an anchovy fish meal with added fish solubles diet. There were 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 The control diet was a standard corn soybean meal-based diet with enzymatically treated soybean meal (HP 300, Hamlet Protein; Findlay, OH) as the specialty protein source.

³ TASA Prime meal, TASA; Lima, Peru.

⁴ TASA Swine, TASA; Lima, Peru.

⁵ BW per pig placed = final ending weight ÷ number of pigs placed.

⁶ F/G was calculated from G:F by taking the inverse, therefore the *P*-values are the same and there are no reported SEM.

⁷ Approximate feeding period of experimental diets.

⁸ ADG per pig placed = (final ending weight – initial weight) ÷ (pigs initially placed × days of trial).

⁹ ADFI per pig placed = (total feed intake) ÷ (pigs initially placed × days of trial).

¹⁰ Percentage of pigs that were removed into a hospital pen.

¹¹ Percentage of pigs that died/euthanized in original pen.

¹² Percentage of pigs that died/euthanized in original pen or hospital pen after being removed.

¹³ Total feed cost per ton were calculated: Phase 1) control = \$377.07; fish meal = \$388.98; fish meal with solubles = \$394.08. Phase 2) control = \$290.11; fish meal = \$302.88; fish meal with solubles = \$307.98.

¹⁴ Feed cost/lb of gain = total feed cost ÷ total gain per pen.

¹⁵ Revenue = (total gain/pig placed × 0.75) × \$0.60.

¹⁶ Income over feed cost = revenue – feed cost.

¹⁷ Total feed cost per ton were calculated: Phase 1) control = \$471.54; fish meal = \$487.58; fish meal with solubles = \$492.68. Phase 2) control = \$395.64; fish meal = \$412.76; fish meal with solubles = \$417.86.

¹⁸ Revenue = (total gain/pig placed × 0.75) × \$0.88.