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Evaluating the Effects of Fish Solubles on Nursery Pig Performance

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Summary

A total of 700 barrows (Line 200 × 400, DNA, Columbus, NE; initially 14.3 lb) were used in a 21-d growth trial with 5 pigs per pen and 28 pens per treatment. Pigs were weaned at approximately 21 d of age, placed in nursery pens according to BW and fed a common pelleted starter diet for 3 d. Pigs were then weighed and pens were blocked by BW to 1 of 5 dietary treatments in a randomized complete block design. Dietary treatments included a corn-soybean meal-based control diet and 4 diets containing 6% LT Prime Menhaden Fishmeal (Daybrook Fisheries Inc., New Orleans, LA). One batch of fish meal contained 0.87% fish solubles and the second batch contained 24.35% solubles. The 2 batches were then blended to provide dietary treatments with 0.87, 8.70, 16.52, and 24.35% fish solubles. A composite sample from each batch of fish meal was collected and analyzed for AA content and proximate analysis prior to formulation to determine nutrient loading values. Dietary treatments contained 10% spray-dried whey and were formulated to contain 1.35% standardized ileal digestible Lys, and were balanced on an NE basis. Overall (d 0 to 21), pigs fed diets with fish meal had increased ($P < 0.05$) ADG and ADFI compared to pigs fed the soybean meal-based control diet. There was no evidence for differences in growth performance with increasing fish solubles. In conclusion, the amount of fish solubles in the whole fish meal do not appear to influence nursery pig growth performance.

Introduction

To encourage feed intake for newly weaned pigs, highly palatable and nutrient dense protein sources, such as fish meal, are commonly added to nursery diets. Fish meal is typically considered a very good protein source due to its balance of AA, vitamins and minerals, and presence of omega 3 fatty acids.[3,4] However, the quality of fish meal used

[1] Appreciation is expressed to Scott Herbert, Jason Smith, and Dalton Berry, Daybrook Fisheries Inc., New Orleans, LA, for their technical support and to Daybrook Fisheries, Inc., New Orleans, LA, for their donation of LT Prime Menhaden Fishmeal for the use of this study.

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[3] Church, D. C., and R. O. Kellems. 1998. Supplemental protein sources. In: R. O. Kellems and D. C. Church, editors, Livestock Feed and Feeding. Prentice Hall, Upper Saddle River, NJ.

[4] Li, Q., J. H. Brendemuhl, K. C. Jeong, and L. Badinga. 2014. Effects of omega-3 polyunsaturated fatty acids on growth and immune response of weanling pigs. J. Anim. Sci. Technol. 56:7. doi: 10.1186/2055-0391-56-7.

can vary considerably based on the species of fish, the freshness of the raw material, and the processing of fish meal among others.[5] Because of these factors, growth responses to fish meal have varied.[6,7,8]

While the most likely explanation for these inconsistencies is a combination of the factors previously mentioned, it is unclear what role, if any, fish solubles may play. Fish solubles (sometimes known as stickwater concentrate) are a by-product derived from the intermediate fraction (liquid phase) during the manufacturing process of fish meal.[9] Several studies examining the chemical and nutritional properties indicated that fish solubles contained various water soluble and insoluble molecules that were rich sources of B vitamins, minerals, and AA.[10] Fish meal commonly produced and sold today on average contains 8 to 15% fish solubles included in the final product.[11] It is unclear if the amount of fish solubles contained within fish meal will influence growth performance of pigs. Therefore, the objective of our study was to evaluate the growth performance of nursery pigs fed fish meal with increasing amounts of fish solubles.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol for this experiment. The studies were conducted at the K-State Segregated Early Weaning facilities (Manhattan, KS). The facility is totally enclosed, environmentally controlled, and mechanically ventilated. Each pen (3.9 × 4.0 ft) had metal tri-bar flooring and was equipped with a 4-hole, stainless-steel, dry self-feeder, and a cup waterer for ad libitum access to feed and water.

Two groups of 350 maternal line barrows (700 total; Line 200 × 400 DNA, Columbus, NE; initially 14.3 lb) were used in a 21-d growth trial with 5 pigs per pen and 14 pens per treatment in each group (28 total pens per treatment). Pigs were weaned at approximately 21 d of age, placed in nursery pens according to BW and fed a common pelleted starter diet for 3 d, at which time pigs were weighed and pens were blocked by BW to 1 of 5 dietary treatments in a randomized complete block design. Dietary treatments (Table 2) included a corn-soybean meal-based control diet and 4 diets containing 6% LT Prime Menhaden Fishmeal (Daybrook Fisheries Inc., New Orleans, LA).

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[5] Pike, I. H., G. Andorsdóttir, and H. Mundheim. 1990. The role of fish meal in diets for salmonids. In: 1990 Inter. Assoc. Fish Meal Manuf. No. 24. p. 1-41.

[6] Bergström, J. R., J. L. Nelssen, M. D. Tokach, R. D. Goodband, S. S. Dritz, K. Q. Owen, and W. B. Nessmith, Jr. 1997. Evaluation of spray-dried animal plasma and select menhaden fish meal in transition diets of pigs weaned at 12 to 14 days of age and reared in different production systems. J. Anim. Sci. 75:3004-3009. doi:10.2527/1997.75113004x.

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[9] Wu, T. H. and P. J. Bechtel. 2012. Screening for low molecular weight compounds in fish meal solubles by hydrophilic interaction liquid chromatography coupled to mass spectrometry. Food Chem. 130:739-745. doi:10.1016/j.foodchem.2011.05.088.

[10] Soares, J., D. Miller, S. Cuppet, and P. Baursfeld. In: 1973 Fishery Bulletin Vol. 71 No. 1. p. 255-265.

[11] Herbert, S., and J. Smith. 2016. Personal Communication.

Two batches of fish meal were used for this experiment, one batch contained 0.87% solubles and the second batch contained 24.35% solubles. A composite sample from each batch of fish meal was collected and analyzed for AA content and proximate analysis prior to formulation to determine nutrient loading values (Table 1). Then, basal diets containing the 0.87% and 24.35% solubles fish meal were manufactured and then blended to create the intermediate diets (Table 2). Diets were formulated to contain 1.35% SID Lys and balanced on an NE basis. All diets were fed in meal form and prepared at the Kansas State University O.H. Kruse Feed Technology and Innovation Center, Manhattan, KS. Pigs and feeders were weighed weekly to determine ADG, ADFI, and F/G.

Complete diet samples were obtained from feeders, composited, and frozen at -4°F for subsequent analysis. Composite samples of diets and fish meal were split using a riffle splitter (Humboldt Mfg. Co., Norridge, IL) and processed through a 1 mm screen in a Wiley Mill (Thomas Scientific, Swedesboro, NJ) prior to analysis. All samples of diets and protein sources were submitted (Ward Laboratories Inc., Kearney, NE) for analysis of DM, CP, ether extract, Ca, P, and ash. Fish meal samples were also analyzed for their complete AA profile (University of Missouri-Columbia College of Agriculture Experiment Station Chemical Laboratories, Columbia, MO). In addition, fish meal samples were submitted to New Jersey Feed Laboratories, Inc., (Trenton, NJ) for analysis of modified Torry digestibility, pepsin digestibility, total volatile N analysis, and biogenic amines. Furthermore, because the two groups of pigs were not started on test concurrently or immediately after one another, an additional sample from the original batches of fish meal was collected and analyzed for biogenic amines prior to the manufacturing of diets for group 2 (Table 3). Both batches of fish meal were stored in 50-lb bags and placed in the O.H. Kruse Feed Technology and Innovation Center warehouse, not environmentally regulated and subject to fluctuations in temperature and humidity based on weather conditions.

Data were analyzed using the PROC GLIMMIX procedure in SAS version 9.4 (SAS Institute, Inc., Cary, NC) with pen as the experimental unit, dietary treatment as a fixed effect, and block serving as the random effect in the model. Preplanned linear and quadratic contrasts were used to determine effects of increasing fish solubles, and a single degree of freedom contrast was used to compare pigs fed the soybean meal control diet and the mean of those fed fish meal on performance criteria. Results were considered significant at $P \leq 0.05$ and marginally significant between $P > 0.05$ and $P \leq 0.10$.

Results and Discussion

The low and high soluble fish meals were high quality as indicated by the total volatile N concentration and modified Torry digestibility (Table 1). These tests are designed as indicators of the degrees of freshness of the raw fish used in the manufacturing process and protein quality of the finished product, respectively. The total volatile N analysis measures free N, which is an indication of volatilization of crude protein.[12] A value less than 0.15% indicates that the fish meal is of good quality. The modified Torry digestibility is calculated as a portion of acid insoluble N that is soluble in acid pepsin solu-

[12] Kjeldsen, N. J., V. Daniel- A. Just, H. E. Nielsen and B. O. Eggum. 1983. Inclusion of fish meal manufactured from fish with different degrees of freshness in diets for early weaned pigs. Natl. Inst. Anim. Sci., Copenhagen Newsletter No. 390.

tion, thus, correcting the amount of protein that is digestible by eliminating the water and fish soluble protein.[13] Digestibility values (Table 1) were above 80% indicating the quality of protein was very good.[10] Biogenic amine concentrations (Table 3) were lower in the low soluble fish meal compared to the high soluble fish meal; however, these values did not change significantly during the extended storage period (5 months) between the groups of pigs that were used for the feeding trials. Thus, this would suggest that the product was stable, as biogenic amines are produced as result of the degradation of AA via bacterial AA decarboxylases over time.[14] Dietary analysis indicated that most nutrients were similar to formulated values (Table 4).

Overall (d 0 to 21), there was no evidence for differences observed for ADG, ADFI, F/G, or final BW as the amount of solubles in the fishmeal increased. However, ADG, and ADFI of the mean of pigs fed fish meal, were greater ($P < 0.001$) compared with pigs fed the corn-soybean meal control diet. There was no evidence for difference detected for F/G among dietary treatments.

In conclusion, ours is the first study to our knowledge to determine the influence of increasing fish solubles contained within fish meal on growth performance of pigs. Based on our findings, both batches of fish meal we tested were of high quality as indicated by the total volatile N analyses and modified Torry digestibility values. Increasing fish solubles included in whole fish meal had no significant influence on growth performance. Thus, our results would suggest that the inconsistencies observed within the literature pertaining to growth responses when feeding fish meal to nursery pigs is not a reflection of the amount of fish solubles in whole fish meal.

[13] Bimbo, A. P. 1998. An evaluation of pepsin digestibility method as practiced and interpreted by IFOMA and associated laboratories. In: Int. Fishmeal & Oil Mfr. Assoc. London, UK.
[14] Opstvedt, J., H. Mundheim, and H. Nygaard. 1996. Freshness of fish used in making fish meal for salmonids and the effects of biogenic amines. In: Int. Fishmeal & Oil Mfr. Assoc. London, UK.

Table 1. Chemical analysis of fish meal (as-fed basis)[1,2]

Item	0.87% Soluble fish meal	24.35% Soluble fish meal
Proximate analysis, %		
DM[3]	92.60	93.01
CP[3]	66.05	63.25
Ca[3]	7.07	5.17
P[3]	3.30	2.61
Ether extract[3]	6.95	10.61
Ash[3]	19.23	19.11
Total volatile N[4]	0.07	0.06
Modified Torry digestibility[4]	86.4	92.4
Total AA, %[5]		
Arg	4.16	3.69
Cys	0.60	0.48
His	1.62	1.51
Ile	2.96	2.52
Leu	4.96	4.28
Lys	5.53	4.82
Met	1.95	1.68
Thr	2.78	2.40
Trp	0.76	0.61
Tyr	2.29	1.79
Val	3.50	3.09

[1] Samples of fish meal were obtained prior to diet manufacturing.

[2] LT Prime Menhaden Fishmeal (Daybrook Fisheries Inc., New Orleans, LA).

[3] Ward Laboratories, Inc., Kearney, NE.

[4] New Jersey Feed Laboratory, Trenton, NJ.

[5] Amino acid analysis for protein sources was analyzed by the University of Missouri-Columbia College of Agriculture, Food and Natural Resources – Agriculture Experiment Station Chemical Laboratories, Columbia, MO.

Table 2. Diet composition (as-fed basis)[1,2]

		Soluble fractions, %	
Ingredient, %	Control	0.87	24.35
Corn	40.31	48.65	48.33
Soybean meal, 46.5% CP	32.77	21.35	21.35
Corn DDGS[3]	10.00	10.00	10.00
Spray-dried whey	10.00	10.00	10.00
Fish meal[4]	---	6.00	6.00
Choice white grease	3.00	1.45	1.25
Limestone	1.07	0.42	0.62
Monocalcium P, 21% P	1.05	0.25	0.45
Sodium chloride	0.50	0.50	0.50
L-Lys HCl	0.35	0.35	0.39
DL-Met	0.15	0.14	0.16
L-Thr	0.11	0.14	0.17
L-Trp	---	0.03	0.04
L-Val	0.03	0.06	0.08
Phytase[5]	0.02	0.02	0.02
Zinc oxide	0.25	0.25	0.25
Trace mineral premix	0.15	0.15	0.15
Vitamin premix	0.25	0.25	0.25
Total	100	100	100

continued

Table 2, *continued*. Diet composition (as-fed basis)[1,2]

		Soluble fractions, %	
Ingredient, %	Control	0.87	24.35
Calculated analysis			
Standardized ileal digestible (SID) amino acids, %			
Lys	1.35	1.35	1.35
Ile:Lys	64	60	58
Leu:Lys	131	127	124
Met:Lys	35	37	38
Met and Cys:Lys	58	58	58
Thr:Lys	63	63	63
Trp:Lys	18.5	18.5	18.5
Val:Lys	71	71	71
ME, kcal/lb	1,543	1,529	1,532
NE, kcal/lb	1,135	1,135	1,135
CP, %	23.4	22.7	22.6
Ca, %	0.78	0.78	0.78
P, %	0.69	0.66	0.66
Available P, %	0.51	0.51	0.51

[1] Diets were fed for 21 d.

[2] Treatments 0.87% solubles and 24.35% solubles were manufactured and then blended at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS, to create intermediate levels of 8.70% and 16.52% solubles.

[3] Dried distillers grain with solubles.

[4] LT Prime Menhaden Fishmeal (Daybrook Fisheries Inc., New Orleans, LA).

[5] Ronozyme HiPhos 2700 (DSM Nutritional Products, Parsippany, NJ) provided 216 phytase units (FTU/lb) of diet with a release of 0.10% available P.

Table 3. Biogenic amines concentrations of fish meal (as-fed basis)[1,2]

Item, ppm	0.87% Soluble fish meal	24.35% Soluble fish meal
Group 1		
Tyramine	6	130
Putrescine	11	135
Cadaverine	38	508
Histamine	4	134
Agmatine	28	181
Spermidine	24	42
Spermine	4	21
Group 2[3]		
Tyramine	16	129
Putrescine	16	133
Cadaverine	52	483
Histamine	2	103
Agmatine	33	170
Spermidine	36	48
Spermine	21	14

[1] Samples of fish meal were obtained at the mill during diet manufacturing, composited, and submitted to New Jersey Feed Laboratory (Trenton, NJ) for analysis.

[2] LT Prime Menhaden Fishmeal (Daybrook Fisheries Inc., New Orleans, LA).

[3] A sample from both batches of fish meal were collected 5 months after pigs in group 1 were placed on test and when pigs in group 2 were placed on test, to determine how stable the fish meal was during storage.

Table 4. Chemical analysis of diets (as-fed basis)[1,2]

		Soluble fractions, %[3,4]			
Item, %	Control[2]	0.87	8.70	16.52	24.35
DM	89.04	88.94	89.30	89.64	89.56
CP	22.7	22.6	21.6	22.6	22.3
Ca	1.15	0.82	0.77	0.93	0.81
P	0.81	0.72	0.70	0.78	0.77
Ether extract	4.7	4.2	4.2	4.8	4.8
Ash	6.50	5.62	5.59	6.02	5.86

[1] Complete diets were sampled at the feeder, pooled, mixed, and then split using a riffle splitter to create a composite sample, and submitted to Ward Laboratories (Kearney, NE) for analysis.

[2] The control diet contained no fish meal.

[3] Treatments 0.87% and 24.35% solubles were manufactured and blended at Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS, to create the intermediate levels of 8.70% and 16.52% solubles.

[4] LT Prime Menhaden Fishmeal (Daybrook Fisheries Inc., New Orleans, LA).

Table 5. Effects of varying levels of fish solubles added back into fish meal on nursery pig performance[1,2,3]

							Probability, $P <$		
		Soluble fractions, %					Control vs.	Soluble fractions	
	Control	0.87	8.70	16.52	24.35	SEM	fish meal	Linear	Quadratic
BW, lb									
d 0	14.3	14.3	14.3	14.3	14.3	0.60	0.568	0.914	0.180
d 21	28.0	29.2	28.8	29.4	29.4	0.32	<0.001	0.349	0.558
d 0 to 21									
ADG, lb	0.65	0.71	0.68	0.71	0.71	0.033	0.001	0.704	0.395
ADFI, lb	0.91	0.97	0.95	0.99	0.99	0.031	0.001	0.282	0.424
F/G	1.41	1.38	1.40	1.39	1.40	0.027	0.277	0.359	0.630

[1] A total of 700 maternal line barrows (200 × 400 DNA, Columbus, NE; initially 14.3 lb) with 5 pigs per pen and 28 pens per treatment were used in 21-d growth trial.

[2] The control diet contained no fishmeal.

[3] Two batches of LT Prime Menhaden Fishmeal (Daybrook Fisheries Inc., New Orleans, LA) were manufactured with 0.87 and 24.35% soluble fractions and used to manufacture diets that were also blended at the Kansas State University O.H. Kruse Feed Technology Innovation Center, Manhattan, KS, to create intermediate diets with 8.70 and 16.52% solubles within the fish meal. All treatment diets contained 6% fishmeal.