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# The effects of poultry meal source and ash level on nursery pig performance<sup>1</sup>

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**ABSTRACT:** Weanling pigs (total of 560) were used in two experiments to determine the effects of poultry meal in nursery diets on pig performance. In Exp. 1, 210 barrows and gilts (initially 7.4 kg and 21 ± 2 d of age) were fed one of five diets, which included a control diet with no specialty protein products or (as-fed basis) the control with 2.5 or 5.0% fish meal, or 2.9 or 5.9% poultry meal (11.8% ash). Poultry meal replaced fish meal on an equal lysine basis. Overall (d 0 to 28), pigs fed diets containing fish meal had greater ( $P < 0.01$ ) ADG than pigs fed poultry meal. Increasing fish meal tended to have increased (quadratic,  $P < 0.07$ ) ADG, with the greatest improvement observed in pigs fed the diet containing 2.5% fish meal. Pigs fed diets containing fish meal had improved ( $P < 0.01$ ) G:F compared with pigs fed diets containing poultry meal. In Exp. 2, a total of 350 barrows

and gilts (initially 8.9 kg and 22 ± 2 d of age) were fed one of seven experimental diets, which included a control diet with no specialty protein products, or the control with 2.5 or 5.0% fish meal, 2.9 or 5.8% low-ash (10.9%) poultry meal, and 3.1 or 6.2% high-ash (13.5%) poultry meal. Poultry meal replaced fish meal on an equal lysine basis. Overall (d 0 to 15), there were no differences in ADG and ADFI ( $P = 0.14$ ); however, pigs fed diets containing fish meal or poultry meal had improved (linear,  $P < 0.01$ ) G:F compared with pigs fed the control diet. Pigs fed diets containing low-ash poultry meal had greater ( $P < 0.01$ ) G:F compared with pigs fed diets containing high-ash poultry meal. Based on these data, quality control specifications, such as ash content, need to be considered when using poultry meal as an animal protein replacement in diets for nursery pigs.

Key Words: Fish meal, Growth, Nursery Pigs, Poultry Byproduct, Protein Source

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## Introduction

The use of complex nursery diets with highly digestible ingredients has increased the need for specialty protein products, such as select menhaden fish meal. Research has shown an improvement in growth performance in weanling pigs with the addition of fish meal (Mason and Weidner, 1964; Stoner et al., 1990); however, specialty protein sources are relatively expensive. Therefore, other ingredients that have the potential to reduce diet cost without decreasing performance must be explored. Poultry meal is a by-product from poultry harvesting facilities that has a CP concentration and AA profile similar to that of select menhaden fish meal. Recent advancements in processing and quality control of poultry meal have improved the consistency and palatability of the

final product. Poultry meal is currently used in the poultry and pet food industries as a protein source (Ewing, 1963; Tadtianant et al., 1993; Yamka et al., 2003). Poultry meal has been evaluated as a replacement in nursery pig diets for high-priced protein sources such as spray-dried animal plasma (Veum and Haque, 1994; Veum et al., 1995). However, limited research is available on replacing fish meal with poultry meal (Moser et al., 1998).

Therefore, due to the similar AA profiles, poultry meal was evaluated as a replacement for select menhaden fish meal in nursery pig diets. In addition, two poultry meal sources with different ash contents were evaluated to determine the effects of ash content on nursery pig performance.

## Materials and Methods

### General

The Kansas State University Institutional Animal Care and Use Committee approved all experimental protocols used in this study.

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**Table 1.** Chemical analysis of protein sources, as-fed basis<sup>a</sup>

Item, %	Soybean meal	Select menhaden fish meal	Poultry meal		
			Exp. 1	Exp. 2	
				Low ash	High ash
CP	48.30	61.21	63.46	60.95	60.87
Ash <sup>b</sup>	6.23	18.60	11.80	10.89	13.49
Ca	0.36	4.27	2.78	2.56	3.11
P	0.64	2.83	1.91	1.82	2.09
Lysine	3.03	5.01	4.30	4.20	3.95
Isoleucine	2.23	2.55	2.59	2.48	2.47
Leucine	3.76	4.55	4.62	4.57	4.36
Methionine	0.71	1.78	1.34	1.29	1.25
Methionine and cystine	1.50	2.34	2.08	2.00	1.93
Threonine	1.87	2.52	2.46	2.41	2.28
Tryptophan	0.68	0.67	0.70	0.70	0.59
Valine	2.42	3.06	3.23	2.97	2.94

<sup>a</sup>Values represent the analysis of one sample of each ingredient.

<sup>b</sup>Values represent duplicate analysis of samples.

Overall, 560 crossbred pigs (Line 327 × C42; PIC, Franklin, KY) were used in two experiments. The pigs were housed in environmentally controlled nursery facilities with slatted metal flooring and mechanical ventilation at Kansas State University. In Exp. 1, each pen (1.8 m<sup>2</sup>) had either five or six pigs (two replicates with six pigs per pen and six replicates with five pigs per pen), and in Exp. 2, each pen (1.44 m<sup>2</sup>) had five pigs. Pens contained one self-feeder and one nipple waterer to provide ad libitum access to feed and water.

Pigs were allotted and assigned to treatments at weaning in Exp. 1 and on d 4 postweaning in Exp. 2. Average daily gain, ADFI, and G:F were determined by weighing pigs and measuring feed disappearance on d 7, 14, 21, and 28 after weaning in Exp. 1, and d 11 and 19 after weaning (d 7 and 15 of the trial) in Exp. 2.

Experimental diets were fed in meal form and were corn-soybean meal-based with 10% edible-grade spray-dried whey. Diets were formulated to meet or exceed nutrient requirements of the pig suggested by NRC (1998). Nutrient compositions for most ingredients that were used in diet formulation were provided by NRC (1998). Select Menhaden fish meal, poultry meal, and soybean meal were analyzed for AA content, Ca, P (AOAC, 2000), and ash percentage (Undersander et al., 1993) before being used in diet formulation in Exp. 1 (Table 1). The analyzed values were then used in diet formulation. The same lot of soybean meal and fish meal was used in both experiments; therefore, only the poultry meal sources were analyzed for Exp. 2. In both experiments, diets were formulated so they had equal lysine levels and similar SBM concentrations in both low and high inclusion levels of specialty protein products. In Exp. 2, before feeding experimental diets, pigs were fed a standard early-wean diet that included 25% spray-dried whey, 6.7% spray-dried animal plasma, 6% fish meal, and 1.7% spray-dried blood meal for 4 d postweaning.

### Experiment 1

Two hundred ten barrows and gilts (initially 7.4 ± 2.1 kg and 21 ± 2 d of age) were blocked by weight and allotted to one of five dietary treatments at weaning. There were eight replicates per treatment. All pigs were fed experimental diets from d 0 to 28 postweaning. There were five experimental diets, which included a control diet with no specialty protein products and a control with 2.5 or 5.0% fish meal or 2.9 or 5.9% poultry meal (11.8% ash). Diets were formulated to contain 1.45% total lysine, 0.90% Ca, and 0.75% P (Table 2).

### Experiment 2

Barrows and gilts (350 total; initially 8.9 ± 2.2 kg and 22 ± 2 d of age) were blocked by weight and allotted to one of seven dietary treatments on d 4. There were 10 replicates per treatment. All pigs were fed experimental diets from d 4 to 19 postweaning. There were seven experimental diets, which included a control diet with no specialty protein products, or the control with 2.5 or 5.0% fish meal, or 2.9 or 5.8% low-ash (10.9%) poultry meal, or 3.1 or 6.2% high-ash (13.5%) poultry meal. Diets were formulated to contain 1.45% total lysine, 0.90% Ca, and 0.76% P (Table 3). Crystalline L-lysine was included at 0.15% in all treatment diets, with crystalline DL-methionine and L-threonine used to maintain constant AA ratios relative to lysine.

### Statistical Analyses

Data were analyzed through the MIXED procedures of SAS Version 8.1 (SAS Inst., Inc., Cary, NC) as randomized complete block designs, with pen as the experimental unit. Contrasts were used to compare pigs fed the fish meal diets to pigs fed poultry meal (Exp. 1 and 2) and low- vs. high-ash poultry meal (Exp. 2). Linear and quadratic comparisons were used to determine the

**Table 2.** Diet composition, as-fed basis (Exp. 1)

Ingredient, %	Control	Select menhaden fish meal		Poultry meal <sup>a</sup>	
		2.5%	5.0%	2.9%	5.9%
Corn	45.41	47.56	49.72	47.04	48.69
Soybean meal, 46.5% CP	34.50	30.18	25.87	30.19	25.87
Spray dried whey	10.00	10.00	10.00	10.00	10.00
Select menhaden fish meal	—	2.50	5.00	—	—
Stabilized poultry meal	—	—	—	2.95	5.90
Soybean oil	5.00	5.00	5.00	5.00	5.00
Monocalcium phosphate, 21% P	1.55	1.35	1.10	1.35	1.18
Limestone	1.05	0.90	0.80	0.98	0.88
Antibiotic <sup>b</sup>	1.00	1.00	1.00	1.00	1.00
Salt	0.35	0.35	0.35	0.35	0.35
Vitamin premix <sup>c</sup>	0.25	0.25	0.25	0.25	0.25
Trace mineral premix <sup>d</sup>	0.15	0.15	0.15	0.15	0.15
L-Lysine-HCl	0.25	0.25	0.25	0.25	0.25
Zinc oxide <sup>e</sup>	0.25	0.25	0.25	0.25	0.25
DL-Methionine	0.15	0.15	0.15	0.15	0.14
L-Threonine	0.10	0.11	0.12	0.10	0.10
Calculated analyses, %					
Lysine	1.45	1.45	1.45	1.45	1.45
Isoleucine:lysine ratio	66	64	62	65	64
Leucine:lysine ratio	128	126	124	127	126
Methionine:lysine ratio	33	35	36	34	35
Met and cys:lysine ratio	60	60	60	60	60
Threonine:lysine ratio	65	65	65	65	65
Tryptophan:lysine ratio	19	19	18	19	18
Valine:lysine ratio	74	73	71	74	73
CP	21.73	21.36	20.99	21.71	21.68
Ca	0.90	0.90	0.90	0.90	0.90
P	0.75	0.75	0.75	0.75	0.75
ME, kcal/kg	3,338	3,449	3,446	3,460	3,455

<sup>a</sup>Poultry meal inclusion rates replaced the lysine provided by fish meal.

<sup>b</sup>Provided 55 mg of carbadox/kg of complete diet.

<sup>c</sup>Provided per kilogram of complete diet: 11,025 IU of vitamin A; 1,654 IU of vitamin D<sub>3</sub>; 44 IU of vitamin E; 4.4 mg of vitamin K (as menadione sodium bisulfite); 55.1 mg of niacin; 33.1 mg of Pantothenic acid (as d-calcium pantothenate); 9.9 mg of riboflavin; and 0.044 mg of B<sub>12</sub>.

<sup>d</sup>Provided per kilogram of complete diet: 39.7 mg of Mn (oxide); 165.4 mg of Fe (sulfate); 165 mg Zn (oxide); 16.5 mg of Cu (sulfate); 0.30 mg of I (as Ca iodate); and 0.30 mg of Se (as Na selenite).

<sup>e</sup>Provided 2,000 mg of Zn/kg of complete diet.

effects of feeding increasing levels of fish meal or poultry meal.

## Results

### Experiment 1

From d 0 to 14, there were no differences ( $P > 0.11$ ) in ADG or ADFI (Table 4) among treatments; however, pigs fed diets containing fish meal had improved ( $P < 0.01$ ) feed efficiency compared with pigs fed diets containing poultry meal. Increasing poultry meal tended to decrease G:F (linear,  $P < 0.09$ ), whereas increasing fish meal tended to increase G:F (quadratic,  $P < 0.09$ ), with the greatest improvement at the 2.5% inclusion level.

From d 14 to 28, increasing fish meal improved (linear,  $P < 0.03$ ) ADG. No difference was noted in ADFI. Pigs fed diets containing fish meal had improved ( $P < 0.01$ ) G:F compared with pigs fed diets containing poultry meal.

For the overall treatment period (d 0 to 28), increasing fish meal in the diet tended to improve (quadratic,  $P < 0.07$ ) ADG, with the greatest improvement observed in pigs fed the diet containing 2.5% fish meal. Again, there were no differences seen in ADFI. However, pigs fed diets containing fish meal had improved ( $P < 0.01$ ) G:F compared with pigs fed diets containing poultry meal.

### Experiment 2

From d 0 to 7, increasing fish meal in the diet improved (linear,  $P < 0.03$ ) ADG (Table 5). Increasing poultry meal (mean of both low- and high-ash sources) tended to increase (quadratic,  $P < 0.06$ ) ADG, with the greatest improvement at the low inclusion level, and then decreasing at the high inclusion level. There was no difference in ADFI. Pigs fed the diet containing low-ash poultry meal had improved ( $P < 0.05$ ) G:F compared with pigs fed the diet containing high-ash poultry meal. Increasing fish meal or poultry meal improved (qua-

**Table 3.** Diet composition, as-fed basis (Exp. 2)

Ingredient, %	Poultry meal <sup>a</sup>						
	Control	Select menhaden fish meal		Low ash		High ash	
		2.5%	5.0%	2.9%	5.8%	3.1%	6.2%
Corn	44.84	46.97	49.04	46.36	47.82	46.25	47.62
Soybean meal, 46.5% CP	37.27	33.10	28.94	33.10	28.95	33.09	28.95
Spray dried whey	10.00	10.00	10.00	10.00	10.00	10.00	10.00
Soy oil	3.00	3.00	3.00	3.00	3.00	3.00	3.00
Select menhaden fish meal	—	2.50	5.00	—	—	—	—
Poultry meal	—	—	—	2.90	5.80	3.10	6.18
Monocalcium phosphate, 21% P	1.45	1.20	0.95	1.30	1.18	1.25	1.08
Limestone	1.10	0.90	0.73	1.00	0.93	0.98	0.85
Antibiotic <sup>b</sup>	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix <sup>c</sup>	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Trace mineral premix <sup>d</sup>	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Zinc oxide <sup>e</sup>	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine·HCl	0.15	0.15	0.15	0.15	0.15	0.15	0.15
DL-Methionine	0.14	0.13	0.13	0.14	0.13	0.13	0.13
L-Threonine	0.05	0.05	0.06	0.05	0.05	0.05	0.05
Calculated analyses, %							
Lysine	1.45	1.45	1.45	1.45	1.45	1.45	1.45
Isoleucine:lysine ratio	68	67	66	68	67	68	67
Leucine:lysine ratio	132	131	130	132	131	132	132
Methionine:lysine ratio	33	34	35	34	34	33	34
Met and cys:lysine ratio	60	60	60	60	60	60	60
Threonine:lysine ratio	65	65	65	65	65	65	65
Tryptophan:lysine ratio	20	19	19	19	19	19	19
Valine:lysine ratio	74	74	73	74	74	75	75
CP	22.35	22.17	21.98	22.31	22.27	22.42	22.48
Ca	0.90	0.90	0.90	0.90	0.91	0.90	0.90
P	0.76	0.76	0.76	0.76	0.76	0.76	0.76
ME, kcal/kg	3,367	3,382	3,398	3,376	3,382	3,378	3,389

<sup>a</sup>Poultry meal inclusion rates replaced the lysine provided by fish meal.

<sup>b</sup>Provided 55 mg of carbadox/kg of complete diet.

<sup>c</sup>Provided per kilogram of complete diet: 11,025 IU of vitamin A; 1,654 IU of vitamin D<sub>3</sub>; 44 IU of vitamin E; 4.4 mg of vitamin K (as menadione sodium bisulfite); 55.1 mg of niacin; 33.1 mg of Pantothenic acid (as d-calcium pantothenate); 9.9 mg of riboflavin; and 0.044 mg of B<sub>12</sub>.

<sup>d</sup>Provided per kilogram of complete diet: 39.7 mg of Mn (oxide); 165.4 mg of Fe (sulfate); 165 mg Zn (oxide); 16.5 mg of Cu (sulfate); 0.30 mg of I (as Ca iodate); and 0.30 mg of Se (As Na selenite).

<sup>e</sup>Provided 2,000 mg of Zn/kg of complete diet.

dratic,  $P < 0.05$ ) G:F, with the greatest improvement at the lower inclusion level for all sources. From d 7 to 15, there was no difference ( $P > 0.11$ ) with the addition of fish meal or either poultry meal source for ADG, ADFI, or G:F.

Overall, d 0 to 15, pigs fed diets containing low-ash poultry meal had improved ( $P < 0.01$ ) G:F compared with pigs fed diets containing high-ash poultry meal. Increasing the level of fish meal or poultry meal within the diet improved (linear,  $P < 0.02$ ) G:F.

## Discussion

The adoption of early weaning within modern swine production has increased the demand for the highly digestible protein sources used in complex nursery diets. Several animal protein sources have been used to stimulate ADFI in weaned pigs. These protein sources include spray-dried animal plasma, blood meal, and fish meal (Bergstrom et al., 1997 and DeRouche et

al., 2002). Because these protein sources are relatively expensive, alternative protein sources could be used to lower feed costs if they could replace the more expensive protein sources without decreasing performance.

Poultry meal is produced from by-products derived in the poultry slaughtering process. Poultry meal consists of products that are not sold for retail use and includes viscera, heads, feet, and other meat waste. As a result of intensification and centralization of poultry slaughtering, the amount of slaughter by-products and poultry meal produced at a single location has increased. Also, the rendering of dead stock generates by-products that are rich in protein, fat, and vitamins and constitute a potentially valuable raw material for use in animal feed (Urlings et al., 1993).

Feeding studies of nursery swine evaluating poultry meal as a replacement for spray-dried animal plasma have been conducted. A 28-d postweaning study was conducted by Veum and Haque (1994), who reported no overall differences in growth performance comparing

**Table 4.** Effects of poultry meal and fishmeal on growth performance of weanling pigs (Exp. 1)<sup>a,b</sup>

Item	Control <sup>c</sup>	Fish meal		Poultry meal <sup>d</sup>		SE	Model <sup>e</sup>	Contrast ( <i>P</i> <)					
		2.5%	5.0%	2.9%	5.9%			Fish vs. poultry	Linear		Quadratic		
									Fish	Poultry	Fish	Poultry	
d 0 to 14													
ADG, g	227	249	231	216	231	13.8	0.22	0.11	0.78	0.75	0.11	0.28	
ADFI, g <sup>f</sup>	267	278	268	259	291	17.2	0.40	0.87	0.96	0.17	0.50	0.18	
G:F	0.85	0.91	0.86	0.83	0.80	0.03	0.03	0.01	0.76	0.09	0.09	0.73	
d 14 to 28													
ADG, g	571	605	605	580	576	15.2	0.08	0.02	0.03	0.73	0.20	0.64	
ADFI, g <sup>f</sup>	648	671	665	673	675	27.1	0.87	0.77	0.56	0.34	0.54	0.64	
G:F	0.88	0.91	0.92	0.86	0.86	0.03	0.10	0.01	0.21	0.32	0.66	0.77	
d 0 to 28													
ADG, g	399	427	418	398	404	11.4	0.06	0.01	0.11	0.68	0.07	0.73	
ADFI, g <sup>f</sup>	458	475	466	466	483	19.9	0.76	0.78	0.67	0.22	0.48	0.79	
G:F	0.87	0.91	0.90	0.85	0.84	0.02	0.02	0.01	0.25	0.12	0.28	0.95	

<sup>a</sup>A total of 210 pigs; initially 7.4 kg and 21 ± 2 d of age (two replications with six pigs per pen and six replications with five pigs per pen).

<sup>b</sup>Experimental diets fed from d 0 to 28 postweaning.

<sup>c</sup>Control diet contained no fish meal or poultry meal.

<sup>d</sup>Poultry meal inclusion rates replaced the lysine provided by fish meal.

<sup>e</sup>*P*-value represents overall treatment effects.

<sup>f</sup>As-fed basis.

pigs fed spray-dried animal plasma or poultry meal on an equal lysine basis. However, during the first week of the trial, pigs fed diets containing spray-dried plasma had improved ADFI and ADG compared with those fed diets containing poultry meal. In a second 28-d postweaning study, Veum et al. (1995) once again compared the effects of spray-dried animal plasma or poultry meal (Phase 1 = d 0 to 14, 10% poultry meal or 8.83% spray-dried animal plasma; Phase 2 = d 14 to 28, 2.83% poultry meal or 2.50% spray-dried animal plasma) on an equal lysine basis. They reported no overall differences in growth performance between the two sources. In a final 28-d postweaning experiment, Veum et al. (1999)

found no differences in ADG, ADFI, or G:F comparing pigs fed spray-dried animal plasma or poultry meal (Phase 1 = d 0 to 14, 10.93% poultry meal or 9.00% spray-dried animal plasma; Phase 2 = d 14 to 28, 3.04% poultry meal or 2.50% spray-dried animal plasma) on an equal lysine basis.

In other swine research evaluating poultry meal, Shelton et al. (2001) reported that finishing pigs fed diets containing poultry meal had decrease ADG and ADFI compared with pigs fed diets containing soybean meal as the sole protein source (30.1 to 114.1 kg BW). Also, Orozco-Hernandez et al. (2003) reported that pigs fed increasing levels of poultry meal up to 7.5% of the

**Table 5.** Effects of poultry meal source and quality on growth performance of weanling pigs (Exp. 2)<sup>a,b</sup>

Item	Control	Poultry meal						SE	Model <sup>d</sup>	Probability, <i>P</i> <					
		Fish meal		Low ash		High ash				Fish vs. poultry	Low vs. high ash <sup>e</sup>	Linear		Quadratic	
		2.5%	5.0%	2.9%	5.8%	3.1%	6.2%					Fish	Poultry	Fish	Poultry
0 to 7															
ADG, g	247	277	295	283	261	272	247	21.6	0.22	0.13	0.43	0.03	0.70	0.75	0.06
ADFI, g <sup>f</sup>	339	338	362	342	322	342	322	22.6	0.63	0.19	0.98	0.31	0.39	0.53	0.47
G:F	0.73	0.82	0.81	0.82	0.81	0.79	0.76	0.02	0.02	0.31	0.05	0.01	0.02	0.05	0.01
d 7 to 15															
ADG, g	488	506	497	497	502	486	522	26.9	0.88	0.99	0.81	0.75	0.32	0.56	0.63
ADFI, g <sup>f</sup>	642	650	643	631	637	660	668	30.0	0.88	0.89	0.16	0.97	0.67	0.75	0.95
G:F	0.76	0.78	0.78	0.79	0.79	0.74	0.78	0.02	0.37	0.92	0.11	0.48	0.30	0.63	0.64
d 0 to 15															
ADG, g	375	399	403	397	389	386	394	18.3	0.80	0.40	0.80	0.14	0.32	0.53	0.51
ADFI, g <sup>f</sup>	500	505	512	496	490	511	507	22.6	0.96	0.60	0.32	0.61	0.92	0.95	0.77
G:F	0.75	0.79	0.79	0.80	0.79	0.76	0.78	0.02	0.01	0.46	0.01	0.02	0.01	0.12	0.24

<sup>a</sup>A total of 350 pigs; initially 8.9 kg and 22 ± 2 d of age with five pigs per pen and 10 pens per treatment.

<sup>b</sup>Experimental diets fed from d 4 to 19 postweaning (d 0 to 15 of experiment).

<sup>c</sup>Poultry meal inclusion rates replaced the lysine provided by fish meal.

<sup>d</sup>*P*-value represents overall treatment effects.

<sup>e</sup>Low- vs. high-ash poultry meal.

<sup>f</sup>As-fed basis.

diet (DM basis) from weaning until market had decreased growth performance compared with control pigs not fed poultry meal.

Fish meal is also a commonly used ingredient in nursery diets and is recognized as a highly digestible protein source with a high concentration of amino acids, vitamins, and minerals. (Mason and Weidner, 1964). Select menhaden fish meal has been used as the major specialty protein source and can replace a portion of the whey typically provided in nursery diets (Stoner et al., 1990). Limited research (Moser et al., 1998) comparing poultry meal and fish meal in nursery diets showed no differences in growth performance between the two protein sources (poultry meal at 2.85 or 5.70% and fish meal at 2.50 or 5.00% of the diet) when fed from d 7 to 28 postweaning. However, pigs fed diets containing poultry meal or fish meal did not have improved performance over control pigs without specialty protein ingredients.

Depending on the processing methods used, the AA profile of poultry meal can be similar to that of fish meal (Moser et al., 1998). In Exp. 1 of this study, the analysis of poultry meal showed a similar AA profile to that of select menhaden fish meal (Table 1). Even though the overall CP is higher (63 vs. 61%), the lysine level is lower in comparison to fish meal (4.3 vs. 5.1%). Therefore, a higher percentage of poultry meal was needed to replace the lysine provided by fish meal. The inclusion levels of fish meal were used based on previous research (Young et al., 2002) conducted in similar facilities.

In Exp. 1, the only difference observed was improved G:F for pigs fed diets containing fish meal. This improvement was mainly due to an increase in gain and intake at the 2.5% inclusion level. Most of the overall difference in Exp. 1 was accounted for from d 14 to 28, when pigs fed the diets containing fish meal had improved growth compared with pigs fed the diets containing poultry meal. This contradicts the results of Young et al. (2002), where the greatest response to fish meal was during the first 14 d postweaning. The late response in this trial was possibly due to the age, initial weight, or health status of the pigs. High-health nursery pigs have been shown to respond less to fish meal in the transition phase (Bergstrom et al., 1997).

The quality of animal protein products depends on the source of the product and the process by which it is derived. Kim and Easter (2001) found that the apparent digestibility of poultry meal and growth response in young pigs can vary depending on the source fish species and meal drying temperature. The nutritional value of fish meal as a protein source depends on its quality and impact on the total AA balance of the diet (Stoner et al., 1990). The same factors that affect fish meal quality can affect the quality of poultry meal. Ash content is often used to assess the quality of different poultry meal sources. Variation in the percentage of ash is directly related to the level of bone included in processed poultry meal. Poultry meal is used as a high-

protein source in pet food diets (Yamka et al., 2003), and poultry meals with different ash contents have been evaluated in canine diets (Murray et al., 1997; Johnson et al., 1998). Two primary factors believed to affect poultry meal quality in canine diets include ash content and processing temperature. Processing has been shown to greatly affect quality; however, the effects of ash content have been inconclusive. Murray et al. (1997) found that rendered poultry products of a higher ash content (13.9 %) seemed to have a slight negative influence on small intestinal, but not total-tract, digestibility. Johnson et al. (1998) found no consistent difference in AA digestibility for dogs fed low- or high-ash poultry meal (7 or 16%). These results agree with Shirley and Parsons (2001), who hypothesized that the reduction in protein quality as ash content increases is due to a decrease in analyzed essential AA and not to a decrease in the digestibility of AA.

In Exp. 2, two different sources of poultry meal were evaluated to determine the effects of poultry meal on nursery pig performance. The ash content of the poultry meal was used to dictate the quality, but diets were formulated to have equivalent lysine and AA ratios. The only difference observed between the two poultry meal sources was in feed efficiency. The low-ash poultry meal resulted in improved efficiency mainly due to numerical increases in gain with lower ADFI. The common segregated early weaning diet that was fed to all pigs from weaning to d 4 postweaning contained 6% fish meal. However, we do not feel that this exposure would have led to any subsequent performance difference when pigs were changed to treatment diets. This is due to the fact that multiple specialty protein sources (spray-dried whey, spray-dried animal plasma, spray-dried blood meal, and fish meal) were in the segregated early weaning diet, thereby reducing the potential for carryover effects from a single ingredient.

Most of the difference between pigs fed fish meal and poultry meal was seen in the first 7 d of the trial and no differences were observed from d 7 to 15. Increasing the inclusion rate of fish meal from 2.5 to 5%, or the equivalent in poultry meal, did not result in improved performance. This contradicts Young et al. (2002), who reported linear improvements with increasing levels of fish meal up to 5%. Based on these results in our production facility, the inclusion rate of 2.5% was adequate to produce the optimal performance response.

## Implications

When using poultry meal, the source and quality of the product may affect pig performance. Based on these data, quality control specifications, such as ash content, need to be considered when using poultry meal as an animal protein replacement in diets for nursery pigs.

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