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Effect of feather meal on barrow performance¹

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ABSTRACT: One hundred ninety-six crossbred barrows of high lean gain potential (21.2 kg BW) were used in an experiment to determine the effect of dietary feather meal (FM) on barrow performance, specifically, the effects of the ingredient on ADG and carcass leanness. Additionally, 28 gilts (26.8 kg BW) were used to compare gender differences on the corn-soybean meal control diets. Treatments were control barrows and control gilts fed corn-soybean meal diets, and barrows fed according to a 2 × 3 factorial arrangement of FM levels (10 or 20%, as-fed basis) and starting weights on the diets (36, 60, or 86 kg BW). All barrow diets were formulated to contain the same apparent digestible lysine and ME. Control barrows ate more feed (2.61 vs. 2.39 kg/d; as-fed), grew faster (0.911 vs. 0.827 kg/d), had greater backfat depth at slaughter (15.6 vs. 11.6 mm), and had lower carcass lean content ($P < 0.001$), with

no difference in daily lean gain ($P = 0.848$) compared with gilts. There was a linear ($P = 0.010$) decrease in ADG for barrows fed increasing amounts of FM from 36 kg BW to slaughter, with no effect of FM additions on ADG when initiated at 60 or 86 kg BW. There was a quadratic reduction ($P = 0.008$) in ADFI and estimated digestible lysine intake with increasing FM for the 36 to 60 kg BW period for barrows fed FM starting at 36 kg BW. There was a linear ($P = 0.006$) decrease in ADFI for the 60 to 86 kg BW period with increasing FM for barrows started on FM at 60 kg BW. There was no effect of experimental diets or starting weight on barrow 10th-rib backfat depth at slaughter. These results suggest that diets containing 10 and 20% FM were effective in decreasing overall ADG and ADFI by barrows when feeding of FM was initiated at 36 kg BW; however, backfat at slaughter was still greater than for control gilts.

Key Words: Barrows, Feather Meal, Feed Intake, Pigs

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Introduction

During the finishing period (from 60 kg to slaughter), barrows eat more feed and grow faster than gilts. Because barrows have greater feed intake and similar lean growth potential in the finishing phase, they have fatter carcasses than gilts at slaughter (Bruner and Swiger, 1968; Schinckel et al., 1996; Nold et al., 1997). Restricting energy intake of finishing pigs has been shown to be effective in decreasing carcass fat deposition (Chiba et al., 1991; Williams et al., 1994; Quiniou et al., 1996). Therefore, if voluntary feed (i.e., energy) intake of barrows can be decreased in the finishing

phase, then carcass leanness may be improved through a decrease in fat deposition.

Feed intake and growth performance were decreased when finishing pigs were fed high-protein diets (Chen et al., 1996, 1999); however, carcass leanness was improved by increasing dietary protein concentrations (Chen et al., 1996; Chiba et al., 1996; Nold et al., 1997) and dietary AA content (Asche et al., 1985). Feather meal (FM), a high-protein feedstuff rendered from poultry feathers, generally contains 80 to 90% CP (Papadopoulos et al., 1985; Han and Parsons, 1991; Wang and Parsons, 1997). Recently, Van Heugten and van Kempen (2002) reported a decrease in ADG and feed intake by pigs fed diets containing 10% FM. Therefore, this study was designed to investigate the effect of incorporating FM into swine diets to decrease feed intake and to improve carcass leanness. The objectives of this study were to investigate: 1) the effect of FM concentration on carcass lean growth and merit and 2) the effect of starting BW on FM response.

Materials and Methods

This experiment was conducted with the approval of the University of Nebraska-Lincoln Institutional Animal Care and Use Committee.

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Experimental Design

The experimental design used in this study was a randomized complete block with initial BW as the blocking criteria. Treatments were arranged as a 2 (dietary FM concentration; 10% [FM10] or 20% [FM20]) \times 3 (starting weight [S]: 36, 60, or 86 kg) factorial. Two control treatments, control barrows (CB) and control gilts (CG), were also included. The CB group served as a benchmark to evaluate the effect of treatments on barrow performance. The CG group served as a benchmark to evaluate the relative performance of barrows. There were four replications for a total of 32 pens in this study. Control barrows and CG were fed corn-soybean meal diets without FM for the entire experimental period. Barrows in each FM \times S treatment group were fed the CB diet until treatments were initiated.

Animals

Two hundred twenty-four crossbred, high lean gain potential feeder pigs (196 barrows and 28 gilts, PIC line 3 semen \times line 42 female) were purchased from a single source. At arrival, all pigs were weighed, given an ear tag, and blocked into four weight groups. Within each block, barrows were assigned randomly to one of seven treatment groups, and gilts were assigned to the control gilt group.

Housing and Management

The experiment was conducted at the swine research unit at the Haskell Agriculture Laboratory at Concord, NE. The facility is a fully slatted, double-wide, naturally ventilated barn with fresh water under-slat flushing. One nipple drinker and two feeder spaces were provided in each pen. There were seven pigs per 2.1 \times 2.4 m pen (0.72 m²/pig). All pigs had ad libitum access to feed and water during the entire experiment.

An ultrasound instrument (LeanMeter, Renco Corp., Minneapolis, MN) was used to measure the backfat depth of pigs on the left and right side at the 10th rib 5 cm off mid-line 5 d before slaughter. Pens of pigs were slaughtered the week when the average pen weight was 110 kg or greater. Carcass characteristics were determined on individually identified pigs by total body electrical conductivity at SiouxPreme Packing Co. (Sioux Center, IA). Initial body lean content, carcass lean percentage, and daily lean gain were calculated on a 5% fat basis (NPPC, 1991).

Feather Meal

The hydrolyzed feather meal used in this study was rendered from turkey feathers without added blood (Central By-Product Co., Redwood Fall, MN). The results of laboratory analysis are presented in Table 1.

Table 1. Nutrient content of feather meal, as-fed basis

Item	Analyzed	NRC (1988)
Nutrient		
CP, %	79.8	84.9
DM, %	92.5	93.0
Ca, %	0.45	0.30
P, %	0.31	0.62
Arginine, %	5.46	5.33
Histidine, %	0.79	0.47
Isoleucine, %	3.57	3.51
Leucine, %	6.47	6.42
Lysine, %	1.84	1.67
Phenylalanine, %	3.91	3.59
Tyrosine, %	2.32	2.35
Threonine, %	3.62	3.63
Tryptophan, %	0.49	0.52
Valine, %	5.06	5.85

Diets

The apparent AA digestibilities of corn (Lys, 64%; Trp, 62%, Thr, 66%)-soybean meal (Lys, 85%; Trp, 80%, Thr, 76%) and feather meal (Lys, 45%; Trp, 60%, Thr, 70%) were obtained from Reese et al. (1995) and used to formulate the experimental diets. Reese et al. (1995) was chosen as the reference because the experimental diets were formulated before NRC (1998) recommendations. Diets (Tables 2 and 3) were formulated according to the recommendations of Reese et al. (1995) using analyzed values for FM. All diets were formulated to contain the same concentration of apparent digestible lysine and energy within sex and phase. This was done to investigate the effect of FM independent of dietary energy or apparent digestible lysine. A blended fat product (FeedEnergy Co., Des Moines, IA) was added to the FM10 and FM20 diets to equalize the dietary ME.

Tylosin (Elanco Animal Health, Indianapolis, IN) was added to diets at (as-fed basis) 110 ppm to 36 kg BW and 44 ppm in all diets thereafter to slaughter. Diets were prepared in meal form and pigs were switched to the next diet the week when pen average weights were 36 (S36), 60 (S60), and 86 kg (S86). The apparent digestible lysine sequence was 0.81, 0.75, 0.71, and 0.54% from 26 kg to market weight for gilts, and 0.81, 0.71, 0.58, and 0.47% for barrows from 21 kg to market weight.

Laboratory Analyses

Feather meal and diet samples were ground to pass a 1-mm screen before analyses. Samples were analyzed in duplicate for DM, CP, GE, Ca, and P according to AOAC (1990) procedures.

For AA determination, with the exception of tryptophan, diet samples were hydrolyzed for 20 h (6 N HCl) at 105°C. Amino acids were separated using ion-exchange chromatography. The AA analyzer contained

Table 2. Experimental diet composition from arrival to 60 kg body weight, as-fed basis, %^a

Item	BW:	Arrival to 36 kg		36 to 60 kg		
	Diet: ^a	Control	CG	CB	FM10	FM20
Ingredient						
Corn		68.95	71.80	73.85	63.95	54.25
Soybean meal, 44% CP		28.40	25.75	23.65	21.30	18.90
Hydrolyzed feather meal		—	—	—	10.00	20.00
Fat ^b		—	—	—	2.30	4.55
Dicalcium phosphate		1.30	1.10	1.15	1.05	0.90
Limestone		0.80	0.80	0.80	0.85	0.85
Salt		0.3	0.3	0.3	0.3	0.3
Vitamin/trace mineral mix ^c		0.25	0.25	0.25	0.25	0.25
Calculated values						
CP, %		18.30	17.40	16.60	23.30	29.90
ME, Mcal/kg		3.27	3.28	3.28	3.28	3.28
Ca, %		0.69	0.65	0.65	0.66	0.65
P, %		0.60	0.55	0.55	0.55	0.55
Lysine, %		1.00	0.93	0.88	0.95	1.02
Apparent digestible lysine, % ^d		0.81	0.75	0.71	0.71	0.71
Tryptophan, %		0.22	0.21	0.20	0.23	0.26
Apparent digestible tryptophan, % ^d		0.20	0.16	0.15	0.16	0.18
Threonine, %		0.71	0.67	0.64	0.93	1.20
Apparent digestible threonine, % ^d		0.62	0.49	0.46	0.66	0.87
Analyzed values						
CP, %		—	16.80	16.50	22.80	28.40
GE, Mcal/kg		—	3.85	3.92	4.14	4.65
Ca, %		—	0.68	0.58	0.69	0.62
P, %		—	0.53	0.53	0.51	0.50

^aCG = control gilts, CB = control barrows, FM10 = diet contained 10% feather meal, and FM20 = diet contained 20% feather meal.

^bFat source: blended fat contained 8,370 kcal/kg of ME from FeedEnergy Co., Des Moines, IA.

^cSupplied per kilogram of diet: vitamin A, 5,500 IU; vitamin D₃, 1,320 IU; vitamin E, 20 IU; vitamin K activity, 1 mg (menadione sodium bisulfite complex); vitamin B₁₂, 0.027 mg; riboflavin, 4.4 mg; D-pantothenic acid, 17.6 mg; niacin, 35.2 mg; choline chloride, 110 mg; Zn, 80 mg as zinc oxide; Fe, 80 mg as ferrous sulfate; Mn, 40 mg as manganous oxide; Cu, 10 mg as copper sulfate; I, 1 mg as ethylenediamine dihydroiodide; and Se, 0.3 mg as sodium selenite.

^dApparent digestible amino acid percent in the diet.

a cation exchange column and AA were eluted by a gradient of lithium buffers. After elution from the column, the AA were quantitated fluorometrically using *o*-phthalaldehyde as the derivatization reagent. Tryptophan concentrations were determined by an automated modification (Lewis et al., 1976) of the method of Hess and Udenfriend (1959) after a 20-h hydrolysis with 5 M NaOH. Amino acid concentrations were not corrected for incomplete recovery resulting from hydrolysis.

Statistical Analyses

The pen of pigs was the experimental unit. Collected data were analyzed by ANOVA using the GLM procedure in SAS (SAS Inst., Inc., Cary, NC). The model used was as follows:

$$Y_{ij} = \mu + b_i + t_j + \beta(n_{ij} - \mu_n) + e_{ij}$$

where Y_{ij} is the observation value of the j th feather meal \times starting weight treatment combination, from the i th block, μ is the overall mean, b_i is the random effect of the i th block, t_j is the fixed effect of the j th

FM \times S treatment combination, β is the slope of regression of Y on covariate, which was carcass weight for carcass characteristics and final weight for backfat depth, n_{ij} is the value of the covariate from the j th treatment combination in the i th block, μ_n is the overall mean of covariate, and e_{ij} is the residual component.

The pigs' final weight was fitted in the model as a covariate for backfat depth because backfat depth is affected by BW (Swensen et al., 1998). Carcass weight was used in the model as a covariate for carcass characteristics because it is reasonable to adjust the carcass weight variation for statistical analysis (Swensen et al., 1998).

Preplanned contrasts were used to examine the effects of FM and starting weight. The approach used with the contrasts was to first examine the interaction of dietary FM concentration and starting weight (FM \times S). Then, within each starting weight, FM additions were examined for linear and quadratic responses.

Results and Discussion

There was no effect of experimental treatments on final weight (Table 4). This was expected because the

Table 3. Experimental diet composition from 60 kg to market weight, as-fed basis, %^a

Item	BW:	60 to 86 kg				86 kg to market			
	Diet: ^a	CG	CB	FM10	FM20	CG	CB	FM10	FM20
Ingredient									
Corn		74.10	79.70	69.85	60.05	81.40	84.55	74.50	64.75
Soybean meal, 44% CP		23.65	18.00	15.60	13.25	16.50	13.25	11.10	8.70
Feather meal		—	—	10.00	20.00	—	—	10.00	20.00
Fat ^b		—	—	2.30	4.55	—	—	2.30	4.55
Dicalcium phosphate		0.75	0.95	0.85	0.75	0.85	0.80	0.70	0.55
Limestone		0.80	0.80	0.85	0.85	0.85	0.85	0.85	0.90
Salt		0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Vitamin/trace mineral mix ^c		0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Calculated values									
CP, %		16.60	14.60	21.20	27.90	14.10	13.00	19.70	26.30
ME, Mcal/kg		3.30	3.30	3.30	3.30	3.30	3.30	3.30	3.30
Ca, %		0.60	0.60	0.60	0.60	0.55	0.55	0.55	0.55
P, %		0.50	0.50	0.50	0.50	0.45	0.45	0.45	0.45
Lysine, %		0.88	0.73	0.84	0.91	0.69	0.60	0.68	0.75
Apparent digestible lysine, % ^d		0.71	0.58	0.58	0.58	0.54	0.47	0.47	0.47
Tryptophan, %		0.20	0.17	0.20	0.23	0.16	0.14	0.17	0.20
Apparent digestible tryptophan, % ^d		0.15	0.12	0.14	0.15	0.12	0.10	0.12	0.13
Threonine, %		0.64	0.56	0.85	1.14	0.54	0.49	0.79	1.00
Apparent digestible threonine, % ^d		0.46	0.40	0.60	0.81	0.38	0.35	0.55	0.76
Analyzed values									
CP, %		16.60	14.90	21.40	27.40	14.80	12.40	18.90	25.20
GE, Mcal/kg		3.88	3.90	4.14	4.43	3.90	3.85	4.10	4.43
Ca, %		0.75	0.50	0.62	0.65	0.55	0.62	0.59	0.59
P, %		0.43	0.48	0.50	0.42	0.48	0.40	0.40	0.36

^aCG = control gilts, CB = control barrows, FM10 = diet contained 10% feather meal, and FM20 = diet contained 20% feather meal.

^bFat source: blended fat contained 8,370 kcal/kg from FeedEnergy Co., Des Moines, IA.

^cSupplied per kilogram of diet: vitamin A, 5,500 IU; vitamin D₃, 1,320 IU; vitamin E, 20 IU; vitamin K activity, 1 mg (menadione sodium bisulfite complex); vitamin B₁₂, 0.027 mg; riboflavin, 4.4 mg; D-pantothenic acid, 17.6 mg; niacin, 35.2 mg; choline chloride, 110 mg; Zn, 80 mg as zinc oxide; Fe, 80 mg as ferrous sulfate; Mn 40 mg as manganous oxide; Cu, 10 mg as copper sulfate; I, 1 mg as ethylenediamine dihydroiodide; and Se, 0.3 mg as sodium selenite.

^dApparent digestible amino acid percent in the diet.

pens of pigs were removed for slaughter on the week they averaged 110 kg BW or greater.

Control barrows consumed 10.2% more feed ($P < 0.001$), grew 9.2% faster ($P = 0.001$) and had 34.5% greater backfat depth than gilts ($P < 0.001$). There was no difference in feed efficiency or daily lean gain between control barrows and control gilts, although gilts had a higher ($P = 0.001$) carcass lean percentage at slaughter. The differences in growth performance and carcass characteristics between gilts and barrows observed in this study are in agreement with previous studies (Watkins et al., 1977; Nold et al., 1997; Swantek et al., 1999).

For barrows that were switched to FM at 36 kg BW, there was a linear ($P = 0.010$) decrease in ADG as FM increased from 0% to 10% to 20% of the diet. There was a linear ($P = 0.004$) and quadratic ($P = 0.014$) response to increasing FM for daily feed intake with FM10 pigs having an increase in overall ADFI and FM20 pigs having a decrease in ADFI compared with CB.

In Table 5, ADFI is reported for the various BW periods. For the 36 to 60 kg BW period, immediately after the FM10 and FM20 pigs were switched to the

FM diets on the S36 treatment, ADFI increased for FM10 and decreased for FM20 vs. CB (linear $P = 0.027$; quadratic $P = 0.008$). For the 60 to 86 kg BW period, ADFI was decreased for both FM diets relative to CB (linear $P = 0.004$; quadratic $P = 0.076$). From 86 kg BW to slaughter, there was no effect of FM on ADFI.

For barrows receiving FM diets beginning at 60 kg BW, there was no effect of experimental diets on ADG, ADFI, G:F, or daily lean gain. Similar to barrows begun on FM at 36 kg BW, barrows fed FM10 and FM20 diets beginning at 60 kg BW had a decrease (linear $P = 0.006$) in ADFI for the 60 to 86 kg BW period immediately after inclusion of FM in the diet relative to CB (Table 5).

There was no effect on overall ADG, G:F, or daily lean gain when barrows were fed FM diets beginning at 86 kg BW. There was a slight quadratic response ($P = 0.052$) in ADFI for the period following the switch to FM10 and FM20 diets, with the lowest ADFI for FM10 followed by FM20 and CB having the highest intake for the 86 kg BW to slaughter period.

These data indicate that for the period immediately following the switch to FM diets, feed intake was always decreased for the FM20 barrows, with the re-

Table 4. Growth performance and carcass characteristics of barrows and gilts

Item	Treatment ^a												P-values ^b					
	S36			S60			S86			CB vs. CG			S36		S60		S86	
	CG	CB	FM10	FM20	FM10	FM20	FM10	FM20	FM10	FM20	SEM	FM × S	Lin	Quad	Lin	Quad	Lin	Quad
No. pens	4	4	4	4	4	4	4	4	4	—	—	—	—	—	—	—	—	—
BW, kg																		
Initial	26.8	21.2	21.1	21.2	21.2	21.2	21.2	21.2	21.2	0.5	0.923	<0.001	0.779	0.523	1.000	0.287	0.305	0.466
Final	113.1	116.2	117.6	114.2	118.2	116.2	112.9	112.9	112.7	2.3	0.500	0.349	0.611	0.498	0.939	0.580	0.472	0.720
CV for within-pen weight at slaughter, %	6.8	9.0	6.6	8.6	7.9	6.2	5.8	5.8	7.0	1.1	0.123	0.415	0.743	0.119	0.024	0.811	0.032	0.015
Growth performance																		
ADG, kg	0.827	0.911	0.895	0.834	0.899	0.885	0.848	0.848	0.876	0.014	0.005	0.001	0.010	0.256	0.128	0.986	0.274	0.125
ADFI, kg (as-fed basis)	2.393	2.614	2.642	2.408	2.620	2.540	2.454	2.454	2.537	0.037	0.001	<0.001	0.004	0.014	0.260	0.438	0.260	0.065
G:F	0.346	0.349	0.339	0.347	0.344	0.349	0.346	0.346	0.346	0.004	0.332	0.625	0.579	0.029	0.968	0.219	0.577	0.845
Daily lean gain, kg ^c	0.318	0.316	0.321	0.291	0.312	0.302	0.307	0.307	0.313	0.007	0.013	0.848	0.023	0.049	0.174	0.680	0.709	0.296
Backfat, mm ^d	11.6	15.6	14.5	13.9	14.2	14.7	13.1	13.1	13.7	0.5	0.230	<0.001	0.116	0.821	0.431	0.328	0.119	0.114
Carcass characteristics																		
Carcass wt, kg	83.0	84.4	85.6	83.2	86.0	84.1	82.0	82.0	81.5	1.5	0.525	0.546	0.653	0.426	0.906	0.351	0.390	0.742
Dressing percent	73.3	72.6	72.9	72.6	72.9	72.2	72.4	72.4	71.9	0.3	0.709	0.109	0.945	0.518	0.217	0.043	0.138	0.741
Carcass lean % ^e	51.5	48.3	48.6	47.5	47.9	47.0	49.0	49.0	48.7	0.6	0.653	0.001	0.380	0.443	0.207	0.884	0.949	0.339

^aCG = control gilts, CB = control barrows, FM10 = 10% feather meal, FM20 = 20% feather meal, S36 = FM diets from 36 kg BW to slaughter, S60 = FM diets from 60 kg BW to slaughter, and S86 = FM diets from 86 kg BW to slaughter.

^bLin = linear; Quad = quadratic.

^cCalculated according to NPPC (1991); contains 5% fat.

^dMeasured by Renco LeanMeter 5 d before slaughter at the 10th rib, 5 cm off mid-line.

^eMeasured by total body electrical conductivity; contains 5% fat.

Table 5. Feed intake, digestible lysine intake, and energy intake by body weight

Item	Treatment ^a										P-values ^b								
	S36			S60			S86			SEM	FM × S	CB vs. CG	S36		S60		S86		
	CG	CB	FM10	FM20	FM10	FM20	FM10	FM20	FM10				FM20	Lin	Quad	Lin	Quad	Lin	Quad
ADFI, kg (as-fed basis)																			
Arrival to 36 kg	1.45	1.48	1.44	1.47	1.48	1.47	1.49	1.49	1.49	0.04	0.612	0.920	0.828	0.517	0.645	0.712	0.388	0.658	
36 to 60 kg	2.03	2.51	2.25	2.45	2.41	2.45	2.44	2.44	2.45	0.06	0.044	<0.001	0.027	0.008	0.466	0.683	0.555	0.684	
60 to 86 kg	2.73	2.97	2.69	2.69	2.89	2.69	2.81	2.98	2.98	0.07	0.007	0.006	0.004	0.076	0.006	0.752	0.624	0.124	
86 kg to market	2.79	3.22	2.93	3.19	3.28	3.19	2.81	2.96	2.96	0.10	0.045	0.013	0.160	0.264	0.931	0.591	0.134	0.052	
Daily digestible lysine intake, g																			
Arrival to 36 kg	11.73	11.97	11.68	11.92	11.95	11.92	12.05	12.07	12.07	0.31	0.612	0.920	0.828	0.517	0.645	0.712	0.388	0.658	
36 to 60 kg	15.23	17.09	16.01	17.41	17.10	17.41	17.30	17.38	17.38	0.46	0.051	0.009	0.027	0.008	0.466	0.683	0.555	0.684	
60 to 86 kg	19.35	17.64	15.61	15.64	16.77	15.64	16.32	17.26	17.26	0.42	0.007	0.009	0.001	0.076	0.006	0.752	0.624	0.124	
86 kg to market	15.04	14.92	13.79	15.00	15.41	15.00	13.22	13.93	13.93	0.48	0.046	0.864	0.160	0.264	0.931	0.591	0.134	0.052	

^aCG = control gilts; CB = control barrows; FM10 = 10% feathermeal; FM20 = 20% feathermeal; S36 = FM diets from 36 kg BW to slaughter; S60 = FM diets from 60 kg BW to slaughter; S86 = FM diets from 86 kg BW to slaughter.

^bLin = linear; Quad = quadratic.

sponse to FM10 being more variable. It seems that over time, barrows adapted to the FM diets, as evidenced by the lack of linear or quadratic effects for S36 or S60 ADFI for the 86 kg BW to slaughter period. Further evidence of this adaptation is the FM × S interaction ($P = 0.001$) for overall ADFI. Unlike the increase in backfat reported by van Heugten and van Kempen (2002) for pigs fed diets FM10 diets, there was no effect of experimental dietary treatments on 10th rib backfat depth for barrows.

The dietary CP content of FM diets was higher than that of CB diets when formulated on an apparent digestible lysine basis (Table 2). Because the FM diets were formulated to have the same apparent digestible lysine as the control barrow diets, any decreases in feed intake led to a decrease in digestible lysine intake. It has been suggested that pigs increase their feed intake to meet their AA and protein requirements (Kyriazakis et al., 1991; Tuitoek et al., 1997). It has also been suggested that AA-imbalanced diets can depress feed intake, growth, and nutrient utilization (D'Mello, 1994). It is possible that the high AA content of FM increased the degree of imbalance, especially with the FM20 treatment, because FM is rich in leucine, arginine, valine, phenylalanine, and cystine (Table 1 and NRC, 1998). Thus, growing pigs (from 36 kg BW) might be more sensitive to dietary AA content than heavier pigs because pigs fed FM20 diets beginning at 60 and 86 kg BW had less severe decreases in feed intake for the period immediately following initiation of experimental diets than pigs started on FM at 36 kg BW.

When dietary CP content is increased, the weight of visceral organs (i.e., liver, kidney, and small intestine) is increased because of increased metabolic activity (Stahly et al., 1979; Noblet et al., 1987; Chen et al., 1996). Because dressing percent includes removal of visceral organs, an increase in the mass of visceral organs would result in a decrease in carcass dressing percent. In this experiment, there was no effect of experimental treatments on carcass dressing percent other than a quadratic increase and then a decrease ($P = 0.043$) for the S60 treatment with increasing amounts of dietary feather meal, suggesting a minimal effect of experimental treatments on visceral mass.

The difference in response to FM depending on starting weight agrees with the results of Apple et al. (2003), who observed reduced performance in the earlier starter period with even lower inclusion levels of feather meal than in the current study. This variation in response due to weight (age) might be caused in part by the difference in growth status associated with the differing starting weights. At 36 kg BW, the pig is in the linear-phase of the protein accretion curve (Whittemore et al., 1988; Whittemore, 1998). At a BW of 60 to 70 kg, protein growth of barrows reaches a plateau and fat deposition increases because feed intake of barrows is greater than that needed for maximal protein growth (Whittemore et al., 1988; Whittemore, 1998). At a BW of 86 kg, protein growth of barrows

and AA requirements expressed as a percentage of the diet are decreasing as feed intake continues to increase. Therefore, fat deposition increases significantly during this phase, resulting in decreased carcass lean content compared with gilts (Whittemore, 1998). This was observed in this experiment for the control barrows vs. the control gilts.

Interestingly, the estimated daily digestible lysine intake was similar among treatments from start to 36 kg BW, and was higher in all barrow treatments vs. CG from 36 to 60 kg BW. From 60 to 86 kg BW, daily digestible lysine intake was estimated to be over 3 g/pig greater for the gilts vs. the previous period, whereas it was only 0.55 g/d higher for CB and lower for all of the FM treatments, including S86, which did not have FM added to the diet yet. The lack of difference in daily lean gain between CB and CG suggests that the CB diets were adequate in digestible lysine to meet the needs of the pigs for lean tissue growth.

There was no effect of FM on the CV for within-pen weight at slaughter for the S36 treatment. There was a linear decrease ($P = 0.024$) in within-pen CV for the S60 treatment with increasing additions of FM to the diet. The reduction in within-pen CV for the S86 treatment was quadratic ($P = 0.015$) in nature, with the lowest CV for the FM10 treatment. However, the CV for the FM20 treatment was still less than the CV for CB. Thus, although FM begun at 36 kg BW had the largest effect on overall performance, inclusion of FM at heavier weights resulted in a larger decrease in within-pen CV at slaughter.

Implications

Dietary additions of feather meal were effective in decreasing daily gain and feed intake by barrows when feeding of feather meal was initiated at 36 kg body weight. Dietary additions initiated at 60 and 86 kg body weight resulted in a decrease in within-pen weight variation at slaughter. These results support the conclusion that feather meal additions to swine diets initiated at lighter body weights affect performance more than similar additions initiated later in the growth process. Feather meal additions were not effective in improving barrow carcass composition relative to gilt carcass composition.

Literature Cited

- AOAC. 1990. Official Methods of Analysis. 15th ed. Assoc. Offic. Anal. Chem., Arlington, VA.
- Apple, J. K., C. B. Boger, D. C. Brown, C. V. Maxwell, K. G. Friesen, W. J. Roberts, and Z. B. Johnson. 2003. Effect of feather meal on live animal performance and carcass quality and composition of growing-finishing swine. *J. Anim. Sci.* 81:172–181.
- Asche, G. L., A. J. Lewis, E. R. Leo, Jr., and J. D. Crenshaw. 1985. The nutritional value of normal and high lysine corns for weanling and growing-finishing swine when fed at four lysine levels. *J. Anim. Sci.* 60:1412–1428.
- Bruner, W. H., and L. A. Swiger. 1968. Effects of sex, season, and breed on live and carcass traits at the Ohio Swine Evaluation Station. *J. Anim. Sci.* 27:383–388.
- Chen, H. Y., A. J. Lewis, and P. S. Miller. 1996. The effects of dietary protein concentration on performance and visceral organ mass in finishing barrows and gilts. Pages 25–27 in *Nebraska Swine Rep. EC96-219*. Univ. of Nebraska, Lincoln.
- Chen, H. Y., A. J. Lewis, P. S. Miller, and J. T. Yen. 1999. The effect of excess protein on growth performance and protein metabolism of finishing barrows and gilts. *J. Anim. Sci.* 77:3238–3247.
- Chiba, L. I., H. W. Ivey, K. A. Cummins, B. E. Gamble. 1996. Hydrolyzed feather meal as a source of amino acids for finisher pigs. *Anim. Feed Sci. Tech.* 57:15–24.
- Chiba, L. I., A. J. Lewis, and E. R. Peo, Jr. 1991. Amino acid and energy interrelationships in pigs weighing 20 to 50 kilograms: I. Rate and efficiency of weight gain. *J. Anim. Sci.* 69:694–707.
- D'Mello, J. P. F. 1994. Amino acid imbalances, antagonisms and toxicities. Page 63 in *Amino Acids in Farm Animal Nutrition*. J. P. F. D'Mello, ed. CAB Int., Wallingford, U.K.
- Han, Y., and C. M. Parsons. 1991. Protein and amino acid quality of feather meals. *Poult. Sci.* 70:812–822.
- Hess, S. M., and S. Udenfriend. 1959. A fluorometric procedure for the measurement of tryptamine in tissues. *J. Pharmacol. Exp. Ther.* 127:175–177.
- Kyriazakis, I., C. Stamataris, G. C. Emmans, and C. T. Whittemore. 1991. The effects of food protein content on the performance of pigs previously given foods with low or moderate protein contents. *Anim. Prod.* 52:337–346.
- Lewis, A. J., P. J. Holden, R. C. Ewan, and D. R. Zimmerman. 1976. An automated fluorometric method for the measurement of tryptophan in plasma. *J. Agric. Food Chem.* 24:1081–1083.
- Noblet, J., Y. Henry, and S. Dubois. 1987. Effect of protein and lysine levels in the diet on body gain composition and energy utilization in growing pigs. *J. Anim. Sci.* 65:717–726.
- Nold, R. A., J. R. Romans, W. J. Costello, J. A. Henson, and G. W. Libal. 1997. Sensory characteristics and carcass traits of boars, barrows, and gilts fed high- or adequate-protein diets and slaughtered at 100 or 110 kilograms. *J. Anim. Sci.* 75:2641–2651.
- NPPC. 1991. Procedures to Evaluate Market Hog Performance. 3rd ed. Natl. Pork Producers Council, Des Moines, IA.
- NRC. 1988. Nutrient Requirements of Swine. 9th ed. Natl. Acad. Press, Washington, DC.
- NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.
- Papadopoulos, M. C., A. R. El Boushy, and E. H. Ketelaars. 1985. Effect of different processing conditions on amino acid digestibility of feather meal determined by chicken assay. *Poult. Sci.* 74:1729–1741.
- Quiniou, N., J. Y. Dourmad, and J. Noblet. 1996. Effect of energy intake on the performance of different types of pig from 45 to 100 kg body weight. 1. Protein and lipid deposition. *Anim. Sci.* 63:277–288.
- Reese, D. E., R. C. Thaler, M. C. Brumm, C. R. Hamilton, A. J. Lewis, G. W. Libal, and P. S. Miller. 1995. Nebraska and South Dakota Swine Nutrition Guide. Nebraska Cooperative Ext. EC 95-273-C.
- Schinckel, A. P., P. V. Preckel, and M. E. Einstein. 1996. Prediction of daily protein accretion rates of pigs from estimates of fat-free lean gain between 20 and 120 kilograms live weight. *J. Anim. Sci.* 74:498–503.
- Stahly, T. S., G. L. Cromwell, and M. P. Aiotti. 1979. The effect of environmental temperature and dietary lysine source and level on the performance and carcass characteristics of growing swine. *J. Anim. Sci.* 49:1242–1251.
- Swantek, P. M., M. J. Marchello, J. E. Tilton, and J. D. Crenshaw. 1999. Prediction of fat-free mass of pigs from 50 to 130 kilograms live weight. *J. Anim. Sci.* 77:893–897.
- Swensen, K., M. Ellis, M. S. Brewer, J. Novakofski, and F. K. McKeith. 1998. Pork carcass composition: I. Interrelationships of compositional end points. *J. Anim. Sci.* 76:2399–2404.
- Tuitoek, J. K., L. G. Young, C. F. M. de Lange, and B. J. Kerr. 1997. Body composition and protein and fat accretion in various body

- components in growing gilts fed diets with different protein levels but estimated to contain similar levels of ideal protein. *J. Anim. Sci.* 75:1584–1590.
- van Heugten, E., and T. A. T. G. van Kempen. 2002. Growth performance, carcass characteristics, nutrient digestibility and fecal odorous compounds in growing-finishing pigs fed diets containing hydrolyzed feather meal. *J. Anim. Sci.* 80:171–178.
- Wang, X., and C. M. Parsons. 1997. Effect of processing systems on protein quality of feather meals and hog hair meals. *Poult. Sci.* 76:491–496.
- Watkins, L. E., L. A. Swiger, and D. C. Mahan. 1977. Effects and interactions of breed group, sex, and protein level on performance of swine. *J. Anim. Sci.* 45:24–29.
- Whittemore, C. T. 1998. *The Science and Practice of Pig Production* 2nd Ed. Blackwell Science Ltd., Oxford, UK.
- Whittemore, C. T., J. B. Tullis, and G. C. Emmans. 1988. Protein growth in pigs. *Anim. Prod.* 46:437–445.
- Williams, N. H., T. R. Cline, A. P. Schinckel, and D. J. Jones. 1994. The impact of ractopamine, energy intake, and dietary fat on finisher pig growth performance and carcass merit. *J. Anim. Sci.* 72:3152–3162.

References

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