The effects of diet form and feeder design on the growth performance of finishing pigs[1,2]

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ABSTRACT: Two studies were conducted to determine the effects of diet form (meal vs. pellet) and feeder design (conventional dry vs. wet/dry) on finisher pig performance. Experiments were arranged as 2 × 2 factorials with 11 replications per treatment and 26 to 29 pigs per pen. In Exp. 1, pigs (n = 1,290; initial BW 46.8 kg) were used in a 91-d study. Pelleted diets averaged approximately 35% fines throughout the study. Overall, pigs fed pelleted diets or via wet/dry feeders had greater (P < 0.07 and 0.001, respectively) ADG than pigs fed meal diets or fed with a dry feeder. Diet form × feeder interactions (P < 0.02) were observed for G:F. Pigs fed either meal or pelleted diets via a wet/dry feeder had similar G:F, but pigs fed pelleted diets in dry feeders had poorer G:F than pigs with meal diets in dry feeders. In Exp. 2, pigs (n = 1,146; initial BW 38.2 kg) were used in a 104-d study. From d 0 to 28, a diet form × feeder design interaction (P < 0.01) was observed for ADG, which was due to decreased ADG in pigs fed pelleted diets from a conventional dry feeder compared with pigs fed meal diets from the same feeder type whereas there was no difference in wet/dry feeders based on diet form. Pigs fed pelleted diets had poorer (P < 0.01) G:F than pigs fed meal diets. This result appeared to be due to poor pellet quality (39.6% fines). From d 42 to 86, pellet quality improved (4.4% fines) and a diet form × feeder interaction was observed for ADG in which pigs fed meal diets in a dry feeder had decreased (P < 0.05) ADG than pigs fed pelleted diets in dry feeders or pigs presented either diet in wet/dry feeders. Pigs fed pelleted diets had improved (P < 0.001) G:F. Pigs fed via wet/dry feeders had increased (P < 0.03) ADFI and G:F compared with pigs fed via dry feeders. Overall, pigs fed with wet/dry feeders had increased (P < 0.02) ADG and ADFI and poorer G:F than pigs with dry feeders whereas pigs given pelleted diets had improved (P = 0.05) G:F compared with pigs presented meal diets. These studies found that pigs fed from wet/dry feeders had increased ADG and ADFI compared with pigs fed via dry feeders regardless of diet form. Additionally, pellet quality appeared to influence responses because pigs fed high-quality pellets via dry feeders had better growth performance than pigs fed meal diets. Conversely, if pellet quality was poor, the feed efficiency benefits associated with pelleting were lost.

Key words: feeder, finishing pig, growth, pelleting

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INTRODUCTION

Feed represents a significant portion of production cost during the finishing phase of growth; therefore, producers are constantly evaluating ways to improve growth performance and lower feed cost. Pelleting diets has been shown to be an effective feed processing method to improve feed efficiency in nursery and finishing pigs (Stark et al., 1993; Wondra et al., 1995). Wondra et al. (1995) observed an increase in G:F of 4 to 6% when pigs were presented pelleted diets vs. meal diets via conventional dry feeders. Stark et al. (1993) observed that pellet quality influenced the response; when pigs were presented pelleted diets containing 30% fines, they had decreased G:F compared with pigs fed a high-quality pellet (no fines).

Limited data are available demonstrating that the growth performance response of pigs to diet form (meal vs. pellets) might be influenced by feeder type. Amornthewaphat et al. (2000a,b) observed little

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difference in pig performance when fed pelleted or meal diets via a wet/dry feeder. However, when using dry feeders, pigs fed pelleted diets had significantly better BW gain and feed efficiency than those fed meal diets. Bergstrom et al. (2012) reported that pigs presented meal diets via wet/dry feeders have increased ADG and ADFI compared with pigs fed with conventional dry feeders. Therefore, an interaction may occur between feeder type and diet form; that is, feeding pelleted diets via a conventional dry feeder might result in a proportionately greater improvement in ADG and G:F than the same diet fed in a wet/dry feeder. Therefore, the objective of the study was to evaluate the effects of diet form (meal vs. pellet) and feeder design (conventional dry vs. wet/dry) on finishing pig performance.

MATERIALS AND METHODS

All practices and procedures used in these experiments were approved by the Kansas State University Institutional Animal Care and Use Committee.

Animal Care

Both studies were conducted at a commercial swine research finishing facility in southwestern Minnesota. The facility was a naturally ventilated double-curtain-sided barn (12.5 by 76.2 m) with pit fans for minimum ventilation. The facility contained forty-eight 3.05 by 5.5 m pens with approximately 0.58 to 0.69 m^2 provided per pig for Exp. 1 and 2, respectively. Pens were located over a completely slatted concrete floor with a deep pit for manure storage. One-half of the pens were equipped with a conventional 5-hole dry feeder (STACO, Shafferstown, PA) with a feed pan dimension of 152.4 by 17.8 by 14.6 cm (length by width by height). The other one-half of the pens contained a double-sided wet/dry feeder that provided both feed and water via a 38.1-cm-wide feeder opening on either side of the feeder (Crystal Springs; Gro Master, Omaha, NE). All pens contained cup waterers, but pens that contained wet/dry feeders had their cup waterers shut off for the duration of the study so the only source of water was the nipple waterer located under a food shelf over the center of the feed pan inside each of the wet/dry feeders. Pigs were provided ad libitum access to feed and water for the duration of both studies. The facility used a computerized feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) that both recorded and delivered diets to pens as specified. Both Exp. 1 and 2 were conducted in the same barn at the research farm. Experiment 1 was conducted from late spring through summer and Exp. 2 was conducted from late summer through fall of the same year.

Experiment 1

A total of 1,290 growing pigs (1050 × 337; PIC, Hendersonville, TN) with an initial BW of 46.8 kg were used in a 91-d study. Pigs were randomly allotted to 1 of 4 experimental treatments based on average initial BW and number of pigs per pen. There were 29 to 30 pigs per pen and 11 pens per treatment. The number of barrows and gilts within each pen were the same across all treatments.

Treatments were arranged in a 2 × 2 factorial with the main effects of diet form (meal vs. pellet) and feeder design (conventional dry vs. wet/dry). All the wet/dry feeders were adjusted to provide a 2.54-cm gap width based on previous research (Bergstrom et al., 2012). Conventional dry feeders that contained meal diets were also adjusted to a minimum gap width of 2.54 cm (Bergstrom et al., 2012) but conventional dry feeders with pelleted diets were adjusted to a 1.78-cm minimum gap width to try to account for differences in flow ability between meal and pelleted diets. All feeder settings were maintained for the duration of the study.

Pigs were fed a common diet containing 45 to 65% by-products [dried distillers grains with solubles (**DDGS**) and bakery meal; Table 1] in 5 dietary phases (47 to 59 kg, 59 to 84 kg, 84 to 97 kg, 97 to 109 kg, and 109 to 126 kg, respectively). The final phase was fed from 109 to 126 kg and contained 5 mg/kg ractopamine HCl (Paylean; Elanco Animal Health Inc., Greenfield, IN). The only difference between diets was diet form. At different periods throughout the study, a large batch of feed was manufactured at the New Horizon Farms feed mill (Pipestone, MN) and then spilt into 2 smaller batches with one-half of the feed transported to a commercial feed mill to be pelleted and the other one-half remaining at the farm feed mill to be fed as the meal diet. Corn was ground to 550 μ using a roller mill. Diets were pelleted at a nearby commercial feed mill with a 125 HP California Pellet Mill (Crawfordsville, IN) equipped with a micro-mini 9.53-mm (hole diameter) by 41.28 mm (effective die thickness) pellet die. Feed was steam conditioned at 65.5°C for 15 s before pelleting. The diets were formulated to meet or exceed NRC (1998) requirement estimates for 20- to 120-kg pigs.

Average daily gain, ADFI, and G:F were determined by weighing pigs and measuring feed disappearance on d 0, 16, 29, 43, 57, 71, and 91. On d 71, 3 pigs (2 barrows and 1 gilt) from each pen were weighed and then removed for marketing as not to exceed the maximum acceptable BW of the packing plant. Although the BW gain of these pigs was included in the growth performance analysis, their carcass data were not collected or included in the analysis. At the conclusion of the study (d 91), pigs were individually tattooed by pen and transported approximately 1 h to a commercial packing plant (JBS Swift and Company, Worthington, MN) where carcass data

Table 1. Composition of diets (as-fed basis), Exp. 1[1]

Item	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Ingredient, %					
Corn	33.32	22.15	21.11	27.72	28.18
Soybean meal, (46.5% CP)	16.70	12.10	9.05	9.20	13.60
Dried distillers grains with solubles	45.00	45.00	35.00	30.00	25.00
Bakery meal	–	15.00	30.00	30.00	30.00
Choice white grease	2.55	3.60	2.94	1.20	1.20
Limestone	1.30	1.25	1.07	1.04	0.99
Salt	0.38	0.14	0.20	0.20	0.20
VTM premix[2]	0.09	0.09	0.08	0.08	0.08
Liquid Lys, 60%	–	–	0.54	0.54	0.59
Lys sulfate	0.64	0.65	–	–	–
L-Thr	–	–	–	0.01	0.12
Phytase[3]	0.01	0.01	0.01	0.01	0.01
Medication[4]	0.01	0.01	–	–	–
Ractopamine HCl[5]	–	–	–	–	0.03
Total	100	100	100	100	100
Calculated analysis					
Standardized ileal digestible AA, %					
Lys	1.06	0.95	0.84	0.84	0.97
Ile:Lys	76	78	76	73	68\\\
Met:Lys	34	35	35	34	30
Met and Cys:Lys	68	72	72	69	61
Thr:Lys	66	67	65	64	70
Trp:Lys	19.7	19.9	19.3	18.6	17.8
Total Lys, %	1.19	1.07	0.94	0.94	1.08
CP, %	23.5	22.0	19.3	18.6	19.5
ME kcal/kg	3,203	3,305	3,377	3,329	3,358
Ca, %	0.65	0.63	0.55	0.53	0.52
P, %	0.56	0.53	0.47	0.45	0.44
Available P,%	0.42	0.42	0.36	0.33	0.31

[1]Phase 1, 2, 3, 4, and 5 diets were fed from 47 to 59, 59 to 84, 84 to 97, 97 to 109, and 109 to 126 kg BW, respectively. All dietary phases were fed in both diet forms to each feeder type.

[2]VTM = vitamin and trace mineral premix, which provided per kilogram premix: 927,818 IU vitamin A, 144,327 IU vitamin D3, 4,984 IU vitamin E, 288 mg vitamin K, 619 mg riboflavin, 2,474 mg pantothenic acid, 3,711 mg niacin, 3,093 mg vitamin B12, 8,247 mg Mn from manganese oxide, 18,556 mg Fe from iron sulfate, 20,618 mg Zn from zinc oxide, 2,062 mg Cu from copper sulfate, and 62 mg Se from sodium selenite.

[3]OptiPhos 2000; Enzyvia LLC, Sheridan, IN, provided 500 FTU/kg, with an expected release of 0.07% available P.

[4]Tylan 40; Elanco Animal Health, Greenfield, IN.

[5]Paylean; Elanco Animal Health.

was obtained on 939 pigs to determine HCW, percentage carcass yield, backfat depth, and LM depth, which was taken by placing an optical probe between the third and fourth rib from the last rib at 7 cm from the dorsal midline. Fat-free lean index (**FFLI**) was calculated using National Pork Producers Council (2000) procedures.

To determine pan coverage, a digital photo of each feeder pan was taken during phase 4. The feeder pan pictures were then scored independently by a trained panel of 4 for percentage of pan coverage. In addition, feed samples were taken from the feeders during each phase and then analyzed for percentage fines and pellet durability index (**PDI**). Percentage fines were determined before testing pellets for durability. A number-6 screen (3.35-mm holes) was used to sift off the fines from a 500-g sample of pellets. The amount of fines was then weighed and percentage fines were calculated using the following formula: weight of fines/weight of sample × 100. After fines were sifted off, PDI was determined (ASAE S269.4; ASAE, 1991). The sample of pellets were placed in a box and tumbled for 10 min. After 10 min, the samples were removed and sieved (number-6 screen), and the percentage of whole pellets was calculated. Pellet durability index was calculated as weight of pellets after tumbling/weight of pellets before tumbling × 100.

Experiment 2

A total of 1,146 growing pigs (1050 × 337; PIC) with an initial BW of 38.2 kg were used in a 104-d study. Pigs were randomly allotted to 1 of 4 experimental treatments based on average initial BW and number of pigs per pen. There were 26 to 27 pigs per pen and 11 pens per treatment. The number of barrows and gilts were equalized across all treatments.

Similar to Exp. 1, treatments were arranged in a 2 × 2 factorial with the main effects of diet form (meal vs. pellet) and feeder design (conventional dry vs. wet/dry). All wet/dry feeders and conventional dry feeders that contained meal diets were initially adjusted to a 2.54-cm minimum gap width. Conventional dry feeders with pelleted diets were adjusted to a 1.78-cm minimum gap width. Unlike Exp. 1, these feeder settings were not maintained for the duration of the study; feeders were adjusted as needed to ensure consistent feeder pan coverage of 40 to 60%. The research site manager checked pigs and feeders twice per day.

Pigs were fed a common corn–soybean meal-based diet containing 20% DDGS during the first 4 dietary phases (38 to 56 kg, 56 to 70 kg, 70 to 85 kg, and 85 to 115 kg, respectively) and 10% DDGS and 5 mg/kg ractopamine HCl in phase 5 (115 to 129 kg; Table 2). Similar to Exp. 1, throughout the study, a large batch of feed was manufactured at the New Horizon Farm feed mill (Pipestone, MN) and then spilt into 2 smaller batches with one-half of the feed transported to a commercial feed mill to be pelleted and the other one-half remaining at the farm feed mill to be fed as the meal diet. Corn was ground to 550 μ using a roller mill. Diets were pelleted at the same commercial feed mill as in Exp. 1 under the same pelleting conditions. The diet was formulated to meet or exceed NRC (1998) requirement estimates for 20- to 120-kg pigs.

Average daily gain, ADFI, and G:F were determined by weighing pigs and measuring feed disappearance on d 0, 14, 28, 42, 56, 70, 86, and 104. On d 86, 5 pigs

Table 2. Composition of diets (as-fed basis), Exp. 2[1]

Item	Phase 1	Phase 2	Phase 3	Phase 4	Phase 5
Ingredient, %					
Corn	59.55	62.77	65.43	68.54	66.16
Soybean meal, (46.5% CP)	18.54	15.36	12.78	9.70	22.21
Dried distillers grains with solubles	20.00	20.00	20.00	20.00	10.00
Limestone	1.00	0.98	0.95	0.95	0.95
Salt	0..35	0.35	0.35	0.35	0.35
VTM premix[2]	0.10	0.09	0.08	0.08	0.08
Liquid Lys, 60%	0.45	0.45	0.40	0.38	0.23
Phytase[3]	0.01	0.01	0.01	0.01	0.01
Ractopamine HCl[4]	–	–	–	–	0.03
Total	100	100	100	100	100
Calculated analysis					
Standardized ileal digestible AA,%					
Lys	0.95	0.87	0.78	0.69	0.90
Ile:Lys	69	69	72	73	74
Met:Lys	31	32	34	37	31
Met and Cys:Lys	64	66	71	76	64
Thr:Lys	62	63	66	68	66
Trp:Lys	17.7	17.4	17.6	17.6	19.8
Total Lys, %	1.10	1.01	0.91	0.82	1.03
CP, %	19.5	18.3	17.2	16.1	18.8
ME kcal/kg	3,366	3,369	3,371	3,372	3,365
Ca, %	0.47	0.45	0.43	0.42	0.46
P, %	0.44	0.42	0.41	0.40	0.41
Available P,%	0.28	0.28	0.26	0.24	0.21

[1]Phase 1, 2, 3, 4, and 5 diets were fed from 38 to 56, 56 to 70, 70 to 85, 85 to 115, and 115 to 129 kg BW, respectively. All dietary phases were fed in both diet forms to each feeder type.

[2]VTM = vitamin and trace mineral premix, which provided per kilogram premix: 927,818 IU vitamin A, 144,327 IU vitamin D3, 4,984 IU vitamin E, 288 mg vitamin K, 619 mg riboflavin, 2,474 mg pantothenic acid, 3,711 mg niacin, 3,093 mg vitamin B12, 8,247 mg Mn from manganese oxide, 18,556 mg Fe from iron sulfate, 20,618 mg Zn from zinc oxide, 2,062 mg Cu from copper sulfate, and 62 mg Se from sodium selenite.

[3]OptiPhos 2000; Enzyvia LLC, Sheridan, IN, provided 500 FTU/kg, with an expected release of 0.07% available P.

[4]Paylean; Elanco Animal Health, Greenfield, IN.

(3 barrows and 2 gilts) from each pen were weighed and then removed for marketing to minimize BW discounts as per Exp. 1. At the conclusion of the study (d 104), pigs were individually tattooed by pen and transported 1 h to a commercial packing plant (JBS Swift and Company, Worthington, MN) where carcass data was obtained for 891 pigs. Carcass data measurements were collected using the same procedures as Exp. 1.

In Exp. 2, a digital photo of each feeder pan was taken on d 54, 78, and 104. Feeder pan pictures were then scored for percentage pan coverage independently by a trained panel of 4. In addition, feed samples were taken from the feeder once during each phase and analyzed for percentage fines and PDI as described in Exp. 1.

Statistical Analysis

Treatments were arranged as a 2 × 2 factorial for both experiments and data were analyzed as a completely randomized design using the PROC MIXED procedure (SAS Inst. Inc., Cary, NC). Pen was the experimental unit in both studies. When significant interactions ($P < 0.05$) were observed, LSD were used to evaluate the means. Results were considered significant at $P \leq 0.05$ and considered a trend at $P \leq 0.10$.

RESULTS

Experiment 1

From d 0 to 43, no diet form × feeder design interactions were observed for the growth performance criteria evaluated (Table 3). Pigs fed pelleted diets had increased ($P < 0.01$) ADG and ADFI compared with those pigs presented meal diets. In addition, pigs fed with wet/dry feeders had increased ($P < 0.01$) ADG compared with pigs with conventional dry feeders. Pigs fed via wet/dry feeders exhibited a tendency toward increased ($P < 0.07$) ADFI compared with pigs fed via conventional dry feeders. There were no differences among any of the treatments for G:F. During this period, pelleted diets averaged 37.5% fines and had a PDI of 74.2.

From d 43 to 71, pigs fed with wet/dry feeders had increased ($P < 0.001$) ADG compared with pigs fed with conventional dry feeders. A diet form × feeder design interaction ($P < 0.001$) was observed for ADFI because pigs fed meal diets via a dry feeder had decreased ADFI compared with pigs fed pellets in the same feeder whereas no change occurred in ADFI in the wet/dry feeders based on diet form. A diet form × feeder design interaction ($P < 0.01$) was observed for G:F, which was driven by pigs fed pelleted diets via dry feeders having poorer G:F compared with pigs fed meal diets in the same feeder, but there was no difference in G:F in the wet/dry feeders based on diet form. During this period, pelleted diets averaged 30.6% fines and a PDI of 80.1.

From d 71 to 91, no diet form × feeder design interactions were observed for ADG or ADFI. Pigs fed with wet/dry feeders showed a tendency toward increased ADG ($P < 0.06$) and an increase in ADFI ($P < 0.001$) compared with pigs fed with conventional dry feeders. A diet form × feeder design interaction was observed ($P < 0.05$) for G:F, primarily due to improved G:F in pigs presented meal diets in conventional dry feeders compared with pigs fed pelleted diets in the same feeder; however, G:F did not differ in the wet/dry feeders based on diet form. Pelleted diets averaged 36.6% fines and had a PDI of 74.0.

Overall (d 0 to 91), no diet form × feeder design interactions were observed for ADG. Pigs fed pelleted diets tended to have improved ($P < 0.07$) ADG compared

Table 3. Effects of diet form and feeder design on finishing pig performance, Exp. 1[1]

	Conventional dry[2]		Wet/dry[3]			P <		
Item	Meal	Pellet	Meal	Pellet	SEM	Diet form × feeder	Diet form	Feeder
d 0 to 43								
ADG, kg	0.81	0.85	0.85	0.87	0.01	0.25	0.0001	0.0001
ADFI, kg	2.07	2.22	2.18	2.23	0.03	0.14	0.01	0.07
G:F	0.395	0.384	0.391	0.391	0.006	0.38	0.34	0.79
Fines, %[4]	–	37.5	–	37.5	–	–	–	–
PDI[5]	–	74.2	–	74.2	–	–	–	–
d 43 to 71								
ADG, kg	0.85	0.86	0.93	0.94	0.01	0.60	0.24	0.0001
ADFI, kg	2.48[a]	2.67[b]	2.72[b]	2.70[b]	0.02	0.0001	0.01	0.0001
G:F	0.344[b]	0.322[a]	0.340[b]	0.350[b]	0.005	0.01	0.21	0.01
Fines, %	–	30.6	–	30.6	–	–	–	–
PDI	–	80.1	–	80.1	–	–	–	–
d 71 to 91								
ADG, kg	0.91	0.86	0.94	0.93	0.03	0.43	0.27	0.06
ADFI, kg	2.55	2.67	2.94	2.90	0.06	0.17	0.44	0.0001
G:F	0.356[b]	0.322[a]	0.319[a]	0.320[a]	0.008	0.05	0.06	0.03
Fines, %	–	36.6	–	36.6	–	–	–	–
PDI	–	74.0	–	74.0	–	–	–	–
d 0 to 91								
ADG, kg	0.84	0.85	0.89	0.91	0.01	0.70	0.07	0.001
ADFI, kg	2.29[a]	2.45[b]	2.50[b]	2.51[b]	0.02	0.04	0.01	0.0001
G:F	0.369[a]	0.349[c]	0.357[b,c]	0.361[a,b]	0.004	0.01	0.07	0.96
Fines, %	–	35.1	–	35.1	–	–	–	–
PDI	–	75.8	–	75.8	–	–	–	–
Feeder coverage score, %[6]	59[a]	90[c]	74[ab]	78[b]	5.70	0.02	0.01	0.79
Carcass measurements[7]								
BW, kg	123.1	124.0	127.2	128.5	2.52	0.85	0.35	0.01
HCW, kg	91.7	92.7	94.1	93.8	1.16	0.54	0.77	0.09
Carcass yield, %	75.6	75.3	75.6	76.0	0.01	0.24	0.95	0.19
FFLI, %[8]	50.4	50.4	49.7	49.9	0.20	0.64	0.52	0.01
Backfat depth, mm[4]	17.3	17.2	18.8	18.3	0.41	0.57	0.40	0.01
Loin depth, cm[4]	6.19	6.05	5.97	5.93	0.12	0.64	0.39	0.11

[a–c]Means without a common superscript within a row differ ($P < 0.05$).

[1]A total of 1,290 growing pigs (PIC 1050 × 337, initially 47 kg) were used with 25 to 27 pigs per pen and 11 pens per treatment.

[2]STACO, Shafferstown, PA.

[3]Crystal Springs, Gro Master, Omaha, NE.

[4]Percentage fines were determined using a number 6 screen.

[5]PDI (pellet durability index) was determined by tumbling 500-g samples of feed for 10 min and then using a number-6 screen (3.35 mm) to sift off the fines.

[6]Pictures of feeder pan coverage were taken once during phase 4. A panel of 5 trained observers then scored feeder pan pictures for percentage of feeder pan coverage.

[7]Carcass data were obtained for 939 pigs from 44 pens with 11 observations per treatment.

[8]FFLI (fat-free lean index; National Pork Producers Council, 2000), backfat depth, and loin depth were adjusted to a common HCW.

with pigs presented meal diets. In addition, pigs with wet/dry feeders had increased ($P < 0.001$) ADG compared with those pigs with conventional dry feeders. A diet form × feeder design interaction ($P < 0.04$) was observed for ADFI in which pigs fed meal diets via dry feeders had decreased ADFI than pigs fed pelleted diets from the same feeder whereas ADFI did not differ in the wet/dry feeders based on diet form. Additionally, a diet form × feeder design interaction for G:F ($P < 0.01$) was observed due to similar G:F in pigs fed both meal and pelleted diets via wet/dry feeders but poorer G:F in pigs fed pelleted diets in a conventional dry feeder than pigs presented meal diets in a conventional dry feeder. A diet form × feeder design interaction was observed for feeder coverage score ($P < 0.02$), in which pigs fed both pelleted and meal diets in wet/dry feeders had similar feeder pan coverage, but pigs fed pelleted diets via dry feeders had increased feeder pan coverage compared with pigs fed meal diets from the same feeder type.

There were no diet form × feeder design interactions or effects for any of the carcass criteria evaluated (Table 3). Pigs fed with wet/dry feeders were heavier at d 104 ($P < 0.01$) and consequently had a tendency toward increased ($P < 0.09$) HCW compared with pigs with conventional dry feeders. However, pigs fed with conventional dry feeders had less ($P < 0.01$) backfat depth than pigs with wet/dry feeders. This resulted in pigs fed with dry feeders having greater ($P < 0.01$) FFLI than pigs with wet/dry feeders. There were no significant differences between diet forms (meal vs. pellet) for any of the carcass criteria evaluated.

Experiment 2

From d 0 to 28, a diet form × feeder design interaction ($P < 0.01$) was observed for ADG because pigs fed pelleted diets from a conventional dry feeder had decreased ADG compared with pigs fed meal diets from the same feeder type whereas there was no difference in wet/dry feeders based on diet form (Table 4). A trend ($P < 0.06$) toward a diet form × feeder design interaction was observed for ADFI. In conventional dry feeders, pigs fed meal or pelleted diets had similar ADFI, which was less than pigs fed meal diets with a wet/dry feeder and even less than pigs fed pelleted diets in a wet/dry feeder. Despite the interaction, pigs fed with wet/dry feeders had increased ($P < 0.001$) ADFI compared with pigs with conventional dry feeders. No diet form × feeder design interactions were observed for G:F. Pigs fed meal diets had increased ($P < 0.001$) G:F compared with pigs fed pelleted diets whereas pigs with conventional dry feeders had increased G:F compared with pigs with wet/dry feeders. Pelleted diets averaged 39.6% fines and had a PDI of 87.2.

From d 28 to 42, there were no diet form × feeder design interactions or effects of diet form for any of the growth performance criteria evaluated; however, pigs with wet/dry feeders tended ($P < 0.10$) to have increased ADFI compared with pigs with dry feeders. Pelleted diets averaged 3.9% fines and had a PDI of 89.8. There were no diet form × feeder design interactions for feeder coverage score, but pigs fed pelleted diets had increased ($P < 0.02$) feeder pan coverage than pigs with meal diets whereas pigs with wet/dry feeders had a tendency toward increased ($P < 0.06$) feeder pan coverage compared with pigs with dry feeders.

From d 42 to 86, a diet form × feeder design interaction ($P < 0.02$) was observed for ADG in which pigs fed meal diet from a conventional dry feeder had decreased ($P < 0.05$) ADG compared with pigs fed pelleted diets from the same feeder type but there was no difference in wet/dry feeders based on diet form. Pigs fed meal diets tended to have increased ($P < 0.08$) ADFI compared with pigs fed pelleted diets. In addition, pigs with wet/dry feeders had increased ($P < 0.001$) ADFI compared with pigs fed with conventional dry feeders. Pigs fed pelleted diets had increased ($P < 0.001$) G:F compared with pigs fed meal diets whereas pigs with wet/dry feeders had reduced ($P < 0.03$) G:F compared with pigs with conventional dry feeders. Pelleted diets averaged 4.4% fines and had a PDI of 93.5. There were no diet form × feeder design interactions for feeder coverage score.

From d 86 to 104, there were no diet form × feeder design interactions or effects of feeder design for any of the growth criteria evaluated. Pigs fed meal diets tended ($P < 0.09$) to have increased ADFI compared with pigs fed pelleted diets. Pigs fed pelleted diets had improved ($P < 0.04$) G:F compared with pigs fed meal diets. Pelleted diets averaged 16.8% fines and had an average PDI of 93.8. Data showed a tendency toward a diet form × feeder design interaction ($P < 0.07$) where pigs fed meal diets in conventional dry feeders had decreased feeder pan coverage compared with pigs fed pelleted diets from the same feeder type, and both had less coverage than the meal or pelleted feed offered via the dry or wet/dry feeders. There were no differences in feeder pan coverage in wet/dry feeders based on diet form.

Overall (d 0 to 104), there were no diet form × feeder design interactions for any of the growth performance criteria evaluated. Pigs fed via wet/dry feeders had increased ($P < 0.01$) ADG and ADFI compared with pigs fed using dry feeders. Furthermore, pigs fed via wet/dry feeders had decreased ($P < 0.02$) G:F compared with pigs fed using dry feeders. Pigs fed pelleted diets had similar ADG but greater ($P = 0.05$) G:F compared with pigs fed meal diets.

No diet form × feeder design interactions were detected for feeder coverage score. Pigs fed pelleted diets had increased ($P < 0.01$) feeder pan coverage compared with pigs fed meal diets, and pigs with wet/dry feeders had increased ($P < 0.01$) feeder pan coverage compared with pigs with dry feeders.

There was no effect of diet form for any of the carcass criteria evaluated (Table 4). Pigs fed with wet/dry feeders had heavier ($P < 0.01$) d-104 BW and subsequently had heavier ($P < 0.01$) HCW than pigs fed with conventional dry feeders; however, pigs fed with dry feeders had increased ($P < 0.03$) carcass yield compared with pigs fed with wet/dry feeders. Data showed tendencies ($P = 0.06$) toward diet form × feeder type interactions for FFLI and backfat depth. For FFLI, pigs fed pelleted diets via a dry feeder had lower FFLI than pigs fed meal diets, but the opposite effect in wet/dry feeders was observed. Pigs fed pelleted diets in dry feeders had greater backfat than meal-fed pigs, but the opposite was true for diets offered in a wet/dry feeder. Despite the interactions, pigs fed with wet/dry feeders had decreased ($P < 0.01$) FFLI and increased ($P < 0.01$) backfat depth compared with pigs fed with conventional dry feeders.

Table 4. Effects of diet form and feeder design on finishing pig performance, Exp. 2[1]

	Conventional dry[2]		Wet/dry[3]			$P <$		
Item	Meal	Pellet	Meal	Pellet	SEM	Diet form × feeder	Diet form	Feeder
d 0 to 28								
ADG, kg	0.66[b]	0.58[a]	0.67[b]	0.63[b]	0.02	0.01	0.06	0.06
ADFI, kg	1.45[a]	1.44[a]	1.56[b]	1.68[c]	0.03	0.06	0.14	0.0001
G:F	0.454	0.404	0.431	0.379	0.010	0.93	0.001	0.02
Fines[4], %	–	39.6	–	39.6	–	–	–	–
PDI[5]	–	87.2	–	87.2	–	–	–	–
d 28 to 42								
ADG, kg	0.96	1.01	1.01	1.01	0.02	0.27	0.33	0.17
ADFI, kg	2.21	2.30	2.35	2.32	0.05	0.24	0.53	0.10
G:F	0.437	0.438	0.433	0.436	0.008	0.90	0.78	0.67
Fines, %	–	3.9	–	3.9	–	–	–	–
PDI	–	89.8	–	89.8	–	–	–	–
Feeder coverage score[6], %	52.40	67.15	63.78	78.84	6.38	0.98	0.02	0.06
d 42 to 86								
ADG, kg	0.96[a]	1.03[b]	1.05[b]	1.06[b]	0.01	0.02	0.01	0.001
ADFI, kg	2.80	2.79	3.09	2.96	0.04	0.14	0.08	0.001
G:F	0.344	0.371	0.340	0.358	0.003	0.20	0.001	0.03
Fines, %	–	4.4	–	4.4	–	–	–	–
PDI	–	93.5	–	93.5	–	–	–	–
Feeder coverage score, %	54.80	60.75	58.46	70.60	6.38	0.62	0.15	0.28
d 86 to 104								
ADG, kg	0.86	0.87	0.90	0.87	0.02	0.62	0.83	0.59
ADFI, kg	2.72	2.54	2.81	2.62	0.10	0.96	0.09	0.41
G:F	0.317	0.345	0.320	0.333	0.010	0.46	0.04	0.66
Fines, %	–	16.8	–	16.8	–	–	–	–
PDI	–	93.8	–	93.8	–	–	–	–
Feeder coverage score, %	31.34[a]	56.18[b]	70.09[b]	72.00[b]	6.38	0.07	0.03	0.001
d 0 to 104								
ADG, kg	0.86	0.88	0.91	0.90	0.01	0.18	0.73	0.01
ADFI, kg	2.33	2.30	2.51	2.46	0.04	0.68	0.25	0.001
G:F	0.370	0.382	0.364	0.368	0.004	0.32	0.05	0.02
Feeder coverage score, %	46.18	61.36	64.11	73.81	4.79	0.56	0.01	0.01
Carcass measurements[7]								
BW, kg	126.0	128.4	132.1	130.1	1.65	0.27	0.90	0.01
HCW, kg	94.0	94.6	98.3	97.4	1.14	0.49	0.88	0.01
Carcass yield, %	75.6	76.3	74.7	74.6	0.01	0.52	0.63	0.03
FFLI[8], %	51.3[b]	51.1[b]	50.4[a]	50.7[a]	0.14	0.06	0.55	0.001
Backfat depth, mm	15.9[a]	16.3[a]	17.8[b]	17.1[b]	0.28	0.06	0.52	0.001
Loin depth, cm	6.17	6.20	6.17	6.18	0.07	0.90	0.72	0.88

[a–c]Means lacking a superscript within row differ ($P < 0.05$).

[1]A total of 1,146 growing pigs (PIC 1050 × 337, initially 38.2 kg) were used with 26 to 27 pigs per pen and 11 pens per treatment.

[2]STACO, Shafferstown, PA.

[3]Crystal Springs, Gro Master, Omaha, NE.

[4]Percentage fines were determined using a number 6 screen.

[5]PDI (pellet durability index) was determined by tumbling 500-g samples of feed for 10 min and then using a number-6 screen (3.35 mm) to sift off the fines.

[6]Pictures of feeder pan coverage were taken on d 54, 78, and 104. A panel of 4 then scored feeder pan pictures for percentage of feeder pan coverage.

[7]Carcass data were obtained for 891 pigs from 44 pens and 11 observations per treatment. Backfat depth and loin depth were adjusted to a common HCW.

[8]FFLI = fat-free lean index (National Pork Producers Council, 2000).

DISCUSSION

Several studies have evaluated the effects of offering feed via a conventional dry feeder vs. a wet/dry feeder on the growth performance of finishing pigs. Gonyou and Lou (2000) found that pigs presented meal diets via wet/dry feeders had a 5% improvement in daily feed intake and gain. Bergstrom et al. (2012) conducted several studies evaluating dry vs. wet/dry feeders at the same commercial facility as the present studies and observed increases in ADG, ADFI, final BW, and HCW when pigs were fed meal diets via wet/dry feeders. Similar to the findings of Gonyou and Lou (2000) and Bergstrom et al. (2012), the present studies observed that pigs fed via wet/dry feeders had about a 4% improvement in ADFI and ADG. Payne (1991) observed an increase in feed intake and daily BW gain in 16 of 17 on-farm studies testing single-space wet/dry feeders. Payne (1991) attributed this increase in BW gain to the fact that pigs presented meal diets via wet/dry feeders consumed more feed and wasted less. Gonyou and Lou (2000) hypothesized that the increase in feed intake was due to an increase in eating speed, where pigs remained at the feeder for the same amount of time but consumed more feed during that meal. Bergstrom et al. (2012) also observed that pigs fed via wet/dry feeders had fewer visits to the feeder with an increase in eating speed compared with pigs fed diets via dry feeders. Increased feed intake and BW gain in pigs presented diets via wet/dry feeders compared with dry feeders has been fairly consistent across studies (Payne, 1991; Gonyou and Lou, 2000; Bergstrom et al., 2012); however, G:F has been variable. Some studies have found that pigs fed with wet/dry feeders showed improvements in G:F (Amornthewaphat et al., 2000a,b; Brumm et al., 2000; Gonyou and Lou, 2000) whereas other studies have indicated an actual decrease in G:F when wet/dry feeders were used (Patterson, 1991; Bergstrom et al., 2012).

Research has indicated that when pigs are presented pelleted diets in conventional dry feeders, G:F typically improves 4 to 6% (Wondra et al., 1995) compared with pigs fed meal-based diets. Contrary to these findings, improvements in G:F were not observed consistently in pigs fed pelleted diets via dry feeders in these studies, and G:F actually worsened in most phases. This response could be a result of the poor pellet quality (a high proportion of fines) resulting in pigs sorting through and wasting feed. Potter et al. (2009) stated that the majority of studies that observed improvements in feed efficiency when feeding pelleted diets were under university research settings where pellet quality might be expected to be better than under large-scale field conditions; therefore, feeding pelleted diets under field conditions might not yield the same advantages in G:F due to poor pellet quality. The feeder management in these studies also could have exacerbated the effects of poor pellet quality. In Exp. 1, the feeders were adjusted to their respective settings on d 0, and the settings were maintained for the duration of the study. This approach could have contributed to the accumulated fines in the feeder pans, increased feed disappearance, and consequently poor feed efficiency. In Exp. 2, feeder adjustments were set to an initial setting but then were adjusted throughout the study to maintain feeder pan coverage of 40 to 60%; however, due to variation in pellet quality and flow ability among batches of feed, maintaining proper feeder adjustments proved rather difficult. Our hypothesis was that feeding pelleted diets via wet/dry feeders, where the pellets and fines alike could mix with water, could negate the effects of poorer quality pellets. When pigs were presented high-quality pellets (<5% fines), no differences among feeder types were observed, but as pellet quality decreased (>30% fines), pigs fed pelleted diets in both feeder types (dry or wet/dry) had poorer G:F.

Interestingly, we did not find a consistent increase in ADG in our studies for pigs fed a pelleted diet compared with a meal diet, but previous research by Wondra et al. (1995) found that pigs fed pelleted diets had a 4 to 6% increase in ADG. Variation in pellet quality throughout both of the present studies could have been a contributing factor. Pigs presented pelleted diets in conventional dry feeders had substantially more feeder pan coverage than pigs fed meal diets in conventional dry feeders. The increased pan coverage in dry feeders could be due to increased sorting of the feed due to poorer-quality pellets for the duration of the study. The pelleted diets averaged 35.1% fines in Exp. 1, with a PDI of 75.8, whereas pellet quality was consistently poorer for the duration of study. In Exp. 2, from d 0 to 28 when pelleted diets averaged 39.6% fines and PDI of 87.2, ADG and G:F decreased in pigs fed pelleted diets; however, from d 28 to 42 and 42 to 86 when pelleted diets averaged 3.9% and 4.4% fines and had an average PDI of 89.8 and 93.5, respectively, ADG and G:F improved. Even from d 86 to 104, when pelleted diets averaged 16.8% fines and 93.8 PDI, the advantage of feeding pelleted diets was maintained whereas pigs fed pelleted diets had improved G:F compared with pigs fed meal diets. Stark et al. (1993) found that as percentage fines increased from 0 to 40% in the diet, feed efficiency was negatively affected, but when feed was presented in the wet/dry feeders, pigs were unable to sort the pelleted diets due to the addition of water. Despite this fact, no advantages in growth performance were observed.

The diet formulation and feeder pan coverage may explain why pigs in Exp. 1 fed pelleted diets had poorer feed efficiency than pigs fed meal diets in the dry feeders. The high inclusion of by-products (40 to 65%) may have played a role in decreased pellet quality during this experiment. Wang et al. (2007) noted that as inclusion rate of DDGS increased from 0 to 15 to 30%, the visual quality of pellets decreased. Stender and Honeyman (2008) found that as DDGS increased from 0 to 20 to 40% in the diet, PDI decreased from 78.9 to 66.8 to 47.4%, respectively. Potter et al. (2009) found that as the inclusion rate of by-products increased in finishing diets, percentage fines increased from 25% in corn–soybean meal diet to 35% in the diet containing increased by-products. In the present studies, all G:F benefits of pelleted diets were negated when the percentage fines exceeded 30%.

Pellet mill throughput could have been a contributing factor to the variation among different batches of pellets. Although all pelleted diets passed through the same pellet mill in both studies, batches varied widely, and differences in pellet quality could be attributed to mill throughput. Greenwood and Beyer (2003) stated that increasing pellet mill throughput would reduce the heating time in the pellet conditioner and decrease friction and shear occurring in the die, resulting in a decrease in particle binding. Consequently, PDI would decrease and incidence of fines would increase. Pellet quality is influenced by multiple factors, but in these studies, diet formulation and increased throughput potentially played a large role in reducing pellet quality. Although pellet throughput was not recorded, anecdotal observations from the pellet mill operator suggest that throughput was negatively correlated with pellet quality.

In conclusion, these experiments support previous findings (Bergstrom et al., 2012) that feeding pigs via wet/dry feeders increase ADG and ADFI. These studies demonstrate the impact of pellet quality on growth performance because pigs provided high-quality pellets via dry feeders had increased growth performance compared with pigs fed meal diets. Conversely, if pellet quality was poor, feed efficiency benefits associated with pelleting were lost. More research needs to be done to evaluate the effects of by-product inclusion on pellet quality and its effect on the growth performance of finishing pigs.

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