The effects of feeder design and dietary dried distillers' grains with solubles on the performance and carcass characteristics of finishing pigs[1,2]

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ABSTRACT: Three experiments were conducted to compare the effects of a conventional dry (five 30.5-cm spaces 152.4 cm wide; Staco Inc., Schaefferstown, PA) vs. a wet–dry (double sided; each side = 38.1-cm space; Crystal Spring; GroMaster Inc., Omaha, NE) finishing feeder (Exp. 1 and 2) and to evaluate the effects of feeder design and dietary level of dried distillers' grains with solubles (DDGS; >10% oil; Exp. 3) on performance and carcass characteristics of finishing pigs. In Exp. 1, 1,186 pigs (32.1 kg BW) were used in a 69-d experiment. There were 26 to 28 pigs per pen and 22 pens per feeder design, and all pigs received the same diets in 4 phases. In Exp. 2, 1,236 pigs (28.7 kg BW) were used in a 104-d experiment, with 25 to 28 pigs per pen and 23 pens per feeder design, and all pigs received the same diets in 5 phases. Carcass measurements were obtained from 11 pens of each feeder design after harvest. In Exp. 3, 1,080 pigs (35.1 kg BW) were used in a 99-d 2 × 2 factorial with main effects of feeder design (dry vs. wet–dry feeders) and DDGS (20 vs. 60%) with 10 pens of 27 pigs per treatment and all diets fed in 4 phases. Jowl fat samples were collected from 2 pigs per pen for fatty acid analysis and iodine value (IV) determination. In all experiments, pigs fed with the wet–dry feeder had greater ($P < 0.05$) ADG, ADFI, and final BW. In Exp. 2 and 3, HCW and backfat depth were increased ($P < 0.05$) for pigs fed with a wet–dry feeder, but G:F and fat-free lean index (FFLI) were reduced. Jowl IV was also reduced ($P < 0.05$) with a wet–dry feeder in Exp. 3. Pigs fed 60% DDGS in Exp. 3 had decreased ($P < 0.05$) ADG, G:F, final BW, HCW, and backfat but increased jowl IV and a tendency ($P < 0.07$) toward greater FFLI regardless of feeder type. In conclusion, pigs fed with this specific type of wet–dry feeder had improved ADG and ADFI, poorer G:F, and increased backfat depth compared to pigs fed with a conventional dry feeder. The poorer growth performance and increased jowl IV of pigs fed diets with 60% DDGS was similarly exhibited for pigs fed on both feeders.

Key words: dried distillers' grains with solubles, feeder design, finishing pigs

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INTRODUCTION

Finishing pig feed costs represent a significant portion of the cost of production, and swine producers are continually evaluating technologies that may improve the performance of finishing pigs and income over feed cost. Feeder design is one technology that is known to impact performance, with 2 main types of feeders typically used in commercial production: conventional dry feeders that offer the feed and water in separate areas or wet–dry feeders that provide pigs with access to dry feed and water at the same location, which creates the opportunity for the pig to consume wet feed. In previous research, some studies have reported that using a wet–dry feeder improved the growth rate of finishing pigs (Brumm et al., 2000; Gonyou and Lou, 2000; Myers et al., 2013), and some have not identified any benefits in pig performance with using a wet–dry feeder design (Patterson, 1991). These studies were mostly conducted in university research facilities; therefore, it is unknown if the responses are directly correlated to that which will be observed in commercial facilities. Additionally, it is not known if diet formulation, specifically the use of byproducts such as dried distillers' grains with solubles (**DDGS**), influences

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the performance of pigs differently if fed with wet–dry vs. conventional dry feeders. Perhaps differences in diet bulk density or flow ability characteristics of the diet may influence responses to different feeder types. Therefore, the objectives of these experiments were to 1) determine the effects of a dry vs. a wet–dry feeder and 2) determine the effects of feeder design and diets with differing bulk density and flow ability (provided by high levels of DDGS) on growth performance and carcass characteristics of finishing pigs raised in a commercial environment.

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

The research was conducted in a commercial finishing research facility in southwestern Minnesota. The facility was double-curtain sided with pit fans for minimum ventilation and completely slatted flooring over a deep pit for manure storage. Individual pens were 3.0 by 5.5 m. Every other pen on each side of the barn was equipped with a single-sided, stainless steel dry feeder (STACO, Inc., Schaefferstown, PA) with five 30.5-cm spaces (152.4 cm wide) and 1 cup waterer in each pen. The cup waterer was adjacent to the feeder, approximately 1 m away. The remaining pens were each equipped with a double-sided, stainless steel wet–dry feeder (Model F1-115; Crystal Spring; GroMaster, Inc., Omaha, NE) with a 38.1-cm-wide feeder space on each side for a total feeder space of 76.2 cm. It provided access to feed and water, with water supplied from a single nipple waterer located under a feed "shelf" located over the center of the feed pan. The dry feeders were positioned parallel and the wet–dry feeders were positioned perpendicular against the fence line of an adjacent pen. The facility was equipped with a computerized feeding system (FeedPro; Feedlogic Corp., Willmar, MN) that delivered and recorded daily feed additions and diets as specified. The equipment provided pigs with ad libitum access to food and water.

Although the pens equipped with a wet–dry feeder also contained a cup waterer, these were shut off during the experiments such that the only source of water for pigs in these pens was through the wet–dry feeder.

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

	Dietary phase[1]			
Ingredient, %	d 0 to 10	d 10 to 28	d 28 to 50	d 50 to 69
Corn	58.88	52.09	55.31	57.93
Soybean meal, 46.5% CP	22.25	18.95	15.92	13.20
DDGS[2]	9.00	20.00	20.00	20.00
Bakery byproduct	5.00	5.00	5.00	5.00
Choice white grease	2.55	2.05	2.10	2.25
Monocalcium P, 21% P	0.25	–	–	–
Limestone	0.80	0.80	0.80	0.80
VTM, amino acids, and phytase[3]	1.27	1.11	0.87	0.82
Total	100.00	100.00	100.00	100.00
Calculated analysis				
Standardized ileal digestible (SID) AA[4]				
Lys, %	1.11	1.05	0.95	0.86
Ile:Lys, %	59	63	64	66
Leu:Lys, %	138	158	168	177
Met:Lys, %	32	31	30	31
Met and Cys:Lys, %	58	60	60	64
Thr:Lys, %	62	62	64	63
Trp:Lys, %	16	16	16	16
Val:Lys, %	68	74	77	79
CP, %	18.9	19.7	18.5	17.4
Total Lys, %	1.24	1.20	1.09	0.99
ME, kcal/kg	3,494	3,483	3,485	3,494
SID Lys:ME, g/Mcal	3.19	3.02	2.72	2.46
Ca, %	0.45	0.40	0.39	0.38
P, %	0.45	0.43	0.42	0.41
Available P, %	0.26	0.26	0.25	0.25

[1]Each dietary phase was fed to all pigs during the periods described in the table.

[2]DDGS = dried distillers' grains with solubles.

[3]VTM = vitamin–trace mineral premix; VTM, amino acids, and phytase added by the feed supplier to meet the desired nutrient specifications.

[4]Standardized ileal digestible AA values were derived from NRC, (1998) with the exception of DDGS, which were derived by Stein et al. (2006).

Experiment 1

A total of 1,186 pigs (line 337 × 1050; PIC, Hendersonville, TN) with an initial BW of 32.1 kg) were used in a 69-d experiment. Pens of pigs were initially weighed and randomly allotted to 1 of 2 treatments (conventional dry feeder vs. wet–dry feeder). There were 22 pens per treatment and each mixed-sex pen contained 26 to 28 pigs with similar numbers of barrows and gilts per treatment. All pigs were fed the same sequence of diets with 4 dietary phases (d 0 to 10, 10 to 28, 28 to 50, and 50 to 69; Table 1). The diets were formulated to meet or exceed the nutrient requirements of pigs for each diet phase (NRC, 1998). On d 14, 28, 42, 56, and 69, pens of pigs were weighed and feed disappearance was measured to determine ADG, ADFI, G:F, and mean BW. This experiment was conducted from December to February.

Experiment 2

A total of 1,236 pigs (line 337 × 1050; PIC) initially 28.7 kg BW were used in a 104-d experiment with the same 2 feeder design treatments used as in Exp. 1. Pens of pigs were initially weighed and randomly allotted to

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

	Dietary phase[1]				
Ingredient, %	1	2	3	4	5
Corn	61.60	54.56	50.05	52.76	59.61
Soybean meal, 46.5% CP	21.60	18.55	13.10	10.45	16.45
DDGS[2]	9.00	20.00	30.00	30.00	17.00
Bakery byproduct	5.00	5.00	5.00	5.00	5.00
Choice white grease	0.65	–	–	–	–
Monocalcium P, 21% P	0.13	–	–	–	–
Limestone	0.80	0.85	0.85	0.85	0.80
VTM, amino acids, and phytase[3]	1.22	1.04	1.00	0.94	1.11
Ractopamine HCl, 20 g/kg[4]	–	–	–	–	0.025
Total	100.00	100.00	100.00	100.00	100.00
Feed budget, kg/pig	26.8	39.9	54.9	59.0	to d 104
Calculated analysis					
Standardized ileal digestible (SID) AA[5]					
Lys, %	1.11	1.05	0.90	0.81	0.94
Ile:Lys, %	59	63	69	71	65
Leu:Lys, %	139	159	190	204	167
Met:Lys, %	32	30	33	35	32
Met and Cys:Lys, %	59	60	68	72	62
Thr:Lys, %	62	62	64	66	65
Trp:Lys, %	16	16	17	17	17
Val:Lys, %	68	74	84	87	77
CP, %	18.9	19.7	19.4	18.4	18.3
Total Lys, %	1.24	1.20	1.06	0.97	1.08
ME, kcal/kg	3,411	3,388	3,391	3,393	3,391
SID Lys:ME, g/Mcal	3.25	3.10	2.66	2.39	2.77
Ca, %	0.42	0.41	0.40	0.39	0.39
P, %	0.42	0.44	0.46	0.45	0.41
Available P, %	0.23	0.26	0.31	0.30	0.24

[1]Each dietary phase was fed to all the pigs in the sequence, and according to the feed budget, outlined in the table.

[2]DDGS = dried distillers' grains with solubles.

[3]VTM = vitamin–trace mineral premix; VTM, amino acids, and phytase added by the feed supplier to meet the desired nutrient specifications.

[4]Paylean (Elanco Animal Health, Greenfield, IN).

[5]Standardized ileal digestible AA values were derived from NRC, (1998) with the exception of DDGS, which were derived by Stein et al. (2006).

treatment with 23 mixed-sex pens per treatment and 25 to 28 pigs per pen. Unlike Exp. 1, all pigs were fed by using a feed budget (diet 1 = 26.8 kg/pig, diet 2 = 39.9 kg/pig, diet 3 = 54.9 kg/pig, and diet 4 = 59.0 kg/pig; Table 2). The diets were formulated to meet or exceed the nutrient requirements of pigs for each diet phase (NRC, 1998). On d 84, the 3 largest pigs per pen were visually selected by the barn manager and marketed. These pigs were not included in the carcass data collection. Afterward, all remaining pigs were switched to a fifth diet containing 5 mg/kg ractopamine HCl (Paylean; Elanco Animal Health, Indianapolis, IN) until d 104. On d 0, 14, 28, 42, 56, 70, 84, and 104, pens of pigs were weighed and feed disappearance was measured to determine ADG, ADFI, G:F, and mean BW.

On d 104 a subsample of 494 pigs (11 pens/feeder type) were individually tattooed and shipped approximately 96 km to a commercial processing plant (JBS Swift and Company, Worthington, MN) for data collection. Standard carcass criteria of percentage carcass yield, HCW, backfat depth, loin depth, and percentage lean were calculated. Hot carcass weight was measured immediately after evisceration, and carcass yield was calculated as HCW divided by live weight at the plant. Fat depth and LM depth were measured with an optical probe (Fat-O-Meater; SFK Technology A/S, Herlev, Denmark) inserted between the third and fourth last rib (counting from the ham end of the carcass) at a distance approximately 7.1 cm from the dorsal midline. Fat-free lean index (**FFLI**) was calculated according to National Pork Producers Council (2000) procedures. This experiment was conducted from April to July.

Experiment 3

A total of 1,080 pigs (line 337 × 1050; PIC) were used in a 99-d experiment. A 2 × 2 factorial arrangement of treatments was used to evaluate the interactive effects of feeder design (conventional dry vs. wet–dry feeder) and dietary concentration of DDGS (20 vs. 60%) on finishing pig performance. The DDGS used in this study contained greater than 10% oil. Pigs (35.1 kg initial BW) were sorted by gender (barrows and gilts) into groups of 27, randomly allotted to pens containing 1 of the 2 feeder designs, and each pen was randomly assigned to a corn–soybean meal–DDGS–based diet with either 20 or 60% corn DDGS with 10 pens per treatment (Table 3).

All pigs were fed their assigned level of DDGS in 3 dietary phases (d 0 to 28, 28 to 56, and 56 to 78). The 2 diets within each of the 3 feeding phases were formulated to an equal Lys concentration on a standardized ileal digestible basis while maintaining other AA at or above their requirement estimate (NRC, 1998). Digestibility values for AA were obtained from the NRC (1998) and used for all ingredients except DDGS. For DDGS, AA digestibility values from Stein et al. (2006) were used. An ME value of 3,420 kcal/kg was used for both corn and DDGS (>10% oil). All dietary nutrient levels were formulated to meet or exceed the requirements of pigs for each diet phase. Pens of pigs were weighed and feed disappearance was recorded on d 0, 14, 28, 42, 56, 78, and 99 to determine ADG, ADFI, G:F, and mean BW.

On d 78, the 2 largest pigs in each pen were visually selected by the barn manager and marketed based on the farm's normal marketing protocol. These pigs were not included in the carcass data collection. All remaining pigs were fed a common diet from d 78 to 99 that contained 20% DDGS and 5 mg/kg of ractopamine HCl. On d 99, the remaining pigs were individually tattooed and

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

	Dietary phase[1]						
	d 0 to 28		d 28 to 56		d 56 to 78		d 78 to 99
DDGS,[2] %:	20	60	20	60	20	60	20
Ingredient, %							
Corn	60.07	26.45	63.00	29.90	66.84	33.55	58.36
Soybean meal, 46.5% CP	18.06	11.20	15.25	7.83	11.49	4.24	19.85
DDGS	20.00	60.00	20.00	60.00	20.00	60.00	20.00
Limestone	1.00	1.40	0.95	1.35	0.90	1.35	1.00
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Liquid lysine, 60%	0.40	0.50	0.35	0.48	0.33	0.43	0.33
VTM and phytase[3]	0.12	0.10	0.10	0.09	0.09	0.08	0.08
Ractopamine HCl, 20 g/kg[4]	–	–	–	–	–	–	0.025
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated analysis							
Standardized ileal digestible (SID) AA[5]							
Lys, %	0.95	0.95	0.85	0.85	0.74	0.74	0.95
Ile:Lys, %	68	77	70	80	72	85	71
Leu:Lys, %	175	231	188	249	204	278	180
Met:Lys, %	31	40	33	43	35	48	32
Met and Cys:Lys, %	63	81	67	86	72	96	65
Thr:Lys, %	61	73	64	76	67	82	64
Trp:Lys, %	17	18	18	18	18	18	18
Val:Lys, %	81	97	85	101	89	110	84
CP, %	18.9	23.8	17.9	22.5	16.5	21.1	19.6
Total Lys, %	1.10	1.18	0.99	1.07	0.87	0.94	1.10
ME, kcal/kg	3,364	3,353	3,366	3,355	3,371	3,358	3,364
SID Lys:ME, g/Mcal	2.82	2.83	2.52	2.53	2.20	2.17	2.82
Ca, %	0.47	0.60	0.44	0.57	0.41	0.56	0.47
P, %	0.43	0.58	0.42	0.56	0.41	0.55	0.44
Available P, %	0.27	0.32	0.25	0.32	0.23	0.31	0.22

[1]Each dietary phase was fed to both feeder designs during the periods described in the table.

[2]DDGS = dried distillers' grains with solubles.

[3]VTM = vitamin–trace mineral premix. Phytase provided 0.07 to 0.12% available P.

[4]Paylean (Elanco Animal Health, Greenfield, IN).

[5]Standardized ileal digestible AA values were derived from NRC, (1998) with the exception of DDGS, which were derived by Stein et al. (2006).

shipped approximately 96 km to a commercial processing plant (JBS Swift and Company), where they were harvested and carcass data were obtained from a subsample of 885 pigs. Carcass data included HCW, carcass yield, and backfat and LM depth measurements obtained by optical probe between the third and fourth rib from the last rib at 7 cm from the dorsal midline. The FFLI was calculated according to National Pork Producers Council (2000) procedures. Jowl fat samples were also collected from the carcasses of 2 average-sized pigs within each pen for fatty acid analysis and the calculation of iodine value (**IV**).

All jowl fat samples collected were obtained 24 h postmortem and stored frozen at 0°C until sample preparation and fatty acid analysis. Fatty acid analyses were performed on the jowl samples at the Kansas State University Analytical Lab (Manhattan, KS; Table 2; Sukhija and Palmquist, 1988). An IV was calculated from the fatty acid analysis using the following equation (AOCS, 1998): IV = [C16:1] × 0.95 + [C18:1] × 0.86 + [C18:2] × 1.732 + [C18:3] × 2.616 + [C20:1] × 0.785 + [C22:1] × 0.723, where the brackets indicate the percentage concentration of the specified fatty acid. This experiment was conducted from August to November.

Statistical Analysis

For both Exp. 1 and Exp. 2, data were analyzed as a completely randomized design using the PROC MIXED procedure of SAS (version 8.2; SAS Inst. Inc., Cary, NC) with pen as the experimental unit.

The data for Exp. 3 were analyzed as 2 × 2 factorial arrangement in a completely randomized design using the PROC MIXED procedure of SAS (version 8.2; SAS Inst. Inc., Cary, NC). Pen was the experimental unit. Because pens were composed of either all barrows or gilts, gender was included in the model as a fixed effect. For all analyses, differences with a *P*-value of less than

Table 4. The effects of feeder design on growth performance of finishing pigs, Exp. 1[1]

	Feeder design			
Item	Conventional dry	Wet–dry	SE	*P*-value
d 0 to 69				
ADG, kg	0.95	1.03	0.005	0.001
ADFI, kg	2.33	2.53	0.015	0.001
G:F	0.408	0.407	0.002	0.131
d 69 BW, kg	98.2	103.2	0.47	0.001

[1]A total of 1,186 pigs (PIC 337 × 1050; PIC, Hendersonville, TN; initial BW = 32.1 kg) with 26 to 28 pigs per pen and 22 pens per treatment.

Table 5. The effects of feeder design on growth performance and carcass characteristics of finishing pigs, Exp. 2[1]

	Feeder design			
Item	Conventional dry	Wet–dry	SE	*P*-value
d 0 to 104 growth performance				
ADG, kg	0.86	0.91	0.006	0.001
ADFI, kg	2.25	2.45	0.015	0.001
G:F	0.382	0.371	0.002	0.002
d 104 BW, kg	118.6	123.8	0.69	0.001
Carcass characteristics[2]				
HCW, kg	88.5	90.8	0.81	0.064
Carcass yield, %	76.9	75.2	0.43	0.022
Backfat depth, mm	16.3	17.8	0.28	0.002
LM depth, cm	6.13	6.21	0.10	0.378
Fat-free lean index, %	50.5	49.9	0.16	0.029

[1]A total of 1,236 pigs (PIC 337 × 1050; PIC, Hendersonville, TN; initial BW = 28.7 kg) with 25 to 28 pigs per pen and 23 pens per treatment.

[2]Carcass data from a subsample of 494 pigs (representing 11 pens/feeder type) were obtained for the comparison of carcass characteristics.

0.05 were considered to be statistically significant, and trends were reported with a *P*-value of less than 0.10.

RESULTS

Experiment 1

Overall (d 0 to 69) ADG, ADFI, and final BW were greater ($P < 0.001$) for pigs fed using a wet–dry feeder than for those fed using the conventional dry feeder (Table 4). Feed efficiency was not different between pigs fed with either feeder design.

Experiment 2

Overall (d 0 to 104) ADG, ADFI, and final BW were increased ($P < 0.001$) but G:F was decreased ($P < 0.002$) for pigs fed using the wet–dry feeder. Hot carcass weight tended ($P < 0.06$) to be greater for pigs fed using the wet–dry feeder (Table 5). No differences in LM depth were observed, but average backfat depth was greater ($P < 0.002$) for pigs fed with the wet–dry feeder. Therefore, carcass yield and FFLI were decreased ($P < 0.03$) for pigs fed using the wet–dry feeder.

Experiment 3

Overall (d 0 to 99), there were no feeder type × DDGS interactions observed. Pigs fed diets using the

Table 6. The effects of feeder design and dietary level of dried distillers' grains with solubles (DDGS) on growth performance of finishing pigs, Exp. 3[1,2]

	Feeder design						
	Wet–dry		Conventional dry			*P*-value	
Item	20% DDGS	60% DDGS	20% DDGS	60% DDGS	SE	Feeder design	DDGS
d 0 to 99							
ADG, kg	0.95	0.92	0.88	0.86	0.007	0.001	0.022
ADFI, kg	2.59	2.59	2.28	2.31	0.022	0.001	0.548
G:F	0.367	0.355	0.384	0.382	0.003	0.001	0.002
BW, kg	129.2	126.9	122.6	121.3	1.03	0.001	0.091
Carcass characteristics[3]							
HCW, kg	96.6	93.5	90.9	89.8	0.89	0.001	0.022
Yield, %	74.9	75.1	74.9	75.2	0.22	0.763	0.327
Backfat depth, mm	19.0	18.1	16.7	16.2	0.38	0.001	0.034
LM depth, cm	5.96	5.89	6.10	5.99	0.097	0.215	0.408
Fat-free lean index, %	49.5	50.0	50.6	50.8	0.18	0.001	0.020
Jowl iodine value							
(*n* = 72)	72.1	80.4	73.5	81.9	0.78	0.042	0.001

[1]A total of 1,080 pigs (PIC 337 × 1050; PIC, Hendersonville, TN; initial BW = 35.1 kg) were placed in 40 pens containing 27 pigs each and were used in a 99-d experiment to compare the growth performance.

[2]No feeder × DDGS interactions were observed for any of these criteria.

[3]After the 2 largest pigs per pen were selected and marketed on d 78, a subsample of 885 pigs (8 to 9 observations per treatment), harvested on d 99, was used to compare carcass characteristics.

wet–dry feeder had greater ($P < 0.001$) ADG, ADFI, final BW, HCW, and backfat depth than pigs using the conventional dry feeders (Table 6). Pigs fed using the wet–dry feeders also had poorer ($P < 0.001$) G:F and decreased ($P < 0.001$) FFLI and jowl fat IV compared to pigs fed with the conventional dry feeder. Despite the DDGS reduction to 20% of the diet for the last 21 d before market, feeding 60% DDGS from d 0 to 78 resulted greater ($P < 0.001$) jowl fat IV when compared to pigs fed 20% DDGS throughout the experiment.

DISCUSSION

These data demonstrated consistent improvements in the ADG and ADFI of finishing pigs fed meal diets ad libitum with these specific wet–dry feeders compared to a conventional dry feeder. This occurred despite the dry feeder providing twice the amount of feeder space per pig. Gonyou and Lou (2000) indicated that both the number of feeding spaces and availability of water at the feeder are the principle feeder design features that influence the performance of pigs. They compared 6 models of dry feeders and 6 models of wet–dry feeders and also observed greater ADG and ADFI for pigs fed using wet–dry feeders. Gonyou (1999) used feeding behavior data from single-space and multiple-space models to estimate the number of pigs required to keep each feeder space occupied 80% of the time. This was a conservative estimate to obtain optimal use of a feeder without decreasing performance. Gonyou (1999) estimates indicated that a 20 to 35% greater stocking rate was appropriate for a wet–dry feeder space (14 to 15 pigs/feeding space) compared to an equal amount of dry feeder space (11 to 12 pigs/feeding space). Bergstrom et al. (2012b) observed that pigs fed with a wet–dry feeder, identical to the one used in the studies herein, visited the feeder less often with no differences observed in the duration of each feeding visit; thus, total time at the feeder was less for those fed using a wet–dry feeder compared with a conventional dry feeder. This change in total time spent at the feeder might explain why stocking density could be increased in pens using wet–dry feeders as observed by Gonyou (1999).

Other studies have also demonstrated improved ADG with ad libitum feeding of meal diets using wet–dry feeders (Anderson et al., 1990; Bergstrom et al., 2012a,b; Myers et al., 2013). However, G:F responses in experiments comparing different feeder designs have been more variable than the gain and feed intake responses reported. As pigs get to heavier BW, their feed efficiency deteriorates. Some of the impact of wet–dry feeders on feed efficiency may be simply due to the pigs growing faster and their feed efficiency getting poorer at a heavier BW.

In a meta-analysis of 13 studies, Nitikanchana et al. (2012) observed similar overall feed efficiency with pigs using a wet–dry feeder, but the variation in G:F among the studies was greater than the ADG response. Gonyou and Lou (2000) indicated no differences in feed efficiency between wet–dry and dry feeder designs in their study. Similar to Exp. 2 and 3, Brumm et al. (2000) observed poorer G:F with the wet–dry compared to the conventional dry feeder. Although feed wastage was not visually considered to be a problem in their study, they did report that a single delivery of coarse-ground feed made adjustment of the wet–dry feeder difficult during the period that this feed was consumed. We speculate that the ideal feeder adjustment is much more sensitive to maintain in a wet–dry feeder compared with a conventional dry feeder.

Various design features may be responsible for the different responses observed among experiments comparing different feeders. Baxter (1991) reported that both a head-and-shoulder or head barrier between each feeding space reduced aggression and feed wastage. Morrow and Walker (1994) also reported that, with 20 pigs per pen, fitting a stall to a single-space wet–dry feeder reduced aggression and the occurrence of tail biting. Although the number of daily feeder visits was reduced and the duration of each visit increased, differences in growth performance and feed wastage were not observed. Gonyou (1999) included a multiple-space "tube" feeder in a study and reported that intake and growth were equal to that of other multiple-space wet–dry feeders, but the data seemed to indicate that the lack of protected and well-defined feeder spaces may result in a reduced stocking rate relative to other wet–dry feeders. Nevertheless, the provision of a head barrier around the feeding space of the wet–dry feeder may have contributed to the differences in performance between the 2 feeder designs in the current studies. Another factor was that the wet–dry feeders were located perpendicular to the pen gating whereas the dry feeders were parallel to the gating. With the wet–dry installation, the pen gating acted as a partial barrier, which could have influenced the number of disruptive behaviors by pen mates affecting the outcome vs. the dry feeder with no such partial barrier. The feeding spaces of the conventional dry feeder were separated only by a nose barrier in the trough. It is important to emphasize that the studies herein only compared the effects of 1 type of conventional dry feeder to 1 wet–dry feeder and care must be taken in the extrapolation of our results to other feeders that differ in design attributes.

In Exp. 3, we experienced difficulties in achieving a feeder setting that provided access to feed without filling the trough, particularly with the diet containing 60% DDGS and the wet–dry feeder. The dry feeder was initially adjusted to a setting determined to be optimal in previous experiments (Myers et al., 2012). The wet–dry feeder was adjusted to an opening suggested by the manufacturer, which had been used in Exp. 1 and 2. Differences in the composition, bulk density, and flow ability of the meal diets between experiments may have contributed to the problem, but the feeders were subsequently adjusted daily as needed to obtain trough coverage of approximately 50% (Myers et al., 2012). Although more difficult initially, maintaining wet–dry feeders at the desired pan coverage became much easier as the pigs grew larger.

The primary objective of using 20 vs. 60% DDGS was to determine possible interactive effects between feeder type and diets with different bulk density and flow ability. However, differences in performance between pigs fed 20 and 60% DDGS in Exp. 3 are consistent with previous experiments. In an extensive review by Stein and Shurson (2009) evaluating increasing DDGS on pig performance, they generally found no negative effects up to an inclusion of 30% DDGS in the diet. The observed differences in jowl fat IV are also supported in the literature. Benz et al. (2010) reported increased jowl fat IV with increasing dietary levels of DDGS. However when comparing the effect of feeder type, jowl fat IV was lower for pigs fed with the wet–dry feeder than those with the conventional dry feeder. This is supported by observations reported by Wood et al. (2008), where faster growing pigs had decreased IV compared with slow growing pigs.

In conclusion, these experiments demonstrate that ADG and ADFI of finishing pigs are improved when fed with the wet–dry feeders used in these studies compared to the conventional dry feeders we used; however, it is not known if these results can be extended to other feeder designs or models. In addition, pigs using a wet–dry feeder also had poorer G:F and fatter carcasses than those fed using a dry feeder. These negative responses may offset any economic advantages obtained from improvements in growth. Further research is necessary to identify the optimum wet–dry feeder design or management strategies that will sustain benefits in growth while minimizing potential negative effects on feed efficiency and carcass lean.

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