Effects of feeder design and changing source of water to a location separate from the wet-dry feeder at 4 or 8 weeks before harvest on growth, feeding behavior, and carcass characteristics of finishing pigs[1,2]

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ABSTRACT: Our objectives were to compare a conventional dry (5-space, 152.4-cm-wide) and a wet-dry (double-sided, each side = 38.1-cm-wide single space) feeder and to determine if changing the source of water to a location separate from a wet-dry feeder would result in improved G:F and carcass characteristics. Water supply to the wet-dry feeder was shut off and the cup waterer was turned on in 8 pens at 8 (d 69) or 4 (d 97) wk prior to harvest. For the remaining 8 wet-dry feeder pens, the feeder provided the sole water source for the entire experiment. A total of 1,296 pigs (PIC, 337 × 1050; initially 19.4 kg BW) were used, with 27 pigs/pen (14 barrows and 13 gilts) and 24 pens/feeder design. From d 0 to 69, pigs fed with the wet-dry feeder had increased ($P < 0.05$) ADG, ADFI, G:F, and d 69 BW compared with those using the conventional dry feeder. Overall (d 0 to 124), pigs using fed with the water source in the wet-dry feeder the entire time had greater ($P < 0.05$) ADG, ADFI, final BW, and HCW the other treatments. The overall G:F was not different ($P > 0.05$) among pigs fed with the different feeder treatments. Pigs fed with the wet-dry feeder where water source was changed at 4 wk before harvest had greater ($P < 0.05$) ADG than pigs that used a conventional dry feeder. Pigs where the water source was changed at 4 wk had greater ($P < 0.05$) ADFI than those were the water source was changed 8 wk prior to harvest, and for pigs fed with the conventional dry feeder ADFI was intermediate. Back fat depth of pigs where the water source was changed at 8 wk before harvest was reduced ($P < 0.05$) compared with all other treatments and LM depth was greater ($P < 0.05$) than that of pigs using a conventional dry feeder and where the water source was changed at 4 week before harvest. Pigs fed using the wet-dry feeder visited the feeder less frequently ($P < 0.05$) and spent less total time at the feeder ($P < 0.05$) than those fed with the conventional dry feeder. The differences in feeding patterns remained even after the access to water was removed from the wet-dry feeder, with no change in the amount of aggressive behavior observed at the feeder. Pigs fed with a wet-dry feeder had an increased growth rate compared with those fed with a conventional dry feeder. Although measures of carcass leanness were improved by changing the location of the water, removing the water from the feeder also eliminated any net improvement in BW from using a wet-dry feeder.

Key words: dry feeder, feeding behaviors, finishing pig, growth, water, wet-dry feeder

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INTRODUCTION

A wet-dry feeder may increase ADG and ADFI of finishing pigs when compared with a conventional dry feeder (Amornthewaphat et al., 2000a; Brumm et al., 2000; Gonyou and Lou, 2000). However, differences in the G:F and carcass characteristics of pigs fed with dry and wet-dry feeders have not been consistent. Comparing 12 different ad libitum feeders (6 dry and 6 wet-dry), Gonyou and Lou (2000) found increased ADG and ADFI and less carcass lean percentage with wet-dry feeders, with no differences in G:F. Brumm et al. (2000) also observed greater ADG and ADFI with a wet-dry feeder, but they reported less G:F with no differences in percentage carcass lean.

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Differences in the G:F of pigs using wet-dry or dry feeder designs are usually attributed to differences in feed wastage, which is influenced by feeder design (Baxter, 1991; Gonyou and Lou, 2000). However, greater ADFI and ADG of pigs throughout the finishing period, leading to increased back fat depth, suggests that differences in efficiency of gain for pigs fed with wet-dry feeders may also be due to compositional gain differences (Barber et al., 1972; Kanis, 1988; Morrow and Walker, 1994).

Collectively, using a wet-dry feeder may provide greater benefits for growth early in the finishing period, but the possibility of using the same feeder and changing the presentation of feed from wet-dry to dry during the late finishing period may improve the efficiency of growth. Therefore, our objective was to determine whether changing the source of water to a location separate from the wet-dry feeder at 4 or 8 wk before harvest would improve feed efficiency and carcass characteristics of pigs fed with a wet-dry feeder while sustaining an improvement in overall ADG compared with pigs fed with a dry feeder.

MATERIALS AND METHODS

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

A total of 1,296 pigs (PIC 337 × 1050; PIC, Hendersonville, TN; initially 19.4 kg BW) were used to evaluate the effects of feeder design (conventional dry vs. wet-dry feeder) and changing the source of water from a wet-dry feeder to a location separate from the feeder during the late finishing period on pig performance. All pigs were fed the same corn-soybean meal-based diets containing 15% dried distillers grains with solubles during 4 dietary phases from d 0 to 39, d 39 to 69, d 69 to 97, and d 97 to 124 (Table 1). During the last dietary phase, the diet contained 5 mg/kg of ractopamine HCl. All diets were formulated to meet or exceed the nutrient requirement estimates of pigs during each diet phase (NRC, 1998).

Facility and Feeders

The research was conducted in a commercial finishing research facility in southwestern Minnesota from March 27, 2009 (average outside low temperature of −7°C and high temperature of 3.9°C), to July 29, 2009 (average outside low temperature of 15°C and high temperature of 29°C). The facility was double-curtain-sided with pit fans for minimum ventilation and completely slatted flooring over a deep pit for manure storage. The facility contained a total of 48 pens (each 3.0 × 5.5 m), and 24 alternating pens were each equipped with a single-sided, 152.4-cm-wide, 5-hole, stainless steel dry feeder (STACO, Inc., Schaefferstown, PA) and a single cup waterer. The feeders were centered on the midpoint of the fence line between pens, and the cup waterer was located on the fence line between the feeder and the ex-

Table 1. Diet composition

	Dietary phase[1]			
Item	23 to 45 kg	45 to 73 kg	73 to 102 kg	102 kg to harvest
Ingredient, %				
Corn	61.46	66.53	71.45	63.35
Soybean meal, 46.5% CP	21.43	16.64	11.85	19.80
DDGS[2]	15.00	15.00	15.00	15.00
Monocalcium P, 21% P	0.15	—	—	—
Limestone	1.00	0.95	0.90	1.00
Salt	0.35	0.35	0.35	0.35
Liquid lysine, 60% Lys	0.45	0.40	0.35	0.35
L-Threonine	0.05	0.03	0.01	0.01
VTM, phytase[3]	0.11	0.10	0.09	0.085
Ractopamine HCl , 20 g/kg[4]	—	—	—	0.025
Total	100.00	100.00	100.00	100.00
Calculated analysis				
SID AA[4]				
Lys, %	1.05	0.90	0.75	0.95
Ile:Lys, %	64	66	69	68
Leu:Lys, %	158	172	191	170
Met:Lys, %	28	30	33	30
Met and Cys: Lys, %	57	62	68	61
Thr:Lys, %	62	63	64	62
Trp:Lys, %	17	17	17	18
Val:Lys, %	75	79	84	80
CP, %	19.3	17.5	15.7	18.7
Total Lys, %	1.19	1.03	0.87	1.09
ME, kcal/kg	3,358	3,366	3,371	3,364
SID Lys:ME, g/Mcal	3.13	2.67	2.23	2.82
Ca, %	0.50	0.44	0.41	0.47
P, %	0.46	0.41	0.39	0.42
Available P, %	0.29	0.25	0.23	0.21

[1]Each dietary phase was formulated to meet the requirements for the BW ranges described in the table.

[2]Dried distiller's grains with solubles.

[3]VTM = vitamin and trace mineral premix that provided 927,818 IU vitamin A, 144,327 IU vitamin D_3, 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 B_{12}, 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 per kilogram of premix. The phytase source (Optiphos, Enzyvia, Sheridan, IN) was assumed to provide 0.12% available P (275 FTU/kg diet) at the greatest inclusion concentration.

[4]SID = standardized ileal digestible.

[5]Paylean, Elanco Animal Health, Greenfield, IN.

terior of the building. The remaining 24 pens were each equipped with a double-sided, stainless-steel wet-dry feeder (Crystal Springs, GroMaster, Inc., Omaha, NE). The 38.1-cm-wide feeder opening on each side of the wet-dry feeder provided a feeding space with access to both feed and water. The feeders were located perpendicular to the fence line and bolted to the back of the dry feeders in alternating pens. Water was supplied in each wet-dry feeder through a single nipple waterer located under the center of a feed shelf and positioned over the feed trough that was shared by the 2 opposing feeding spaces. In the pens equipped with a wet-dry feeder, the feeder was positioned so that both feeder openings were only accessible to pigs within the same pen. The feeder within each pen was located along a fence line shared with a neighboring pen that was equipped with the opposite feeder design. Therefore, the 2 feeder designs were equally distributed among pens in an alternating pattern throughout the facility.

The original cup waterer remained in all pens that were equipped with a wet-dry feeder; however, both sources of water in these pens were equipped with individual shutoff valves so that the water sources could be controlled. Every cup waterer in the pens containing a wet-dry feeder was shut off at the beginning of the experiment so that the only source of water in these pens was through the wet-dry feeder during the initial 69 d of the experiment. Beginning on d 69, the water source at the feeder was shut off, and the cup waterer was simultaneously turned on in 8 of the pens equipped with a wet-dry feeder. This was repeated in another 8 pens equipped with a wet-dry feeder on d 97 of the experiment. Consequently, in the 8 remaining pens equipped with the wet-dry feeder, the feeder provided the sole source of water throughout the 124-d finishing experiment.

Assignment to Feeder Design and Water Source

Upon arrival from a nursery facility equipped with dry feeders, pigs were randomly placed into pens of 27 with each pen consisting of 14 barrows and 13 gilts. The next day, pens were weighed and complete pens were exchanged across feeder type to obtain 24 pens for each of the 2 feeder designs with a similar initial average BW and pen-to-pen SD of BW. This initial pen weigh day was considered d 0 of the experiment.

On d 69 of the experiment, 8 pens equipped with a wet-dry feeder were identified (to have previous performance and BW similar to the remaining 16 pens equipped with a wet-dry feeder), and their water source at the feeder was shut off and the cup waterer was turned on. This process was repeated with an additional 8 pens equipped with a wet-dry feeder on d 97. For the remaining 8 pens with a wet-dry feeder, the feeder provided the sole source of water until the end of the experiment on d 124. This resulted in 2 feeder treatments for comparison from d 0 to 69 (wet-dry and dry feeder) and 4 feeder treatments for comparison from d 69 to 124 and for the overall experiment (d 0 to 124). Therefore, the 4 treatments created in the last 8 wk of the experiment consisted of pens of pigs fed with either the 1) dry feeder, 2) wet-dry feeder changed to a dry feeder for the final 8 wk, 3) wet-dry feeder changed to a dry feeder for the final 4 wk, or 4) wet-dry feeder used as a wet-dry feeder throughout the experiment.

Data Collection

Pens of pigs were weighed and feed disappearance was measured on d 0, 14, 28, 42, 56, 69, 97, and 124 to determine ADG, ADFI, G:F, and mean BW. On d 104, the 3 largest pigs (2 barrows and 1 gilt) from each pen were weighed and removed for marketing. At the conclusion of the experiment on d 124, the remaining pigs were individually tattooed and shipped approximately 96 km to a commercial processing plant (Swift, Worthington, MN), where they were harvested and carcass data were obtained. Carcass data included HCW, carcass yield, and back fat and LM depth measurements, which were obtained by optical probe between the third and fourth ribs from the last rib at 7 cm from the dorsal midline. The fat-free lean index (**FFLI**) was calculated according to the National Pork Producers Council (2000) procedures.

To determine whether changing the source of water to a location separate from a wet-dry feeder would affect feeding behaviors, the following traits were quantified: number of visits to the feeder trough, duration of each visit to the feeder trough, total time at the feeder trough, and number and duration of aggressive interactions at the feeder trough. These behaviors were evaluated using video recordings taken from d 94 to 96, d 97 to 99, and d 109 to 111. The periods selected for observation were chosen to represent the feeding behaviors associated with 3 of the feeder treatments shortly before, shortly after, and approximately 2 wk after the change in water source for the wet-dry feeders switched on d 97. Nine pens were randomly selected for repeated, continuous video recording during the 3 time periods, with 3 pens chosen to represent each of 3 treatments: conventional dry feeder, wet-dry feeder with water continuously available at the feeder, and wet-dry feeder with the water source switched to the cup waterer on d 97.

A video camera was suspended from the ceiling and positioned to capture approximately 24 h of digital video around the feeder trough of the first pen for each treatment on d 94, second pen for each treatment on d 95, and third pen for each treatment on d 96 (**d 94 to 96**). This process was repeated again on d 97, 98, and 99 (**d 97 to 99**), and again on d 109, 110, and 111 (**d 109 to 111**). Immediately before initiation of video recording, the first 4 barrows and 4 gilts that could be successfully identified by the stockperson with a legible and unique identification number after entering each pen were selected for observation. Aerosolized livestock marking paint was used to apply the number to the back of each pig so it was easily visible in the video. Each recording was initiated at approximately 1200 h on each of the predetermined days and concluded at approximately 1200 h on the next day. The time-stamped videos were stored on an external hard drive after each session.

The methods used to collect this information were based on the limitations of the equipment available for data collection. Three video cameras (Panasonic, Model SDR-H40P-Hard Disk Drive, Panasonic, Secaucus, NJ) capable of recording up to 36 h of continuous digital video were available at the time of the study, and the combination of limitations imposed by the cameras and facilities prevented the simultaneous observation of drinking behaviors in pens with water sourced separately from the feeder. Methods for differentiating the feeding and drinking behavior of pigs provided access to both feed and water in the wet-dry feeder were beyond the capability of this study. However, the simultaneous consumption of feed and water with wet-dry feeding is associated with feeding behaviors.

Even although approximately 24 h of continuous video were recorded during each of the 3 periods of interest in the current study, the barn lighting was lowered at night to reduce the number of insects during periods of natural ventilation, which made observation of behaviors during this time period difficult. Therefore, behaviors at the feed trough of the 8 identified pigs in each pen were observed continuously for two 3 h time blocks during each of the 3 periods (d 94 to 96, d 97 to 99, and d 109 to 111); one 3-h block was selected between 1300 and 1800 h and the second 3-h block was selected between 0600 and 1100 h. Video was reviewed using the combined 6-h time (3 h in the morning and 3 h in the afternoon) for each pen during each of the 3 periods, and the average number of visits to the feeder trough (head positioned in or above the feeder trough), duration of each visit (minutes), and total time at the feeder trough (sum of the duration of the feeder visits, minutes) were determined for the 8 identified pigs. Additionally, the average number and duration of aggressive interactions (pushing, nudging, biting, or a combination of these directed toward a pen mate) of the identified pigs at the feeder were recorded. All observations were made by a single observer who was unaware of treatment within the 2 wet-dry feeder types.

Statistical Analysis

The data were analyzed as a completely randomized design using the PROC MIXED procedure (SAS Inst. Inc., Cary, NC) with treatment as a fixed effect. Pen served as the experimental unit in this study. Additionally, the behavioral data of the 3 selected feeder treatments were analyzed as repeated measures to compare the average number of feeder visits, duration of each feeder visit, total time at the feeder, number of aggressive occurrences, and duration of each aggressive occurrence for pigs on each treatment by period (d 94 to 96, 97 to 99, and 109 to 111) and overall. For the behavioral data, the statistical model included the fixed effects of treatment, period, and their interaction.

The differences between treatments were determined using the PDIFF option of SAS for performance responses that had an overall treatment effect ($P < 0.05$). Differences among treatments with a *P*-value of less than 0.05 were considered to be statistically significant, and a *P*-value of greater than 0.05 and less than 0.10 was considered a trend.

RESULTS

Growth Performance

From d 0 to 69, pigs fed using the wet-dry feeder had greater ($P < 0.05$) ADG, ADFI, G:F, and d 69 BW than those fed with the conventional dry feeder (Table 2). When the availability of water was removed from the wet-dry feeder and provided by a cup waterer beginning on d 69, pigs fed using this arrangement had reduced ($P < 0.05$) ADG, ADFI, and G:F from d 69 to 97 when compared with those fed with a wet-dry feeder that continued to provide the sole source of water or a dry feeder and separate cup waterer. Additionally, pigs fed using a wet-dry feeder with water in the feeder from d 69 to 97 had greater ($P < 0.05$) ADG, ADFI, and d 97 BW than those fed with a conventional dry feeder, but G:F between these treatments did not differ. Although pigs fed using a wet-dry feeder with water in the feeder had greater ($P < 0.05$) d 97 BW than those fed using a wet-dry feeder with a separate water source, the d 97 BW of pigs using the dry feeder and wet-dry feeder with a separate water source were similar.

From d 97 to 124, when the source of water was removed from the wet-dry feeder and provided by a cup waterer beginning on d 97, the affected pigs had reduced ($P < 0.05$) ADG compared with all other treatments. Also, pigs fed with a wet-dry feeder that provided water throughout the study had greater ($P < 0.05$) ADG during this period than those fed with a conventional dry feeder, and the ADG of pigs fed using the wet-dry feeder

Table 2. Effects of feeder design and changing the water source to a location separate from the wet-dry feeder at 4 and 8 wk before harvest on growth performance and carcass characteristics of growing-finishing pigs

Item	Wet-dry feeder: Water with feed throughout	Wet-dry feeder: Water with feed to d 97	Wet-dry feeder: Water with feed to d 69	Dry feeder with separate cup waterer	SEM	Wet-dry vs. dry P-value[1]
Growth performance[2]						
d 0 to 69						
ADG, kg	0.83	0.82	0.82	0.79	0.012	<0.001
ADFI, kg	1.90	1.85	1.83	1.80	0.030	<0.02
G:F	0.44	0.44	0.45	0.44	0.003	<0.05
d 69 BW, kg	77.6	76.5	76.1	74.1	0.82	<0.001
d 69 to 97[3]						
ADG, kg	0.87[a]	0.90[a]	0.74[b]	0.83[c]	0.017	—
ADFI, kg	2.78[a]	2.76[a]	2.40[b]	2.58[c]	0.031	—
G:F	0.32[ab]	0.33[a]	0.31[b]	0.32[a]	0.005	—
d 97 BW, kg	102.2[a]	101.7[a]	96.9[b]	97.3[b]	0.80	—
d 97 to 124						
ADG, kg	1.06[a]	0.91[b]	1.01[ac]	0.99[c]	0.029	—
ADFI, kg	3.09[a]	2.66[b]	2.77[b]	2.78[b]	0.061	—
G:F	0.34[a]	0.34[a]	0.37[b]	0.36[ab]	0.007	—
d 0 to 124						
ADG, kg	0.89[a]	0.86[b]	0.84[bc]	0.84[c]	0.007	—
ADFI, kg	2.33[a]	2.21[b]	2.14[c]	2.17[bc]	0.019	—
G:F	0.38	0.39	0.39	0.39	0.003	—
Final BW, kg	128.7[a]	124.7[b]	122.2[b]	122.5[b]	1.08	—
Carcass characteristics[4]						
HCW, kg	96.0[a]	93.2[b]	91.6[b]	92.4[b]	1.02	—
Carcass yield, %	75.4	75.4	75.4	75.9	0.41	—
Back fat depth, mm	19.6[a]	19.7[a]	17.7[b]	18.9[a]	0.47	—
LM depth, cm	6.18[ab]	5.86[bc]	6.48[a]	5.84[c]	0.165	—
FFLI[5]	49.5	49.2	50.0	49.6	0.24	—

[a–c]The protected treatment means within the same row having different superscripts differ ($P < 0.05$).

[1]The main effects of feeder design were not compared for response criteria after d 69.

[2]A total of 1,296 pigs (PIC, 337 × 1050, initially 19.4 kg) were placed in 48 pens containing 27 pigs each on d 0.

[3]Beginning on d 69, differences between feeder treatments were determined using the PDIFF option of SAS for performance responses that had an overall treatment effect ($P < 0.05$).

[4]Carcass data were obtained for 829 pigs from 38 pens (20 conventional dry and 18 wet-dry feeders) to determine the effects of feeder treatment on carcass characteristics.

[5]FFLI = fat-free lean index.

with the water source changed to the cup waterer on d 69 was intermediate. Pigs using a wet-dry feeder that provided water throughout the study had greater ($P < 0.05$) ADFI from d 97 to 124 than all other feeder treatments. Also, from d 97 to 124, pigs fed with the wet-dry feeder used as a dry feeder beginning on d 69 had improved ($P < 0.05$) G:F compared with those fed with a wet-dry feeder that provided water in the feeder until d 97 or throughout the study, and the G:F of pigs fed with a conventional dry feeder was intermediate.

Overall (d 0 to 124), pigs fed using a wet-dry feeder that provided water in the feeder throughout the study had greater ($P < 0.05$) ADG, ADFI, and final BW than all other treatments. However, pigs fed with a wet-dry feeder that provided water in the feeder from d 0 to 97 had greater ($P < 0.05$) overall ADG than those fed using a conventional dry feeder, and the overall ADG of pigs fed with a wet-dry feeder that provided water in the feeder from d 0 to 69 was intermediate. Pigs fed with a wet-dry feeder that provided water in the feeder from d 0 to 97 also had greater ($P < 0.05$) overall ADFI than those fed with a wet-dry feeder that provided water in the feeder from d 0 to 69, and the overall ADFI of pigs fed with a conventional dry feeder was intermediate. The overall G:F was not different ($P > 0.05$) among pigs fed with the different feeder treatments. The final BW of pigs fed with the wet-dry feeder used as a dry feeder beginning on either d 69 or 97 was not different from those fed with a conventional dry feeder.

Pigs fed using a wet-dry feeder that provided water in the feeder throughout the study had greater ($P < 0.05$) HCW than those using all other feeder treatments. No differences were measured in the carcass yield between treatments. However, back fat depth was reduced ($P < 0.05$) for pigs fed with a wet-dry feeder that was used as a dry feeder beginning on d 69 when compared with those fed using all other feeder treatments. The LM depth of pigs fed with a wet-dry feeder that was used as a dry feeder beginning on d 69 was greater ($P < 0.05$) than that of pigs fed using a wet-dry feeder that provided water from d 0 to 97 or a conventional dry feeder. Also, the LM depth of pigs using a wet-dry feeder that provided water throughout the study was greater ($P < 0.05$) than that of pigs fed with a conventional dry feeder, and the LM depth of pigs fed using a wet-dry feeder that provided water from d 0 to 97 was intermediate. Despite the differences in back fat and LM depth that were observed among pigs fed with the different feeder treatments, there were no differences in FFLI.

Feeding Behaviors

Overall, no feeder treatment × period interactions were observed for the feeding behaviors evaluated in this study (Table 3). For the d 94 to 96 period, pigs visited the feeder more frequently ($P < 0.05$) during the sampled 6 h of time than on d 109 to 111, but the duration of each feeder visit and total time spent at the feeder did not differ between periods. For the d 94 to 96 period and overall (d 94 to 96, d 97 to 99, and d 109 to 111 periods combined), pigs fed with a wet-dry feeder visited the feeder less frequently ($P < 0.05$) and spent less

Table 3. Effects of feeder design and changing the water source to a location separate from the wet-dry feeder at d 97 on feeding behaviors and aggression of finishing pigs on d 94 to 96, d 97 to 99, and d 109 to 111

Item	Wet-dry feeder: Water with feed throughout	Wet-dry feeder: Water with feed to d 97	Dry feeder with cup waterer	SEM
Feeding behaviors (per pig)[1]				
d 94 to 96				
No. of feeder visits	5.7[a]	6.5[a]	12.4[b]	1.85
Duration/visit, min	4.3	5.3	4.3	1.74
Total time at feeder, min	18.0[a]	20.0[a]	41.6[b]	5.58
d 97 to 99				
No. of feeder visits	4.1	3.9	6.8	1.49
Duration/visit, min	4.2	5.5	4.7	1.46
Total time at feeder, min	13.8[a]	15.8[a]	30.0[b]	4.47
d 109 to 111				
No. of feeder visits[2]	2.8[A]	3.3[A]	7.6[B]	1.85
Duration/visit, min	6.3	5.8	5.1	1.74
Total time at feeder, min	16.2	18.3	30.2	5.58
Overall				
No. of feeder visits	4.2[a]	4.6[a]	9.0[b]	0.75
Duration/visit, min	4.9	5.5	4.7	1.18
Total time at feeder, min	16.0[a]	18.0[a]	33.9[b]	2.49
Feeding aggression (per pig)				
d 94 to 96				
No. of occurrences	1.8	2.5	4.8	1.27
Duration/occurrence, s	2.6	2.2	4.0	1.07
d 97 to 99				
No. of occurrences	4.7	2.1	4.0	1.01
Duration/occurrence, s	4.8	3.6	4.0	0.86
d 109 to 111				
No. of occurrences	2.2	1.8	3.5	1.27
Duration/occurrence, s	2.9	3.2	2.6	1.07
Overall				
No. of occurrences	2.9	2.1	4.1	0.69
Duration/occurrence, s	3.4	3.0	3.5	0.59

[a,b]The protected treatment means within the same row having different lowercase superscripts differ ($P < 0.05$).

[A,B]The protected treatment means within the same row having different uppercase superscripts tended to differ ($P < 0.10$).

[1]A total of 9 pens (3 from each feeder treatment) were randomly selected for repeated video recording of feeding behaviors at d 94 to 96, d 97 to 99, and d 109 to 111.The time periods represented just before, just after, and approximately 2 wk after switching the water source on d 97. Within each period, 1 pen from each of the 3 treatments was recorded on each of the 3 d of the period. Eight pigs per pen (4 barrows and 4 gilts) were observed continuously for 6 h (3 h in the morning + 3 h in the afternoon) within each period. The differences between treatments were determined using the PDIFF option of SAS for performance responses that had an overall treatment effect ($P < 0.05$).

[2]The number of feeder visits was less ($P < 0.05$) during the 6 h sampled during the d 109 to 111 period when compared with the d 94 to 96 period.

total time ($P < 0.05$) at the feeder than pigs fed with a conventional dry feeder, with no differences observed in the duration of each feeder visit. For each period and overall, no differences occurred in the feeding behaviors measured for pigs fed with the wet-dry feeder that provided water throughout the experiment and those fed using a wet-dry feeder with water provided separately beginning on d 97. No treatment, period, or overall differences were detected in the number and duration of aggressive occurrences that occurred near the feeder.

DISCUSSION

Similar to previous experiments, pigs fed with a wet-dry feeder that provided water in the feeder had greater ADG, ADFI, and subsequent BW than pigs fed using a dry feeder and separate water source (Brumm et al., 2000; Gonyou and Lou, 2000; Bergstrom, 2011). Although G:F was slightly improved for pigs fed with the wet-dry feeder from d 0 to 69, no difference was detected in the overall G:F of pigs fed with access to water in the wet-dry feeder throughout the study and those fed using the conventional dry feeder. The absence of expected differences in the G:F, back fat depth, and carcass FFLI between pigs fed with access to water in the wet-dry feeder throughout the study and those fed using the conventional dry feeder could reflect the magnitude of differences in ADG and ADFI when compared with some other studies. Payne (1991) suggested that the greater feed intake obtained with a single-space wet-dry feeder could lead to increased carcass fat in some pig genotypes and that a loss in value with some carcass grading systems may negate the observed growth benefits. Other of our experiments support that conclusion, but they also have demonstrated that ADG, ADFI, subsequent BW, and carcass back fat depth can be reduced and G:F improved with a decreased feeder opening of the wet-dry feeder (i.e., reduced accessibility of feed; Bergstrom, 2011). On the basis of the results of these experiments, in which ADG, ADFI, final BW, HCW, and carcass back fat depth increased and G:F was reduced with an increased feeder opening, a feeder opening of 2.54 cm was used for the wet-dry feeder in the current experiment.

As suggested by Amornthewaphat et al. (2000b) and Gonyou and Lou (2000), these data indicate that the availability of water with feed in the wet-dry feeder was responsible for the increase in ADFI, ADG, and subsequent BW. Despite a considerable reduction in ADFI and ADG during d 69 to 97 for pigs with the source of water removed from the wet-dry feeder to a separate source on d 69, the subsequent (d 97 to 124) and overall growth performance of these pigs was not different from those fed with a conventional dry feeder. Therefore, when utilized as a dry feeder, the 2 feeding spaces provided by the wet-dry feeder were sufficient to achieve growth performance similar to that of the conventional dry feeder that provided double the amount of feeder space for 24 to 27 pigs. Likewise, Amornthewaphat et al. (2000b) and Gonyou and Lou (2000) indicated that a single-space feeder with a separate waterer could maintain the growth performance of up to 12 pigs, but the reduced performance observed during the first 28 d after the water source was removed from the wet-dry feeder on d 69 eliminated the net benefit in whole-body growth that had been obtained with the wet-dry feeder up to that point.

Compared with all other feeder treatments during d 97 to 124, pigs fed using the wet-dry feeder with access to water removed to a separate source on d 97 also experienced a considerable reduction in ADG during the following 27 d. Even though the overall ADG of these pigs remained slightly greater than that of pigs fed with the conventional dry feeder, overall ADFI, G:F, final BW, and carcass characteristics were not different. Therefore, despite the demonstrated ability of the wet-dry feeder to function as a dry feeder and to slow late finishing growth when the availability of water was removed from the feeder, the abrupt removal of water from the feeder during the late finishing period seems to require a substantial modification of feeding or drinking behavior or both to maintain any previous benefit in whole-body growth.

Any difference in ADG observed between pigs fed with the wet-dry and dry feeders primarily resulted from a difference in ADFI. Differences in ADFI are demonstrated to be associated with important differences in feeding behaviors. Regardless of the feeder design, when feeding spaces do not seem to be limiting, growing-finishing pigs in groups fed for ad libitum intake have demonstrated a diurnal pattern of feeding similar to that observed for individually housed pigs (de Haer and Merks, 1992; Nielsen et al., 1995a; Bornett et al., 2000). Others also have reported that 2 peak periods of feeding activity may occur during the day, a morning period and an afternoon period (Walker, 1991; de Haer and Merks, 1992; Nielsen et al., 1995a). Although approximately 24 h of continuous video were recorded during each of the 3 periods of interest in the current study, the barn lighting was lowered at night to reduce the number of insects during periods of natural ventilation, which made observation of behaviors during this time period difficult. The ability to observe feeding behaviors during the assumed peak feeding times was both practical and suitable for evaluating potential differences among the selected treatments.

Similar to the observations of Gonyou and Lou (2000), pigs eating from the wet-dry feeder spent less total time eating and had fewer feeder entrances than those fed with the conventional dry feeder during the periods observed; however, little information is available on how these differences in feeding behavior may have developed. All pigs used in the current experiment were received from a commercial nursery where every pen was equipped with a multispace, conventional dry feeder. Magowan et al. (2008) reported that, when compared with pigs maintained on the same type of feeder, ADFI decreased during the first 2 wk in the finisher when groups of 20 pigs were moved from pens with a 4-space dry feeder in the nursery to pens with a single-space wet-dry feeder or vice versa. In their study, the reduced ADFI during the first 2 wk after pigs were moved from the multispace dry feeder to the single-space wet-dry feeder probably reflected the need to adapt to an increased number of pigs per feeding space. Although Magowan et al. (2008) did not report feeding behaviors on a per pig basis, the feeder occupancy rate and aggressive behaviors at the feeder during the first and fourth weeks in the finisher were greatest for pigs moved from the multispace dry feeder to the single-space wet-dry feeder. Nearly 50% more pigs were in each wet-dry feeder space than in the current study, yet the pigs moved from the multispace dry feeder to the single-space wet-dry feeder had slightly greater ADG during the finishing period and overall when compared with the other treatments. Even though pelleted diets were fed throughout the Magowan et al. (2008) experiment, the reduced ADFI during the first 2 wk after pigs were moved from the single-space wet-dry feeder to the multispace dry feeder indicates that a period of adaptation may have been required to adjust for a reduced eating rate.

Using meal diets to compare the eating rate of individual small (41 to 54 kg BW) and large (85 to 94 kg BW) pigs fed with 6 dry and 6 wet-dry feeder designs, Gonyou and Lou (2000) used pigs previously fed from a dry feeder and found no differences in the amount of feed consumed in 10 min from dry and wet-dry feeders after a 6-h period without feed, but large pigs ate faster than small pigs. In another experiment using large pigs held without feed for 6 h, Gonyou and Lou (2000) found that pigs consumed 500 g of feed nearly 3 times faster when it was premixed with an equal amount of water. Hsia and Lu (1985) and Hurst et al. (2008) also have reported a considerably faster eating rate for wet-fed compared with dry-fed pigs. In the current experiment, providing access to water with feed likely increased eating speed for pigs using the wet-dry feeder. This probably resulted in larger meals and the greater ADFI observed, despite the apparent adaptation to fewer meals (or feeder visits) and reduced total time spent feeding compared with those fed with the conventional dry feeder during the late finishing periods (Nielsen, 1999). When access to water with feed was abruptly removed from the wet-dry feeder during the late finishing period, the eating speed of these pigs was most likely reduced, with no apparent adaptation in meal frequency or duration to sustain ADFI.

The food intake and feeding behavior of growing-finishing pigs fed for ad libitum intake are generally influenced by genotype, age, BW, physiological needs, experiences, preferences, and social and environmental constraints (Torrallardona and Roura, 2009). The social and environmental constraints are especially relevant in studies evaluating ad libitum feeders for group-housed finishing pigs. Individually housed pigs achieve greater ADG and ADFI than pigs in groups by consuming feed more frequently in smaller meals of shorter duration at a slower eating rate (de Haer and Merks, 1992; Bornett et al., 2000). When pigs are group housed, a decreased number of feeding spaces and/or an increased degree of protection of the feeder space (or difficulty of access) also can lead to a reduced number of daily meals that are greater in duration with no differences in ADFI or growth performance (Morrow and Walker, 1994; Nielsen et al., 1995a, 1996). However, Walker (1991) reported no difference in the number of daily feeder visits per pig when the number of pigs using a single-space wet-dry feeder was increased from 10 to 30, but the mean duration of each visit decreased as the number of pigs increased. Despite this result, ADG was similar, but ADFI was greater and feed efficiency poorer when there were 20 or 30 pigs per feeder compared with 10. These responses indicate a possible increase in eating rate, feed wastage, or both when 20 or 30 pigs shared feeder space. Nielsen et al. (1995b) reported fewer and longer feeder visits and an increased eating rate when 20 pigs were grouped per single-space dry feeder when compared with 5, 10, and 15 pigs per feeder, but ADG, ADFI, and G:F were similar.

The eating rate of individual pigs in a group offered a particular diet for ad libitum intake has been reported to be relatively stable, regardless of the meal size (Nielsen, 1999). However, eating rate increases during growth (i.e., increased body size), with a concomitant decrease in the daily number of feeder visits or total eating time or both (Hyun et al., 1997; Nielsen, 1999; Gonyou and Lou, 2000). Also, as mentioned previously, eating rate may be influenced by the type or form of the feed presented to the pig (i.e., eating rate for wet feed > pelleted feed > meal feed; Hsia and Lu, 1985), which can result in a reduced time budget for feeding that is accomplished with fewer visits to the feeder (Gonyou and Lou, 2000).

Pigs are social animals, and the number, duration, and size of meals established by pigs fed for ad libitum intake in a group seem to represent adaptations in feeding motivation to attempt to achieve synchrony or cohesion in feeding and other behaviors (Nielsen, 1999; Bornett et al., 2000). In the current experiment, the reduction in ADFI (and ADG) observed after pigs were changed abruptly from wet-dry to dry feeding in the late finishing period did not appear to induce changes in the feeding pattern when they were maintained on the same feeder and provided a separate water source. Also, the amount of aggression observed at the feeder did not increase and was numerically less for pigs with the wet-dry feeder design overall. This was probably due to the protected head space provided by the sides of the wet-dry feeder, whereas the 5 feeding spaces of the conventional dry feeder were simply divided by nose barriers (Baxter, 1991). Several weeks may have been required for these pigs to adapt an eating rate that resulted in ADFI similar to those fed with the conventional dry feeder.

In conclusion, pigs fed with the wet-dry feeder that provided access to water with feed throughout the experiment had greater ADG, ADFI, final BW, and HCW than pigs fed with the conventional dry feeder or wet-dry feeder with access to water removed to a separate source. The greater ADFI and ADG obtained when access to water was provided in the wet-dry feeder seemed to result from an increased eating rate. Abruptly changing the source of water in the wet-dry feeder to a separate cup waterer during the finishing period was followed by a 4-wk period of reduced growth that eliminated the net benefit in growth that had been obtained with the wet-dry feeder. This indicates that pigs did not rapidly increase their eating time duration when abruptly changing the water source for the wet-dry feeder. Thus, the pigs had an eating time duration similar to a wet-dry feeder with water and a slower eating rate similar to pigs fed with a dry feeder. Removing access to water at the wet-dry feeder to a separate water source did not result in changes in the feeding pattern or aggression but required an adaptation for increased eating speed to achieve ADFI and ADG similar to that obtained with the conventional dry feeder. This research provides useful information for the further development of novel feeding concepts to manipulate growth and perhaps improve the efficiency of growing-finishing pigs fed for ad libitum intake.

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