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Effects of abrupt introduction and removal of high and low digestibility corn distillers dried grains with solubles from the diet on growth performance and carcass characteristics of growing-finishing pigs[1]

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ABSTRACT: Two experiments were conducted to evaluate the effects of feeding continuously a diet containing 40% dried distillers grains with solubles (DDGS) or intermittently diets containing 20 or 40% DDGS on growth performance and carcass quality of pigs. Responses of the pigs to abrupt introduction and removal of dietary DDGS with differing concentrations of standardized ileal digestible (SID) AA were also evaluated. In Exp. 1, crossbred pigs (n = 216; initial BW = 51.3 ± 3.1 kg) were assigned randomly to 1 of 4 treatments, which included a corn-soybean meal control (CON), a 20% DDGS diet (D20), a switch between D20 and CON (D20-CON), and a switch between a 40% DDGS diet and CON (D40-CON) with 6 pens per treatment. Pigs abruptly introduced and removed from a 20% DDGS diet (D20-CON) exhibited no differences in growth performance or carcass quality compared with CON pigs. However, intermittently feeding a 40% DDGS diet (D40-CON) resulted in lighter HCW (P < 0.05) compared with all other treatments. In Exp. 2, crossbred pigs (n = 324; initial BW = 33.2 ± 3.0 kg) were assigned randomly to 1 of 6 treatments, including a corn-soybean meal control (CON), a 40% low SID AA DDGS diet (LD), a 40% high SID AA DDGS diet (HD), LD and CON diets alternated (LD-CON), HD and CON diets alternated (HD-CON), or HD and LD diets alternated (HD-LD) with 6 pens per treatment. Final BW and ADG were less (P < 0.05) for LD and HD-LD pigs compared with CON pigs, but HD pigs tended to have reduced (P < 0.10) final BW and ADG. Loin muscle area was smaller for LD and HD-LD pigs compared with CON pigs (P < 0.05). Percentage carcass lean was not affected by dietary treatment. Backfat of DDGS-fed pigs was more unsaturated than CON pigs, but AA digestibility of DDGS did not affect this response. Digestibility of AA in DDGS can influence pig performance and carcass quality when fed at high concentrations (40% or more). The use of a high SID AA DDGS source may diminish some of the negative responses observed for growth performance and carcass characteristics when feeding high concentrations of DDGS if accurate values of SID AA are used in diet formulation. Periodic inclusion and removal of 40% DDGS from diets did not adversely affect growth performance or carcass quality regardless of the SID AA digestibility of the DDGS used. These results indicate that it is possible to abruptly incorporate and remove DDGS from grower-finisher swine diets without meaningful detrimental effects on growth performance or carcass quality.

Key words: carcass quality, distillers dried grains with solubles, performance, pigs

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INTRODUCTION

Low cost ingredients capable of reducing overall feed expense without affecting pig performance and carcass quality are advantageous to producers. Dried distillers grains with solubles (**DDGS**) added to diets at moderate levels (10 to 20%) decrease diet cost without affecting pig performance (Stein and Shurson, 2009). Grower-finisher pigs consuming a 30% DDGS diet formulated on a total AA basis had reduced growth and carcass leanness compared with pigs receiving 10 or 20% DDGS (Whitney et al., 2006). However, Xu et al. (2010a) demonstrated DDGS may be added to growing-

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finishing swine diets at up to 30% without reducing growth performance and carcass quality when diets were formulated on a standardized ileal digestible (**SID**) AA basis. Economic advantages often exist for feeding diets with increased levels (40 to 50%) of DDGS, but few studies (Cromwell et al., 2011) have been reported that evaluated the feasibility of feeding such high concentrations.

The physical appearance, chemical composition, and nutrient digestibility of DDGS vary considerably among sources because of differences in processing and drying procedures (Cromwell et al., 1993; Spiehs et al., 2002). Drescher et al. (2009) demonstrated that DDGS with low SID AA may reduce pig performance, but DDGS with greater SID AA can support performance similar to a corn-soybean meal diet.

Fluctuations in DDGS pricing and availability may make its inclusion in swine diets economical intermittently throughout the grower-finisher phase. To capture the economic advantages, producers may need to abruptly switch between diets with and without DDGS. The response of growth and carcass traits of the pigs to abrupt inclusion and removal of dietary DDGS differing in quality have not been studied. Thus, the objectives of the experiments in this study were to determine the effects of abrupt introduction and removal of DDGS from growing-finishing pig diets, the effects of continuously feeding a diet containing 40% DDGS, and if the response of the pigs to abrupt introduction and removal of dietary DDGS is influenced by AA digestibility of the DDGS.

MATERIALS AND METHODS

The experimental protocols used in these studies were approved by the University of Minnesota Institutional Animal Care and Use Committee.

The experiments were conducted in the swine research unit at the University of Minnesota's West Central Research and Outreach Center (Morris, MN). Pigs were housed in an environmentally-controlled, grower-finisher barn with a target room temperature of 20°C. Each pen (1.60 × 4.5 m) was equipped with 2 nipple waterers, one 4-space self-feeder, and totally-slatted, concrete floors. Diets were formulated on a SID AA basis using digestibility coefficient values obtained from a previous study (Urriola et al., 2007). All diets met or exceeded NRC (1998) nutrient requirements for growing-finishing pigs gaining 350 g lean/day. Pigs were allowed ad libitum access to feed and water throughout the experiments. Pigs were Duroc (Compart's Boar Store, Nicollet, MN) sired terminal offspring of Yorkshire × Landrace sows (Genetically Advanced Pigs, Winnipeg, MB).

Experiment 1

Pigs (n = 216; BW = 51.3 ± 3.1 kg) were segregated into 6 blocks by initial BW (4 pens/block; 9 pigs/pen) and assigned randomly to 1 of 24 pens. Sex ratio (5 barrows and 4 gilts) was kept similar among pens. Pens within a block were assigned randomly to 1 of 4 treatments fed in 3 phases, resulting in 6 pens per treatment.

Dried distillers grain with solubles (Bushmills Ethanol, Inc., Atwater, MN) was obtained in a single lot (Table 1). The 3 diets (Table 2) used during the experiment consisted of a corn-soybean meal control diet (**CON**), a corn-soybean meal diet containing 20% DDGS (**D20**), and a corn-soybean meal diet containing 40% DDGS (**D40**). Diets were fed in 3 phases based on BW (Phase 1: 50 to 70 kg, Phase 2:70 to 90 kg, and Phase 3:90 to 112 kg). Phase changes were made when the average BW of pigs within a pen was within 2.3 kg of the targeted beginning BW of a phase. All pigs consumed a standard corn-soybean meal diet before the beginning of the experiment. A feed sample (about 1 kg) collected from each batch of feed mixed was frozen (–20°C) for subsequent analysis. Three samples of each diet (1 sample from each of the 3 phases; 9 samples total) were selected randomly for analysis of nutrient composition (University of Missouri, Columbia, MO). Diets were analyzed according to AOAC (2006)

Table 1. Analysis of distillers dried grains with solubles (DDGS) from different sources used in Exp. 1 and 2 (as-fed basis)

	DDGS Source[1,2]		
Item	Exp 1, DDGS	Exp. 2, High SID AA DDGS	Exp. 2, Low SID AA DDGS
DM, %	88.2	88.4	90.5
CP, %	29.1	27.8	27.2
ME,[3] kcal/kg	3,467	3,400	3,280
Crude Fat, %	10.4	9.9	10.5
ADF, %	12.4	14.6	16.0
NDF, %	–	40.0	30.6
Available P, %	0.61	0.51	0.41
Total Lys, %	1.02	0.90	0.67
Total Met, %	0.54	0.59	0.51
Total Cys, %	–	0.63	0.51
Total Thr, %	0.96	0.99	0.99
Total Trp, %	0.20	0.24	0.22
SID Lys, %	0.70	0.58	0.41
SID Met, %	0.39	0.49	0.42
SID Cys, %	–	0.48	0.38
SID Thr, %	0.71	0.70	0.69
SID Trp, %	0.16	0.16	0.14

[1]DDGS sources: Exp. 1, DDGS = Bushmills Ethanol, Inc. (Atwater, MN); Exp. 2, High standardized ileal digestible (SID) AA DDGS = Lincolnland Agri-Energy, LLC (Palestine, IL); Exp. 2, Low SID AA DDGS = Center Ethanol Company, LLC (Sauget, IL).

[2]Estimates of SID AA concentrations were derived from the IDEA assay (NOVUS International, St. Louis, MO).

[3]ME values estimated from prediction equations (Pedersen et al., 2007).

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

	Phase 1 (50 to 70 kg BW)			Phase 2 (70 to 90 kg BW)			Phase 3 (90 to 112 kg BW)		
Item	CON[1]	D20[1]	D40[1]	CON	D20	D40	CON	D20	D40
Ingredient, %									
Corn	78.98	63.51	47.91	83.36	67.90	52.25	88.36	72.91	57.19
Soybean meal, 46% CP	18.60	14.32	10.03	14.36	10.07	5.79	9.50	5.20	0.95
DDGS	–	20.00	40.00	–	20.00	40.00	–	20.00	40.00
Limestone ($CaCO_3$)	0.95	1.21	1.36	0.87	1.13	1.26	0.80	1.06	1.16
Monocalcium phosphate	0.77	0.26	–	0.71	0.20	–	0.64	0.13	-
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
VTM premix[2]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lys · HCl	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated composition									
ME, kcal/kg	3,293	3,321	3,344	3,308	3,336	3,358	3,324	3,352	3,373
Available P, %	0.23	0.23	0.28	0.21	0.21	0.28	0.19	0.19	0.27
SID[3] Lys, %	0.74	0.74	0.74	0.65	0.65	0.65	0.53	0.53	0.53
SID Met + Cys, %	0.47	0.52	0.58	0.43	0.49	0.55	0.39	0.45	0.51
SID Thr, %	0.46	0.51	0.51	0.41	0.45	0.50	0.35	0.39	0.44
SID Trp, %	0.14	0.14	0.14	0.12	0.12	0.12	0.10	0.10	0.10
Analyzed composition									
DM, %	86.48	86.95	87.53	86.69	86.81	86.43	86.80	86.43	87.73
CP, %	13.70	17.59	20.22	13.21	15.95	19.03	10.96	14.26	17.62
Ca, %	0.50	0.65	0.68	0.60	0.56	0.71	0.53	0.54	0.50
P, %	0.46	0.46	0.48	0.45	0.43	0.46	0.40	0.38	0.44
ADF, %	2.24	4.06	5.84	2.21	3.95	6.03	1.92	3.91	5.72
Crude fat, %	2.49	3.92	5.58	2.50	4.00	6.25	2.55	4.12	6.30

[1]Diets: CON = corn-soybean meal control; D20 = diet containing 20% distillers dried grains with solubles (DDGS); D40 = diet containing 40% DDGS.

[2]VTM premix = vitamin-trace mineral premix, which supplied per kilogram of diet: vitamin A, 8,820 IU; vitamin D_3, 1,653 IU; vitamin E, 33.1 IU; vitamin K, 4.4 mg; riboflavin, 6.6 mg; niacin, 38.9 mg; pantothenic acid, 22.1 mg; vitamin B_{12}, 0.04 mg; I, 1.1 mg as potassium iodide; Se, 0.30 mg sodium selenite; Zn, 60.6 mg as zinc oxide; Fe, 36.4 mg as ferrous sulfate; Mn, 12.1 mg as manganous oxide; and Cu, 3.6 mg as copper sulfate.

[3]SID = Standardized ileal digestible.

procedures for DM (Method 934.01), CP (Method 990.03), Ca (Method 985.01), P (Method 985.01), ADF (Method 973.18), crude fat (Method 920.39), and AA (Method 982.30). The 4 treatments consisted of: i) CON diet fed continuously throughout the trial (CON), ii) D20 diet fed continuously throughout the trial (D20), iii) D20 and CON diets alternated every 2 wk throughout the trial (**D20-CON**), and iv) D40 and CON diets alternated every 2 wk (**D40-CON**). There were five 2-wk feeding periods with pigs assigned to the D20-CON and D40-CON treatments starting and ending the trial consuming the DDGS based diets (Table 3).

Body weight of individual pigs and pen feed disappearance were measured every other week and used to calculate ADG and ADFI, respectively, as well as G:F. Pigs were harvested on a single day after the 72-d feeding period in a commercial abattoir (Sioux-Preme Packing Co., Sioux Center, IA) when the average final BW of all pigs was 112 kg. Tenth rib backfat depth (**BF**), loin muscle area (**LMA**), and HCW were recorded at the abattoir and used to calculate dressing percentage (**DP**) and carcass lean percentage (**CLP**). Carcass lean percentage was calculated using the following formula: CLP = {[3.895 – (0.391 × BF, mm) + (0.00211 × 10th rib LMA, mm^2) + (0.465 × HCW, kg)]/HCW, kg} × 100 (NPPC, 2000). Complete carcass data were recorded from a total of 188 pigs. Two pigs were removed from the experiment due to death or illness, 19 randomly selected pigs (1 pig per pen) were retained due to limitations in the harvest capacity of the abattoir, and data from 7 pigs were missing from the abattoir.

Two pigs from each test pen (1 barrow and 1 gilt), with final BW closest to the mean pen BW, were selected

Table 3. Diet assignments for each experimental treatment, Exp. 1

	Diet received[2]				
Treatment[1]	wk 1 to 2	wk 3 to 4	wk 5 to 6	wk 7 to 8	wk 9 to 10
CON	CON	CON	CON	CON	CON
D20	D20	D20	D20	D20	D20
D20-CON	D20	CON	D20	CON	D20
D40-CON	D40	CON	D40	CON	D40

[1]Treatments: CON = CON diet fed continuously; D20 = D20 diet fed continuously; D20-CON = switch between D20 and CON diets; and D40-CON = switch between D40 and CON diets.

[2]Diets: CON = corn-soybean meal control; D20 = diet containing 20% distillers dried grains with solubles (DDGS); and D40 = diet containing 40% DDGS.

preharvest for fatty acid analysis of backfat. At 24 h postmortem, a 2.54-cm-diameter core sample of backfat was collected opposite the 10th rib on the right side of the carcass. Samples were packaged in presterilized wire twirl closure sample bags and stored at –20°C until laboratory analysis. Fatty acid analysis was performed using the rapid direct extraction derivation method developed by Long et al. (1988).

Experiment 2

Three hundred twenty-four pigs (initial BW = 33.2 ± 3.0 kg) were segregated into 6 blocks by initial BW (6 pens/block; 9 pigs/pen) and assigned randomly to 1 of 36 pens. Sex ratio was kept similar among pens (5 barrows and 4 gilts or 4 barrows and 5 gilts). Pens within a block were assigned randomly to 1 of 6 treatments, resulting in 6 pens per treatment.

Two sources of DDGS, a high SID AA DDGS (LincolnLand Agri-Energy, LLC, Palestine, IL) and a low SID AA DDGS (Center Ethanol Company, LLC, Sauget, IL), were obtained (Table 1). Estimates of SID AA content of DDGS sources were derived from an assay (IDEA assay; NOVUS International, St. Louis, MO), whereas NRC (1998) estimates for SID AA content for corn and soybean meal were used. Metabolizable energy values for the DDGS sources were derived from ME prediction equations (Pedersen et al., 2007), and ME values for corn and soybean meal were obtained from NRC (1998). Each source of DDGS was purchased in a single lot. Three diets were formulated on a SID AA basis and fed in 4 phases (Table 4). Diets consisted of a typical corn-soybean meal control (CON), a corn-soybean meal diet containing 40% low SID AA DDGS (**LD**), and a corn-soybean meal diet containing 40% high SID AA DDGS (**HD**). All pigs consumed a standard corn-soybean meal diet before the beginning of the experiment. Individual feed samples (about 1 kg) were taken from each batch of feed mixed and frozen at –20°C for future analysis. From all samples, 4 samples of each diet (1 sample from each of the 4 phases; 12 samples total) were selected randomly for analysis of nutrient composition and mycotoxin content by a commercial laboratory (Minnesota Valley Testing Laboratories, Inc., New Ulm, MN). Diets were analyzed according to standardized procedures for DM (Shreve et al., 2006), CP (Method 990.03; AOAC, 2006), Ca (Method 985.01; AOAC, 2006), P (Method 985.01; AOAC, 2006), NDF (Method 2002.04; AOAC, 2006), ADF (Method 973.18; AOAC, 2009), crude fat (Method 920.39; AOAC, 2006;) and mycotoxins [aflatoxins B1, B2, G1, and G2 (Method 991.31); zearalenone (Method 985.18), fumonsin B1 and B2 (Method 2001.04); and vomitoxin (DON Test); AOAC, 2006]. The 6 treatments included: i) CON fed continuously (CON); ii) LD fed continuously (LD); iii) HD fed continuously (HD); iv) LD and CON diets alternated by phase (**LD-CON**); v) HD and CON diets alternated by phase (**HD-CON**); and vi) HD and LD diets alternated by phase (**HD-LD**). All diet phase changes were made on a pen basis when the average BW of pigs in the pen was within 2.3 kg of the target weight for the phase change (Table 5). Phases were based on BW (Phase 1: 33 to 50 kg, Phase 2: 50 to 70 kg, Phase 3: 70 to 90 kg, and Phase 4: 90 to 120 kg).

Body weight of individual pigs and pen feed disappearance were measured every other week and used to calculate ADG, ADFI, and G:F. To better understand how diet changes affected ADFI, feed disappearance was also measured on d 3 and 7 after a diet phase change coinciding with actual diet changes for LD-CON, HD-CON, and HD-LD treatments.

After a 98-d feeding period, pigs were harvested on a single day at a commercial abattoir (Hormel Foods Corp., Austin, MN) when the average final BW of all pigs was 120 kg. Five days preharvest, real-time ultrasound imaging (Aloka 500V SSD; Hitachi-Aloka Medical Ltd., Tokyo, Japan) by a trained and certified technician was used to collect LMA and BF on all pigs (n = 324). Hot carcass weight was collected at the abattoir and used with the ultrasound data and final BW to calculate DP and CLP. Carcass lean percentage was calculated using this formula: CLP = [({[0.378 × sex of pig (barrow = 1, gilt = 2)] – (0.295 × BF, mm) + (0.00381 × 10th rib LMA, mm^2) + (0.291 × BW, kg) – 0.242}/BW, kg) × 100]/0.74 (NPPC, 2000). Backfat samples from 2 pigs/pen (1 barrow and 1 gilt) were obtained as described for Exp. 1. The iodine value (**IV**) of fat was calculated using this 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 brackets indicate concentration. Body weight of 9 pigs was too low to meet optimum BW for commercial harvest resulting in HCW, DP, and CLP determinations for 315 pigs.

Statistical Analysis

Data in both experiments were analyzed in a randomized complete block design using the Mixed procedure (SAS Inst. Inc., Cary, NC). The statistical model for overall performance and carcass characteristics included treatment as a fixed effect and block as a random effect. The pen was the experimental unit. For analysis of fatty acid composition of backfat, the pig served as the experimental unit and the statistical model included fixed effects of treatment, sex, and their interaction.

Repeated measures analysis was used to determine the effects of treatments on growth performance data collected across consecutive diet phases. Treatment and time were fixed effects, block was a random effect, and pen was the experimental unit in the model. In Exp. 1, heterogeneous compound-symmetry, first-order autoregressive, and unstructured covariance structures were used to model the errors within experimental units across time. Unstructured, first-order autoregressive, and first-order antedependence covariance structures were used in Exp. 2. Akaike's Information Criterion (**AIC**) was used to determine the most appropriate covariance structure for each variable. The model with the smallest AIC value was considered the best fit for the data and is reported here.

The effects of diet changes on ADFI in Exp. 2 were analyzed using a repeated measures analysis. Days, phase, and sequence were included as fixed effects, block was a random effect and pen was the experimental unit. The covariance structure used was first-order antedependence.

All reported means are least square means. Means separation was accomplished by the PDIFF option of

Table 5. Diet assignments for each experimental treatment, Exp. 2

	Diet received[2,3]			
Treatment[1]	Phase 1	Phase 2	Phase 3	Phase 4
CON	CON	CON	CON	CON
LD	LD	LD	LD	LD
HD	HD	HD	HD	HD
LD-CON	LD	CON	LD	CON
HD-CON	HD	CON	HD	CON
HD-LD	HD	LD	HD	LD

[1]Treatments: CON = CON diet fed continuously; LD = LD diet fed continuously; HD = HD diet fed continuously; LD-CON = alternated between LD and CON diets; HD-CON = alternated between HD and CON diets; and HD-LD = alternated between HD and LD diets.

[2]Diets: CON = corn-soybean meal control; LD = diet containing 40% low standardized ileal digestible (SID) AA distillers dried grains with solubles (DDGS); and HD = diet containing 40% high SID AA DDGS.

[3]Phases: Phase 1 = 33 to 50 kg BW; Phase 2 = 50 to 70 kg BW; Phase 3 = 70 to 90 kg BW; and Phase 4 = 90 to 120 kg BW.

Table 4. Composition of experimental diets (as-fed basis), Exp. 2

	Phase 1 (33 to 50 kg BW)			Phase 2 (50 to 70 kg BW)			Phase 3 (70 to 90 kg BW)			Phase 4 (90 to 120 kg BW)		
Item	CON[1]	LD[1]	HD[1]	CON	LD	HD	CON	LD	HD	CON	LD	HD
Ingredient, %												
Corn	73.67	37.73	40.64	81.12	45.22	48.12	83.40	47.47	50.40	86.19	50.26	53.18
Soybean meal, 46% CP	23.85	20.10	17.27	16.51	12.72	9.90	14.31	10.56	7.71	11.50	7.75	4.90
Low SID AA DDGS[2]	0.00	40.00	0.00	0.00	40.00	0.00	0.00	40.00	0.00	0.00	40.00	0.00
High SID AA DDGS[2]	0.00	0.00	40.00	0.00	0.00	40.00	0.00	0.00	40.00	0.00	0.00	40.00
Limestone ($CaCO_3$)	0.94	1.29	1.39	0.83	1.18	1.28	0.74	1.09	1.19	0.76	1.12	1.22
Monocalcium phosphate	0.85	0.19	0.00	0.85	0.18	0.00	0.85	0.18	0.00	0.85	0.18	0.00
Salt (NaCl)	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
VTM premix[3]	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25	0.25
L-Lysine HCl	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated composition:												
ME, kcal/kg	3,278	3,241	3,299	3,299	3,263	3,321	3,307	3,271	3,329	3,313	3,277	3,335
Available P, %	0.26	0.26	0.26	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24	0.24
SID Lys, %	0.87	0.87	0.87	0.69	0.69	0.69	0.64	0.64	0.64	0.57	0.57	0.57
SID Met + Cys, %	0.52	0.68	0.73	0.46	0.62	0.66	0.44	0.60	0.64	0.41	0.57	0.62
SID Thr, %	0.56	0.69	0.65	0.46	0.59	0.55	0.43	0.56	0.52	0.39	0.52	0.49
SID Trp, %	0.17	0.18	0.18	0.13	0.15	0.14	0.12	0.14	0.13	0.11	0.12	0.12
Analyzed composition:												
DM, %	87.47	89.31	88.55	88.47	89.64	88.86	86.40	89.18	88.30	87.01	88.90	88.64
CP, %	17.30	23.40	23.00	10.90	20.80	19.40	11.40	19.10	17.70	13.80	18.10	17.60
Ca, %	0.58	0.70	0.46	0.56	0.51	0.17	0.49	0.60	0.58	0.58	0.55	0.66
P, %	0.48	0.63	0.53	0.44	0.47	0.34	0.46	0.59	0.54	0.58	0.52	0.53
NDF, %	8.30	17.50	16.10	9.40	17.10	15.10	10.00	17.90	16.60	9.40	15.50	17.00
ADF, %	2.58	6.79	5.98	1.96	7.28	6.62	2.70	6.53	5.61	1.81	6.85	5.35
Fat, %	2.49	5.29	4.56	2.69	5.36	4.89	2.64	5.27	5.04	2.86	5.38	4.90
Mycotoxins,[4] ppm:												
Fumonisin B1	<0.2	0.73	0.79	<0.2	0.82	0.82	<0.2	0.78	0.82	<0.2	0.79	0.78
Vomitoxin	0.32	1.06	1.26	0.30	1.04	1.14	0.36	1.10	1.07	0.31	1.11	1.08

[1]Diets: CON = corn-soybean meal control; LD = diet containing 40% low standardized ileal digestible (SID) AA distillers dried grains with solubles (DDGS); and HD = diet containing 40% high SID AA DDGS.

[2]Sources: Low SID AA DDGS = Center Ethanol Company, LLC (Sauget, IL); and High SID AA DDGS = LincolnLand Agri-Energy, LLC (Palestine, IL).

[3] VTM premix = vitamin-trace mineral premix, which supplied per kg of diet: vitamin A, 8,820 IU; vitamin D_3, 1,653 IU; vitamin E, 33.1 IU; vitamin K, 4.4 mg; riboflavin, 6.6 mg; niacin, 38.9 mg; pantothenic acid, 22.1 mg; vitamin B_{12}, 0.04 mg; I, 1.1 mg as potassium iodide; Se, 0.30 mg sodium selenite; Zn, 60.6 mg as zinc oxide; Fe, 36.4 mg as ferrous sulfate; Mn, 12.1 mg as manganous oxide; and Cu, 3.6 mg as copper sulfate.

[4]Concentrations of Alfatoxin (B1, G1, B2, and G2), Fumonisin B2 and Zearalenone below detection limit of assay.

SAS with the Tukey-Kramer adjustment. Satterthwaite's procedure was used to approximate the denominator degrees of freedom. The significance level was set at $P < 0.05$, with $0.05 < P < 0.10$ indicating a trend.

RESULTS AND DISCUSSION

Experiment 1

Pigs experienced a generalized outbreak of *Streptococcus suis* on d 42 of the experiment and subsequently all pigs received amoxicillin treatment via drinking water. Additional morbidity among treatments represented 27, 10, 36, and 30 total pig-treatment days for the CON, D20, D20-CON, and D40-CON treatments, respectively. One pig from the D20-CON treatment was removed from the experiment due to illness, and 1 pig from the CON treatment was removed due to death. Total number of pigs completing the experiment was 53, 54, 53, and 54 for the CON, D20, D20-CON, and D40-CON treatments, respectively.

Growing-finishing pigs can consume diets containing up to 20% DDGS without negatively affecting growth performance (Stein and Shurson, 2009). Likewise, in our experiment, growth performance (Table 6) and carcass quality (Table 7) were not affected by continuously feeding a diet with 20% DDGS (D20) when compared with CON. Traditionally, nutritionists have recommended gradual increases in dietary inclusion rates when incorporating new ingredients in swine diets to allow pigs a gradual adaptation to new formulations without hindering performance (Thaler and Holden, 2010). In our current study, pigs experiencing abrupt changes between a 20% DDGS diet and a corn-soybean meal diet with no DDGS (D20-CON) exhibited no differences in growth performance or carcass quality when compared with pigs assigned to CON. As a result, this is the first evidence demonstrating the feasibility of capturing increased economic returns by abruptly introducing or removing DDGS (at or below 20% dietary inclusion rate) in grower-finisher diets. When pigs were introduced abruptly to a diet containing 40% DDGS (D40-CON), HCW was reduced ($P < 0.05$) along with periodic reductions in feed intake associated with the consumption of a 40% DDGS diet (Fig. 1). However, ADFI of pigs assigned to D40-CON rebounded when they were switched back to the CON diet, resulting in no overall differences in feed intake between the D40-CON and CON treatments. The depression in ADFI when pigs were offered D40 indicates DDGS concentration was too high for abrupt diet changes. Drescher et al. (2009) demonstrated that DDGS with low digestible AA may reduce pig performance, but greater digestible AA DDGS can support performance similar to a corn-soybean meal diet. This led us to the hypothesize that it may be possible to intermittently include a very high concentration (40%) of DDGS in grower-finisher swine diets without compromising pig performance if a DDGS source with an accurately estimated high SID AA content is used.

Table 6. Effects of dietary distillers dried grains with solubles (DDGS) inclusion and removal on pig growth performance, Exp. 1

	Treatment[1]				
Trait	CON	D20	D20-CON	D40-CON	SEM
No. of pens	6	6	6	6	–
No. of pigs	53	54	53	54	–
Initial BW, kg	51.3	51.3	51.3	51.4	0.01
Final BW, kg	112.2^{xy}	112.2^{xy}	113.0^{x}	110.6^{y}	0.8
ADG, kg	0.87	0.87	0.88	0.85	0.001
ADFI, kg	2.70^{xy}	2.75^{x}	2.71^{xy}	2.63^{y}	0.002
G:F	0.323^{ab}	0.317^{a}	0.325^{b}	0.322^{ab}	0.001

[a–c]Within a row, means without a common superscript differ ($P < 0.05$).

[x,y]Within a row, means without a common superscript differ ($P < 0.10$).

[1]Treatments: CON = control diet fed continuously; D20 = 20% DDGS diet fed continuously; D20-CON = switch between D20 and CON diets; and D40-CON = switch between a 40% DDGS diet and the CON diet.

Experiment 2

Final BW and ADG were less ($P < 0.05$; Table 8) for LD and HD-LD pigs when compared with CON pigs, but HD pigs only tended to have decreased ($P < 0.10$) final BW and ADG compared with pigs assigned to the CON treatment. Pigs continuously fed the LD diet tended to exhibit a decrease in ADFI compared with the CON pigs ($P < 0.10$). Efficiency of BW gain was not affected by dietary treatments. These results indicate that pigs continuously fed a 40% low digestible AA DDGS based diet formulated on a SID AA basis have decreased ADG compared with pigs continuously consuming a corn-soybean meal based diet and tended ($P < 0.10$) to have reduced ADFI. The use of a high SID AA DDGS source was able to partially diminish some of the reductions observed in growth performance when feeding DDGS at 40% of the diet. This could indicate that the estimated SID

Table 7. Effects of dietary dried distillers grains with solubles (DDGS) inclusion and removal on pig carcass quality, Exp. 1

	Treatment[1]				
Trait	CON	D20	D20-CON	D40-CON	SEM
No. of pens	6	6	6	6	–
No. of pigs	49	47	47	45	–
10th rib backfat depth, mm	19.3	20.1	20.4	19.8	0.6
LM area, cm^2	48.8	48.3	48.2	47.6	2.3
HCW, kg	83.8^{a}	83.6^{a}	84.3^{a}	81.1^{b}	0.6
Carcass lean, %	54.4	54.0	53.8	54.2	0.4
Dressing %	74.8	74.6	74.6	73.8	0.2

[a,b]Within a row, means without a common superscript differ ($P < 0.05$).

[1]Treatments: CON = control diet fed continuously; D20 = 20% DDGS diet fed continuously; D20-CON = switch between D20 and CON diets; and D40-CON = switch between a 40% DDGS diet and the CON diet.

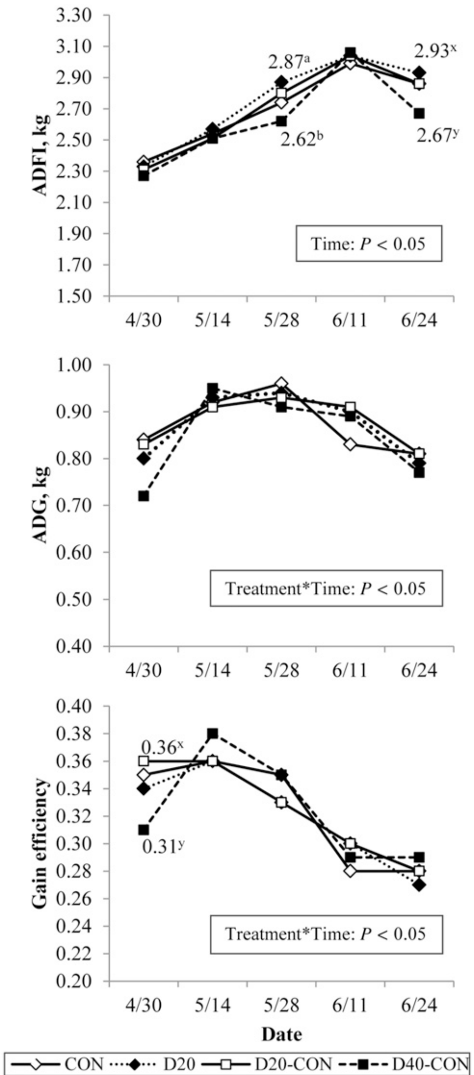

Figure. 1. Effect of continuous and intermittent feeding of dried distillers grains with solubles (DDGS) on ADG, ADFI, and G:F over time (Exp. 1). Treatments: CON = corn-soybean meal diet fed continuously; D20 = 20% DDGS diet fed continuously; D20-CON = switch between D20 and CON diets; and D40-CON = switch between a 40% DDGS diet and CON diet. [a,b]Means within dates differ ($P < 0.05$). [x,y]Means within dates differ ($P < 0.10$).

AA value or calculated ME content of the LD diet (or both) was overestimated when formulating diets. Differences in production methods and drying procedures can lead to increased variability in AA digestibility and nutrient content of DDGS among ethanol plants (Cromwell et al., 1993; Spiehs et al. 2002). These differences can lead to inaccuracies in diet formulation when using estimated nutrient values. It is unknown if the negative responses observed for growth performance and carcass characteristics in the LD and HD-LD pigs would have occurred if more accurate nutrient values were used. The tendency for improved performance of pigs continuously consuming the high SID AA DDGS based diet indicates that estimated SID AA values and ME content of the HD diets were more accurate than values obtained for the LD diet formulations. Loin muscle area was smaller for LD and HD-LD pigs compared with CON pigs ($P < 0.05$; Table 9). Hot carcass weights were reduced ($P < 0.05$) for LD, HD, and HD-LD pigs compared with CON. However, percentage carcass lean was not affected by dietary treatment, and DP was less for the LD, HD, and HD-LD pigs compared with CON ($P < 0.05$). These results are in agreement with previous findings where HCW and DP decreased as levels of DDGS in the diet increased (Feoli et al., 2007; Linneen et al., 2008). Stein and Shurson (2009) noted a reduction in DP in 8 of the 18 experiments they reviewed when corn DDGS was fed at levels up to 30% of the diet to grower-finisher pigs. The addition of high fiber ingredients, such as DDGS, to pig diets may result in decreased DP because of increased gut fill and increased intestinal mass (Kass et al., 1980). Regardless of the AA digestibility of the DDGS source fed, pigs continuously consuming a 40% DDGS based diet had reductions in growth performance and carcass quality. Cromwell et al. (2011) reported a linear decline in ADG with no effects on ADFI or G:F when pigs were fed 0 to 45% DDGS continuously in diets from 33 to 121 kg BW.

Table 8. Effects of distillers dried grains with solubles (DDGS) inclusion and removal and DDGS quality on pig growth performance, Exp. 2

	Treatment[1]						
Trait	CON	LD-CON	HD-CON	LD	HD	HD-LD	SEM
No. of pens	6	6	6	6	6	6	–
No. of pigs	54	54	54	54	54	54	–
Initial BW, kg	33.2	33.2	33.2	33.2	33.2	33.2	0.01
Final BW, kg	$121.5^{ab,x}$	$121.6^{ab,x}$	$123.0^{a,xy}$	$115.9^{c,xy}$	$118.3^{bc,y}$	$117.8^{c,xy}$	1.1
ADG, kg	$0.92^{ab,x}$	$0.92^{ab,x}$	$0.93^{a,xy}$	$0.86^{c,xy}$	$0.89^{bc,y}$	$0.88^{c,xy}$	0.01
ADFI, kg	$2.70^{ab,x}$	$2.72^{a,xy}$	$2.78^{a,xy}$	$2.57^{b,y}$	$2.73^{ab,xy}$	$2.68^{ab,xy}$	0.002
G:F	0.34	0.34	0.34	0.34	0.33	0.33	0.001
Lean gain/d, kg	0.395^{ab}	0.396^{ab}	0.405^{a}	0.362^{d}	0.383^{bc}	0.367^{cd}	0.001
Lean gain efficiency	0.15	0.15	0.15	0.14	0.14	0.14	0.002

[a–c]Within a row, means without a common superscript differ ($P < 0.05$).

[x,y]Within a row, means without a common superscript differ ($P < 0.10$).

[1]Treatments: CON = corn-soybean meal diet fed continuously; LD = diet containing 40% low standardized ileal digestible (SID) AA DDGS fed continuously; HD = 40% high SID AA DDGS diet fed continuously; LD-CON = alternated between LD and CON diets; HD-CON = alternated between HD and CON diets; and HD-LD = alternated between HD and LD diets.

The periodic inclusion and removal of 40% DDGS from the diets of finishing pigs (LD-CON and HD-CON treatments) did not adversely affect overall growth performance regardless of the AA digestibility of the DDGS fed. This observation is consistent with results of our first experiment where growth performance was similar among pigs intermittently consuming a DDGS based diet compared with pigs continuously consuming a corn-soybean meal based diet regardless of the amount of DDGS added to the diet. Carcass quality was also not affected by treatment in the current study, but differed from our first experiment where HCW was reduced when pigs were intermittently fed a diet containing 40% DDGS.

Average daily feed intake averaged over the 3 d after a diet change was used to determine the immediate effects of an abrupt change of diet on ADFI (Fig. 2). Average daily feed intakes were measured again 4 d after the 3-d measurement to determine how pigs adjusted to the dietary changes. There were 9 possible dietary switches throughout the study including: i) CON followed by LD (**CL**), ii) CON followed by HD (**CH**), iii) LD followed by LD (**LL**), iv) HD followed by LD (**HL**), v) HD followed by HD (**HH**), vi) CON followed by CON (**CC**), vii) LD followed by HD (**LDH**), viii) LD followed by CON (**LC**), and ix) HD followed by CON (**HC**). These switches are independent of the treatments and were included any time a pig switched from 1 diet to another regardless of treatment or time. For example, CH represents anytime a pig switched from the CON diet to the HD diet. Recalling that all pigs were consuming a standard corn-soybean meal based diet before the experiment began, CH includes switches from CON diet to HD diet for the HD, HD-CON, and HD-LD treatments at the beginning of the trial, as well as anytime throughout the trial when the HD-CON pigs made the switch from the CON to the HD diet. Conversely, HC represents any switch from HD to CON, which only occurred for the HD-CON pigs. Because of the treatment design, there are unequal observations for each

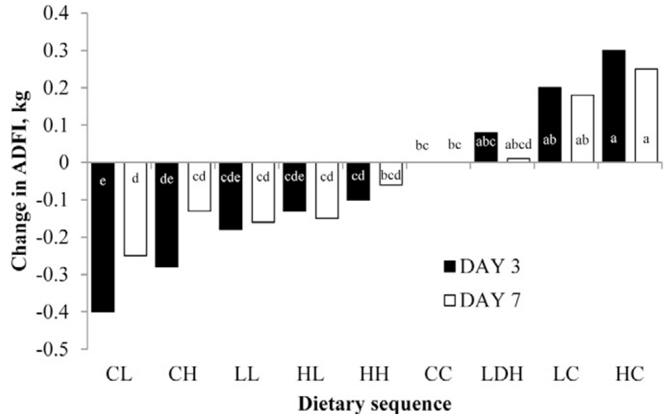

Figure. 2. Effect of dietary sequence on ADFI measured on d 3 and 7 after a feed change. Diets: CON = corn-soybean meal control diet, LD = diet containing 40% low standardized ileal digestible (SID) AA DDGS, and HD = diet containing 40% high SID AA DDGS; diet sequence: CL = CON followed by LD, CH = CON then HD, LL = LD then LD, HL = HD then LD, HH = HD then HD, CC = CON then CON, LDH = LD then HD, LC = LD then CON, and HC = HD then CON. [a–e]Means within the same day without a common superscript differ ($P < 0.05$).

of the 9 possible dietary switches. This analysis approach was used to understand the immediate effects of an abrupt diet change on feed consumed by each pen of pigs, as well as their adjustment to the dietary change. Pigs switching from a CON diet to a DDGS based diet (CL and CH), regardless of the digestibility of the DDGS, exhibited the greatest reductions ($P < 0.05$) in feed intake during the 3 d immediately after a dietary change compared with pigs continuously consuming a CON diet (CC). Four days later, when feed intake was measured again, ADFI rebounded for those pigs switching to a high SID AA DDGS diet, but remained less ($P < 0.05$) for pigs switching to a low SID AA DDGS based diet when compared with CON pigs. Conversely, pigs experiencing a switch from a high SID AA DDGS based diet to a CON diet (HC sequence) consumed more feed 3 d after the switch than CC pigs ($P < 0.05$). These differences were still apparent 7 d after the dietary switch. Considering these results, voluntary feed intake of pigs clearly is affected by abrupt dietary changes

Table 9. Effects of dietary distillers dried grains with solubles (DDGS) inclusion and removal and DDGS quality on pig carcass characteristics, Exp. 2

	Treatment[1]						
Trait	CON	LD-CON	HD-CON	LD	HD	HD-LD	SEM
No. of pens	6	6	6	6	6	6	–
No. of pigs	54	54	54	54	54	54	–
Ultrasound measurements							
Backfat, mm	21.3^{a}	19.9^{ab}	20.4^{ab}	18.9^{ab}	18.1^{b}	19.8^{ab}	0.9
LM area, cm^2	44.7^{a,xy}	44.7^{a,xy}	45.3^{a,x}	40.4^{b,xy}	42.7^{ab,y}	40.6^{b,xy}	0.6
HCW[2], kg	93.3^{a,xy}	92.3^{ab,x}	94.4^{a,xy}	87.2^{c,xy}	89.4^{bc,y}	88.5^{c,xy}	1.0
Carcass lean,[2] %	51.8	52.1	52.1	51.3	52.3	50.8	0.3
Dressing, %	76.2^{a,xy}	75.8^{ab,xy}	76.0^{ab,x}	74.7^{c,xy}	75.1^{bc,y}	74.6^{c,xy}	0.1

[a–c]Within a row, means without a common superscript differ ($P < 0.05$).

[x,y]Within a row, means without a common superscript differ ($P < 0.10$).

[1]CON = CON diet fed continuously; LD = 40% low digestible AA DDGS fed continuously; HD = 40% high digestible AA DDGS fed continuously; LD-CON = alternated between LD and CON diets; HD-CON = alternated between HD and CON diets; and HD-LD = alternated between HD and LD.

[2]Observations were n = 52, 53, 53, 51, 52, and 54 for CON, LD-CON, HD-CON, LD, HD, and HD-LD, respectively.

but if given the chance, pigs are able to adapt and even compensate for the reductions in ADFI experienced. In the current study, even though pigs switching from a CON diet to a diet containing low digestibility DDGS took more time to adjust than those pigs switching to a high SID AA DDGS diet, they still were able to compensate enough to exhibit overall feed intakes similar to CON pigs.

The prolonged reductions in ADFI for those pigs switched to a low SID AA DDGS-based diet along with the reduced overall ADFI for the LD treatment pigs indicates that the poorer performance was partially due to reduced palatability of the LD diets. Hastad et al. (2005) demonstrated that when given a choice, pigs prefer a corn-soybean meal diet over a diet containing DDGS. However, in the current study, ADFI was similar to control when pigs were offered only a DDGS-containing diet, which indicates there were other factors besides palatability responsible for the reduced growth rates. Diets containing DDGS formulated on a SID AA basis result in increasing levels of CP as the level of DDGS increases in the diet (Stein and Shurson, 2009). Excessive CP in the diet can increase plasma urea nitrogen concentration and reduce ADFI and ADG in growing-finishing pigs (Goerl et al., 1995; Chen et al., 1999). The increased dietary CP levels of our DDGS diets may have contributed to some of the reductions we observed in ADFI and ADG when diets contained 40% DDGS. Vomitoxin can cause small reductions in feed intake (3.8%) when present in the diet at levels of 1 mg/kg (House et al., 2002), which led several authors to recommend swine diets containing 1 mg/kg or less of vomitoxin to avoid depressions in feed intake (Thaler and Reese, 2010). Laboratory analysis of the diets revealed average vomitoxin levels of 0.32, 1.08, and 1.14 mg/kg for the CON, LD, and HD diets, respectively, indicating that greater levels of vomitoxin found in the DDGS could have been responsible for some of the immediate reductions in ADFI experienced when pigs switched from a CON diet to a DDGS diet. Pigs can adapt to prolonged exposure to vomitoxin-containing feeds, with the greatest reductions in feed intake occurring during the first 7 d after the introduction of the vomitoxin to the diet (Pollmann et al., 1985; Foster et al., 1986; Friend et al., 1986). Although this adaptation to vomitoxin may explain why our pigs were able to compensate for the initial reductions in ADFI experienced when switching to a DDGS based diet, it does not explain why those pigs switching to a high SID AA DDGS diet were able to compensate more quickly than those being switched to a low SID AA DDGS diet. Therefore, the dietary concentration of vomitoxin contamination does not appear to be responsible for the reductions in ADFI of pigs continuously consuming a low SID AA DDGS based diet.

Effects on Fatty Acid Profile of Backfat

Pigs assigned to the 3 treatments with dietary DDGS in Exp. 1 exhibited increased ($P < 0.05$) concentrations of PUFA, total unsaturated fatty acids, linoleic acid, and PUFA to SFA ratio compared with pigs assigned to CON (Table 10). Fatty acid composition of backfat was similar for pigs assigned to D20-CON and D40-CON which was unexpected. Other authors (Xu et al., 2010a; Cromwell et al., 2011) have reported a linear increase in unsaturation and IV of backfat as dietary DDGS concentrations increase in diets for growing-finishing pigs. More surprising was the

Table 10. Effect of distillers dried grains with solubles (DDGS) inclusion and removal and DDGS quality on fatty acid profile of backfat, Exp.1

	Treatment[2]											
	CON		D20		D20-CON		D40-CON			*P*-value		
Item[1]	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt	Barrow	Gilt	SEM	Treatment	Sex	Treatment × sex
SFA	47.05^{a}	45.43^{ab}	45.20^{ab}	43.03^{c}	43.39^{bc}	45.15^{ab}	42.73^{c}	43.55^{bc}	0.60	0.003	0.59	0.04
PUFA	12.15^{c}	12.25^{c}	14.90^{b}	15.33^{b}	17.94^{a}	16.22^{ab}	17.74^{a}	17.76^{a}	0.50	<0.0001	0.56	0.40
MUFA	40.78^{bc}	42.30^{a}	39.85^{cde}	41.63^{ab}	38.67^{e}	39.89^{bcd}	39.56^{cde}	38.69^{de}	0.30	<0.0001	0.006	0.02
Total UFA[3]	52.93^{d}	54.55^{cd}	54.75^{bcd}	56.96^{a}	56.61^{a}	56.11^{abc}	57.30^{a}	56.45^{ab}	0.50	<0.0001	0.19	0.06
Myristic	1.63^{a}	1.52^{ab}	1.70^{a}	1.56^{ab}	1.61^{ab}	1.42^{b}	1.62^{ab}	1.63^{a}	0.03	0.04	0.002	0.17
Palmitic	28.24^{a}	27.34^{ab}	27.76^{a}	26.47^{b}	26.78^{b}	26.69^{b}	26.51^{b}	26.42^{b}	0.20	0.003	0.02	0.23
Stearic	16.82^{a}	16.28^{ab}	15.45^{abc}	14.70^{bc}	14.72^{bc}	16.74^{a}	14.34^{c}	15.18^{abc}	0.40	0.03	0.36	0.07
Oleic	40.78^{bc}	42.30^{a}	39.85^{cde}	41.63^{ab}	38.67^{e}	39.89^{cd}	39.56^{cde}	38.69^{de}	0.30	<0.0001	0.006	0.02
Linoleic	11.00^{a}	11.67^{a}	14.26^{b}	14.70^{b}	17.24^{c}	15.62^{bc}	17.13^{c}	17.14^{c}	0.50	<0.0001	0.80	0.33
Linolenic	1.15	0.58	0.64	0.63	0.70	0.60	0.61	0.63	0.10	0.55	0.22	0.42
Eiconsanoic	0.34	0.29	0.28	0.29	0.27	0.30	0.26	0.31	0.02	0.55	0.39	0.09
PUFA:SFA	0.26^{d}	0.27^{d}	0.33^{c}	0.36^{bc}	0.42^{a}	0.36^{abc}	0.42^{a}	0.41^{ab}	0.01	<0.0001	0.75	0.22

[a–e]Within a row, means without a common superscript differ ($P < 0.05$).

[1]All fatty acids are expressed as grams of fatty acid/100 g fat.

[2]Treatments: CON = control diet fed continuously; D20 = 20% DDGS diet fed continuously; D20-CON = CON and D20 diets alternated every 2 wk and D40-CON = CON and a 40% DDGS diet alternated every 2 wk.

[3]UFA = unsaturated fatty acid.

reduced ($P < 0.05$) concentrations of PUFA and linoleic acid, and the decreased PUFA to SFA ratio of backfat from D20 pigs compared with D20-CON and D40-CON pigs. It is not clear why pigs continuously fed a diet containing 20% DDGS expressed a decreased degree of unsaturation in backfat than pigs fed the same diet alternated every 2 wk with a control diet containing no DDGS.

Pigs continuously consuming a DDGS-based diet in Exp. 2, regardless of the SID AA digestibility of the DDGS, had a decreased concentration of SFA ($P < 0.05$), increased ($P < 0.05$) concentration of PUFA, MUFA, and total unsaturated fatty acid, and increased IV ($P < 0.05$) in backfat compared with pigs receiving no DDGS or DDGS intermittently (Table 11). The intermittent inclusion of DDGS in diets also increased ($P < 0.05$) concentrations of unsaturated fatty acids and increased IV ($P < 0.05$) when compared with CON but the increases were of lesser magnitude. The reduced degree of unsaturation in backfat at harvest for LD-CON and HD-CON pigs compared with pigs continuously fed DDGS is explained by the fact that these pigs received the control diet with no DDGS during the last 4 wk of the experiment before pigs were harvested. This observation is consistent with previous findings that noticeable changes in fatty acid composition of carcass fat can be evident in as little as 14 d (Warnants et al., 1999) or 21 d (Xu et al., 2010b) after a change in or removal of dietary fat consumed by finishing pigs. In Exp. 1, alternating DDGS with a control diet did not reduce unsaturation of backfat, but in Exp. 2, the alternating pattern did reduce unsaturation of backfat. This apparent difference in responses can be explained by the fact that pigs consumed DDGS-containing diets in the 2 wk before harvest in Exp. 1, but consumed the control diet in the 4 wk before harvest in Exp. 2. Although not directly tested in these experiments, one may speculate that composition of the diet consumed in the 3 to 4 wk immediately preceding harvest has more influence on fatty acid composition of backfat than composition of diets consumed throughout the earlier portions of the growing-finishing period.

Results from this study indicate that pigs continuously fed a 40% low SID AA DDGS based diet experience decreased ADG, lighter HCW, and smaller LMA than those pigs continuously or intermittently consuming a corn-soybean based diet. Continuously feeding a low SID AA DDGS based diet also tended to reduce ADFI of pigs compared with pigs fed a corn-soybean meal. It appears that the use of a high SID AA DDGS source with accurate estimates of SID AA may diminish some of the negative responses observed in growth performance and carcass characteristics when feeding DDGS at 40% of the diet.

Table 11. Effect of dietary dried distillers grains with solubles (DDGS) inclusion and removal and DDGS quality on fatty acid profile of backfat, Exp. 2

	Treatment[2]						Sex			*P*-value		
Item[1]	CON	LD-CON	HD-CON	LD	HD	HD-LD	Barrows	Gilts	SEM	Treatment	Sex	Treatment × sex
SFA	36.13^{a,x}	33.94^{b,xy}	34.30^{ab,y}	30.77^{c,xy}	32.00^{c,xy}	30.89^{c,xy}	33.50	32.51	0.50	<0.001	0.01	0.29
PUFA	9.31^{a}	13.91^{b}	12.91^{b}	20.87^{c}	18.91^{c}	19.80^{c}	15.40	16.50	0.60	<0.001	0.01	0.92
MUFA	49.21^{a,x}	46.77^{b,xy}	47.39^{ab,y}	42.96^{c,xy}	43.68^{c,xy}	43.90^{c,xy}	45.71	45.60	0.40	<0.001	0.77	0.29
Total UFA[3]	58.52^{a,x}	60.69^{b,xy}	60.30^{ab,y}	63.83^{c,xy}	62.59^{c,xy}	63.69^{c,xy}	61.12	62.08	0.50	<0.001	0.01	0.26
Capric	0.09	0.09	0.09	0.07	0.09	0.09	0.09	0.08	0.00	0.24	0.34	0.05
Lauric	0.07	0.07	0.08	0.06	0.06	0.07	0.07	0.07	0.00	0.52	0.30	0.07
Myristic	1.35^{a,x}	1.21^{b,xy}	1.24^{ab,y}	1.15^{b,xy}	1.19^{b,xy}	1.23^{b,xy}	1.24	1.21	0.00	0.001	0.18	0.55
Palmitic	23.73^{a}	22.19^{b}	22.35^{b}	20.25^{c}	20.87^{c}	20.62^{c}	22.05	21.29	0.20	<0.001	0.001	0.15
Sapienic	2.86^{a,xy}	2.38^{b,x}	2.37^{b,x}	1.92^{d,xy}	2.01^{bc,y}	2.24^{bc,xy}	2.34	2.25	0.02	<0.001	0.21	0.03
Stearic	10.61^{a}	10.10^{ab}	10.26^{ab}	8.97^{c}	9.51^{bc}	8.63^{c}	9.77	9.58	0.20	<0.001	0.38	0.15
Oleic	46.35^{a}	44.39^{b}	45.02^{ab}	41.04^{c}	41.67^{c}	41.67^{c}	43.36	43.35	0.40	<0.001	0.97	0.37
Linoleic	8.64^{a,xy}	13.12^{b,xy}	12.13^{b,xy}	19.91^{c,y}	17.97^{c,x}	18.81^{c,xy}	14.59	15.60	0.60	<0.001	0.02	0.92
Linolenic	0.68^{a}	0.80^{b}	0.77^{ab}	0.96^{c}	0.94^{c}	0.99^{c}	0.81	0.90	0.00	<0.001	0.001	0.92
Arachidic	0.30^{a}	0.29^{a}	0.29^{a}	0.27^{ab}	0.29^{a}	0.25^{b}	0.28	0.29	0.00	0.001	0.66	0.04
trans-MUFA	0.34	0.35	0.39	0.37	0.37	0.41	0.36	0.38	0.00	0.28	0.15	0.69
trans-PUFA	0.010^{x}	0.026^{xy}	0.017^{xy}	0.037^{xy}	0.044^{y}	0.018^{xy}	0.03	0.02	0.00	0.06	0.21	0.27
Total trans-UFA	0.340	0.380	0.040	0.041	0.042	0.042	0.038	.040	0.002	0.26	0.35	0.63
Iodine value	61.19^{a}	67.05^{b}	65.80^{b}	75.75^{c}	72.94^{c}	74.82^{c}	68.74	70.44	1.44	<0.001	0.01	0.78

[a–c]Within a row, means without a common superscript differ ($P < 0.05$).

[x,y]Within a row, means without a common superscript differ ($P < 0.10$).

[1]All fatty acids are expressed as grams of fatty acid/100 g fat.

[2]Treatments: CON = corn-soybean meal diet fed continuously; LD = diet containing 40% low standardized ileal digestible (SID) AA DDGS fed continuously; HD = 40% high SID AA DDGS fed continuously; LD-CON = alternated between LD and CON diets; HD-CON = alternated between HD and CON diets; and HD-LD alternated between HD and LD

[3]UFA = unsaturated fatty acid.

The periodic inclusion and removal of 40% DDGS from the diets of finishing pigs did not adversely affect growth performance regardless of the SID AA digestibility of the DDGS source being used, but may result in reduced HCW. These results indicate that it is possible to abruptly incorporate and remove DDGS from grower-finisher swine diets without affecting growth performance but when fed at greater levels (40%), HCW may be reduced.

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