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Effects of increasing NDF from either dried distillers grains with solubles or wheat middlings, individually or in combination, on the growth performance, carcass characteristics, and carcass fat quality in growing-finishing pigs

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Effects of Increasing NDF from Either Dried Distillers Grains With Solubles or Wheat Middlings, Individually or in Combination, on the Growth Performance, Carcass Characteristics, and Carcass Fat Quality in Growing-Finishing Pigs[1]

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Summary

A total of 288 pigs (PIC TR4 × 1050, initially 83.6 lb) were used in an 87-d study to determine the effects of increasing dietary NDF from wheat middlings (midds) and dried distillers grains with solubles (DDGS) on growth performance, carcass characteristics, and carcass fat quality of growing-finishing pigs. Pens of pigs were randomly allotted by initial weight and gender (4 barrows and 4 gilts per pen) to 1 of 6 dietary treatments with 6 replications per treatment. Treatments were arranged in a 2 × 2 factorial plus 2 additional treatments with the main effects of added wheat middlings (0 or 19%) or DDGS (0 or 30%) to corn-soybean meal-based diets. The additional treatments were a diet containing 9.5% midds and 30% DDGS and a diet containing 19% midds and 15% DDGS. These combinations of midds and DDGS provided diets with different NDF concentrations ranging from 9.3 to 18.9%. Diets were fed in 4 phases. Choice white grease (CWG) was added to the diets to maintain similar ME in all diets within each phase. The only DDGS × midds interaction was a trend for carcass yield ($P = 0.09$). Adding either midds or DDGS to the diet reduced carcass yield by a similar magnitude, but the effect was not additive. Overall, (d 0 to 87), adding midds to the diet decreased (linear, $P < 0.01$) ADG, final BW, and HCW, and worsened (linear, $P < 0.001$) F/G and jowl iodine value (IV). Increasing DDGS did not influence growth performance or carcass traits except for an increase (linear, $P < 0.001$) in jowl fat IV. Pigs fed increasing NDF had decreased (linear, $P < 0.05$) ADG and HCW and poorer (linear, $P < 0.02$) F/G; however, these effects were driven by the pigs fed diets containing midds and do not appear to be attributed solely to increased NDF levels. Increasing NDF also increased jowl fat iodine value, but increasing NDF with DDGS had a greater negative effect than increasing NDF through midds (due to the oil content of DDGS). Thus, increasing NDF has negative impacts on pig performance, carcass yield, and fat IV, but the effects appear to be more closely related to the individual ingredients used to increase NDF rather than NDF itself.

Key words: DDGS, fiber, NDF, wheat middlings, finishing pig

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Introduction

Feed ingredients such as wheat middlings (midds) and DDGS are often used as alternatives to corn and soybean meal in swine diets. Although these ingredients are used with the intent of lowering feed costs, they have been shown to have the potential to negatively affect performance and carcass characteristics. Thus, whether the reduction in performance and carcass yield is due to fiber or related more closely with individual ingredients must be determined.

Wheat middlings are among the cereal by-products commonly used in commercial pig feed. Often referred to as wheat midds, they are by-products from flour milling. Most U.S. wheat that is not exported is processed into flour, so milling by-products are widely available for use in the animal feed industry. Midds have higher crude protein and fiber but lower dietary energy than corn (corn ME = 1,551 kcal/lb; wheat middlings ME = 1,372 kcal/lb; NRC, 1998[3]). Because of the lower ME content, producers can expect reduced gains and poorer feed efficiency in finishing pigs. To mitigate this effect, dietary fat can be added to increase the dietary energy level; however, limited data are available on the effects of combining midds with choice white grease (CWG) in diets for finishing pigs. Also, due to opportunities to reduce diet cost with midds, its effect on performance needs further investigation.

Considerable research has been conducted in recent years on the addition of DDGS to finishing diets. With proper diet formulation and high-quality DDGS, up to 30% DDGS can be fed without reducing pig performance, but carcass yield is often reduced and fat iodine value (IV) is increased with DDGS inclusion in the diet. Adding DDGS and midds to the diet increases dietary fiber levels, but little information is available on the potential relationships between these ingredients.

Therefore, the objective of this trial was to determine the effects of increasing fiber levels from midds and DDGS on growth performance, carcass characteristics, and carcass fat quality of growing-finishing pigs.

Procedures

The Kansas State University Institutional Animal Care and Use Committee approved the protocol used in this experiment. The study was conducted at the K-State Swine Teaching and Research Center in Manhattan, KS. The facility was a totally enclosed, environmentally controlled, mechanically ventilated barn containing 36 pens (8 × 10 ft). The pens had adjustable gates facing the alleyway that allowed for 10 ft^2/pig. Each pen was equipped with a cup waterer and a Farmweld (Teutopolis, IL) single-sided, dry self-feeder with 2 eating spaces located in the fence line. Pens were located over a completely slatted concrete floor with a 4-ft pit underneath for manure storage. The facility was also equipped with a computerized feeding system (FeedPro; Feedlogic Corp., Willmar, MN) that delivered and recorded diets as specified. The equipment provided pigs with ad libitum access to food and water.

A total of 288 pigs (PIC TR4 × 1050, initially 83.6 lb) were used in an 87-d growth trial. Pens of pigs (4 barrows and 4 gilts per pen) were randomly allotted by initial weight to 1 of 6 dietary treatments with 6 replications per treatment. Treatments were

[3] NRC. 1998. Nutrient Requirements of Swine. 10th ed. Natl. Acad. Press, Washington, DC.

arranged in a 2 × 2 factorial design plus 2 additional treatments with the main effects of added midds (0 or 19%) and DDGS (0 or 30%). The additional treatments were a diet containing 9.5% midds and 30% DDGS and a diet containing 19% midds and 15% DDGS. Dietary treatments were corn-soybean meal-based and fed in 4 phases (Tables 1 and 2). All diets were fed in meal form and balanced to similar ME concentrations and SID lysine:ME ratios within each phase. Choice white grease was added to diets to maintain the same ME level within phase. The ME values used in formulation for dietary ingredients included: DDGS = 1,552 ME kcal per lb; midds = 1,375 ME kcal per lb; and CWG = 7,995 ME kcal per lb.

Wheat middlings and DDGS samples were collected at the time of feed manufacture and a composite sample was analyzed (Table 3). Feed samples were also collected from each feeder during each phase and combined for a single composite sample by treatment for each phase to measure bulk density (Table 4). Bulk density of a material represents the mass per unit volume (lb per bushel).

Pigs and feeders were weighed approximately every 3 wk to calculate ADG, ADFI, and F/G. On d 87, all pigs were weighed and transported to Triumph Foods LLC, St. Joseph, MO. Before slaughter, pigs were individually tattooed according to pen number to allow for carcass data collection at the packing plant and data retrieval by pen. Hot carcass weights were measured immediately after evisceration and each carcass was evaluated for percentage yield, backfat, loin depth, and percentage lean. Because there were differences in HCW, it was used as a covariate for backfat, loin depth, and percentage lean. Also, jowl fat samples were collected and analyzed by Near Infrared Spectroscopy (NIR) at the plant for IV. Percentage yield was calculated by dividing HCW at the plant by live weight at the farm before transport to the plant.

Data were analyzed as a completely randomized design using the PROC-MIXED procedure (SAS Institute, Inc., Cary, NC) with pen as the experimental unit. The main effects of the different treatment regimens of midds and DDGS and their interaction were tested. Linear and quadratic contrasts were used to determine the effects of midds, DDGS, and NDF levels. The contrast coefficients for NDF were determined using PROC IML for unequally spaced treatments in SAS. Differences between treatments were determined by using least squares means ($P < 0.05$), and trends were declared at $P < 0.10$.

Results and Discussion

Analyzed samples of DDGS and midds had higher levels of NDF than those used in formulation (Table 3), and thus resulted in higher levels in the final diets than formulated; however, the incremental increase in NDF levels persisted. Using the actual NDF values from analysis, the NDF levels in the diet were 9.2, 15.4, 18.4, and 21.6, which was a 3% increase over the planned levels of 9.2, 14.0, 16.4, and 18.8, which had an increase of 2.4% between levels. Although the dietary NDF was higher than planned, the increase in fiber between treatments was still proportionally the same.

Bulk density tests showed that adding midds to the diet decreased diet bulk density more severely than the addition of DDGS (Table 4).

The only DDGS × midds interaction that occurred was a trend ($P = 0.09$) for carcass yield (Tables 5 and 6). Adding DDGS and midds to the diet decreased carcass yield; however, the interaction occurred because the effects were not additive. Overall (d 0 to 87), adding midds to finishing pig diets decreased (linear $P < 0.001$) ADG, final BW, hot carcass weight, and worsened (linear, $P < 0.001$) F/G and jowl IV. Increases in DDGS had no influence on growth performance or carcass characteristics with the exception of the expected linear increase ($P < 0.001$) in jowl fat IV. Pigs fed increasing dietary NDF had decreased (linear; $P < 0.05$) ADG and hot carcass weight as well as poorer (linear; P <0.02) F/G; however, these effects were driven by the pigs on the midds diets and do not appear to be attributed solely to increased dietary NDF. Increasing NDF also increased jowl fat IV (linear; $P < 0.001$), but increasing NDF with DDGS had a greater negative effect than by increasing NDF through midds (due to the oil content of DDGS). Thus, increasing NDF has negative impacts on pig performance, yield, and fat IV, but the effects appear to be more closely related to the individual ingredients used to increase NDF than the NDF itself.

The decrease in growth rate and poorer F/G with midds suggest that we may have overestimated the energy content of midds, but the pigs do not appear to have compensated by eating more feed. Thus, ADG and F/G were both impaired by the addition of midds to the diet. Diets with high levels of midds had decreased bulk density, which could result in increased gut fill. Adding only midds to the diet to achieve a diet with 14% NDF worsened both ADG and F/G by 4%. Interestingly, adding only DDGS to the diet to achieve the same 14% NDF resulted in a 4% increase in ADG and similar F/G. Diets containing high levels of wheat middlings consistently resulted in poorer ADG and F/G regardless of NDF level or simultaneous inclusion of DDGS; therefore, this result implies that the decrease in performance is related to the addition of midds themselves and not the dietary NDF level.

Table 1. Phase 1 and 2 diet composition (as-fed basis)[1]

	Phase 1						Phase 2					
NDF, %:	9.2	14.0	14.0	16.4	16.4	18.8	9.2	14.0	14.0	16.4	16.4	18.8
Wheat midds, %:	0	19	0	9.5	19	19	0	19	0	9.5	19	19
DDGS, %[2]:	0	0	30	30	15	30	0	0	30	30	15	30
Ingredient												
Corn	77.05	61.10	52.90	44.90	49.10	36.90	81.70	65.80	57.45	49.45	53.70	41.30
Soybean meal (46.5% CP)	20.05	15.60	14.70	12.35	12.80	10.05	15.65	11.15	10.25	7.90	8.35	5.70
DDGS	---	---	30.00	30.00	15.00	30.00	---	---	30.00	30.00	15.00	30.00
Wheat middlings	---	19.00	---	9.50	19.00	19.00	---	19.00	---	9.50	19.00	19.00
Choice white grease	0.20	1.70	---	0.80	1.60	1.60	0.15	1.65	---	0.80	1.60	1.60
Monocalcium P, 21% P	0.55	0.25	---	---	---	---	0.40	0.10	---	---	---	---
Limestone	0.98	1.10	1.28	1.28	1.25	1.28	1.03	1.15	1.25	1.25	1.23	1.25
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
L-Lysine HCl	0.28	0.35	0.34	0.38	0.39	0.42	0.24	0.32	0.31	0.35	0.35	0.38
DL-Methionine	0.03	0.03	---	---	---	---	0.01	0.01	---	---	---	---
L-Threonine	0.07	0.09	---	---	0.05	0.01	0.04	0.06	---	---	0.03	---
Phytase[3]	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

continued

Table 1. Phase 1 and 2 diet composition (as-fed basis)[1]

	Phase 1						Phase 2					
NDF, %:	9.2	14.0	14.0	16.4	16.4	18.8	9.2	14.0	14.0	16.4	16.4	18.8
Wheat midds, %:	0	19	0	9.5	19	19	0	19	0	9.5	19	19
DDGS, %[2]:	0	0	30	30	15	30	0	0	30	30	15	30
Crude fiber, %	2.5	3.3	4.0	4.4	4.1	4.8	2.4	3.2	4.0	4.4	4.0	4.8
ADF, %:	3.2	4.6	5.2	5.9	5.6	6.6	3.1	4.5	5.1	5.8	5.5	6.5
Standardized ileal digestible (SID) amino acids, %												
Lysine	0.92	0.92	0.92	0.92	0.92	0.92	0.78	0.78	0.78	0.78	0.78	0.78
Isoleucine:lysine	62	59	70	68	62	66	64	60	72	70	64	68
Leucine:lysine	147	136	191	185	157	179	161	147	211	204	172	198
Methionine:lysine	29	29	33	33	29	32	29	29	37	36	32	36
Met & Cys:lysine	57	57	68	67	60	67	59	59	74	74	65	74
Threonine:lysine	62	62	64	62	62	62	62	62	67	66	62	64
Tryptophan:lysine	17	17	17	17	17	17	17	17	17	17	17	17
Valine:lysine	72	70	84	83	76	82	76	74	90	89	80	88
SID lysine:ME/Mcal	2.75	2.75	2.75	2.75	2.75	2.75	2.33	2.33	2.33	2.33	2.33	2.33
ME, kcal/lb	1,518	1,518	1,518	1,518	1,518	1,518	1,519	1,519	1,519	1,519	1,519	1,519
Total lysine, %	1.02	1.01	1.08	1.08	1.04	1.07	0.87	0.86	0.93	0.93	0.89	0.92
CP, %	16.21	15.89	19.82	19.60	17.64	19.39	14.48	14.14	18.09	17.87	15.90	17.71
Ca, %	0.56	0.56	0.56	0.56	0.56	0.56	0.54	0.54	0.54	0.54	0.54	0.54
P, %	0.47	0.51	0.46	0.51	0.51	0.56	0.42	0.46	0.44	0.49	0.49	0.54
Available P, %	0.29	0.29	0.32	0.35	0.31	0.38	0.25	0.25	0.32	0.35	0.3	0.38

[1] Phase 1 diets were fed from approximately 80 to 130 lb; Phase 2 diets were fed from 130 to 180 lb.

[2] Dried distillers grains with solubles.

[3] Phyzyme 600 (Danisco Animal Nutrition, St Louis, MO) provided per pound of diet: 353.8 FTU/lb and 0.11% available P released.

Table 2. Phase 3 and 4 diet composition (as-fed basis)[1]

	Phase 3						Phase 4					
NDF, %:	9.3	14.0	14.0	16.4	16.4	18.9	9.3	14.1	14.1	16.5	16.5	18.9
Wheat midds, %:	0	19	0	9.5	19	19	0	19	0	9.5	19	19
Ingredient DDGS, %[2]:	0	0	30	30	15	30	0	0	30	30	15	30
Corn	85.05	69.10	60.75	52.65	56.90	44.50	87.05	71.10	62.60	54.60	58.85	46.45
Soybean meal (46.5% CP)	12.45	7.95	6.95	4.70	5.15	2.50	10.55	6.00	5.10	2.80	3.25	0.60
DDGS	---	---	30.00	30.00	15.00	30.00	---	---	30.00	30.00	15.00	30.00
Wheat middlings	---	19.00	---	9.50	19.00	19.00	---	19.00	0.00	9.50	19.00	19.00
Choice white grease	0.15	1.65	---	0.80	1.60	1.60	0.10	1.60	0.00	0.80	1.60	1.60
Monocalcium P (21% P)	0.25	---	---	---	---	---	0.20	---	0.00	0.00	0.00	0.00
Limestone	1.10	1.20	1.25	1.25	1.23	1.25	1.10	1.20	1.25	1.25	1.23	1.25
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Trace mineral premix	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15	0.15
L-Lysine HCl	0.22	0.29	0.28	0.32	0.33	0.36	0.20	0.28	0.27	0.31	0.31	0.34
DL-Methionine	---	0.01	---	---	---	---	---	---	---	---	---	---
L-Threonine	0.02	0.05	---	---	0.01	---	0.03	0.05	---	---	0.02	---
Phytase[3]	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13	0.13
Total	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

continued

Table 2. Phase 3 and 4 diet composition (as-fed basis)[1]

	Phase 3						Phase 4					
NDF, %:	9.3	14.0	14.0	16.4	16.4	18.9	9.3	14.1	14.1	16.5	16.5	18.9
Wheat midds, %:	0	19	0	9.5	19	19	0	19	0	9.5	19	19
Ingredient DDGS, %[2]:	0	0	30	30	15	30	0	0	30	30	15	30
Crude fiber, %	2.4	3.2	3.9	4.3	3.9	4.7	2.3	3.1	3.9	4.3	3.9	4.7
ADF, %:	3.1	4.4	5.0	5.7	5.4	6.4	3.0	4.3	5.0	5.7	5.3	6.3
Standardized ileal digestible (SID) amino acids, %												
Lysine	0.68	0.68	0.68	0.68	0.68	0.68	0.62	0.62	0.62	0.62	0.62	0.62
Isoleucine:lysine	66	61	75	72	65	70	67	62	77	74	66	72
Leucine:lysine	174	158	2	223	187	216	183	166	247	238	198	230
Methionine:lysine	30	30	40	39	34	39	32	31	42	42	36	41
Met & Cys:lysine	63	62	81	80	71	80	66	65	86	85	75	85
Threonine:lysine	62	62	71	69	62	67	65	65	74	71	65	69
Tryptophan:lysine	17	17	17	17	17	17	17	17	17	17	17	17
Valine:lysine	79	77	95	94	85	93	82	79	99	98	88	97
SID lysine:ME/Mcal	2.03	2.03	2.03	2.03	2.03	2.03	1.85	1.85	1.85	1.85	1.85	1.85
ME, kcal/lb	1,520	1,520	1,520	1,520	1,520	1,520	1,520	1,520	1,520	1,520	1,520	1,520
Total lysine, %	0.77	0.76	0.82	0.82	0.78	0.81	0.7	0.69	0.76	0.75	0.72	0.75
CP, %	13.24	12.89	16.83	16.64	14.65	16.47	12.51	12.16	16.11	15.89	13.91	15.73
Ca, %	0.53	0.53	0.53	0.53	0.53	0.53	0.52	0.52	0.52	0.52	0.52	0.52
P, %	0.38	0.42	0.43	0.48	0.48	0.53	0.36	0.42	0.42	0.47	0.47	0.52
Available P, %	0.22	0.23	0.31	0.34	0.3	0.37	0.21	0.22	0.31	0.34	0.30	0.37

[1] Phase 3 diets were fed from approximately 180 to 230 lb; Phase 4 diets were fed from 230 to 280 lb.
[2] Dried distillers grains with solubles.
[3] Phyzyme 600 (Danisco Animal Nutrition, St Louis, MO) provided per pound of diet: 353.8 FTU/lb and 0.11 % available P released.

Table 3. Chemical analysis of dried distillers grains with solubles (DDGS) and wheat middlings (as-fed basis)

Item	DDGS	Wheat middlings
Nutrient,%		
DM	90.40	89.55
CP	24.92 (27.2)[1]	14.09 (15.9)
Fat (oil)	12.21	4.10
Crude fiber	5.44 (7.7)	9.55 (7.0)
ADF	9.38 (9.9)	12.53 (10.7)
NDF	30.44 (25.3)	42.13 (35.6)
Ash	6.04	6.47

[1] Values in parenthesis indicate those used in diet formulation.

Table 4. Bulk density of experimental diets (as-fed basis)[1]

	Treatments					
NDF, %:	9.2	14.0	14.0	16.4	16.4	18.8
Wheat midds, %:	0	19	0	9.5	19	19
Bulk density, lb/bu[1, 2] DDGS, %[3]:	0	0	30	30	15	30
Phase 1	48.9	39.4	46.4	42.1	38.2	37.2
Phase 2	50.4	39.5	46.4	41.5	38.1	36.7
Phase 3	49.0	40.2	44.9	40.8	38.2	36.7
Phase 4	48.3	40.3	44.8	40.7	38.7	38.3

[1] Diet samples collected from the top of each feeder during each phase.
[2] Phase 1 was d 0 to 23; Phase 2 was d 23 to 43; Phase 3 was d 43 to 64; Phase 4 was d 64 to 87.
[3] Dried distillers grains with solubles.

Table 5. Effects of dietary NDF on finishing pig growth performance and carcass characteristics[1]

Treatment:	1	2	3	4	5	6	
NDF, %:	9.2	14	14	16.4	16.4	18.8	
Wheat midds, %:	0	19	0	9.5	19	19	
DDGS, %[2]:	0	0	30	30	15	30	SEM
Initial wt, lb	83.6	83.6	83.6	83.7	83.7	83.6	1.68
Day 0 to 87							
ADG, lb	2.34	2.24	2.44	2.38	2.26	2.23	0.03
ADFI, lb	6.41	6.37	6.61	6.46	6.32	6.48	0.12
F/G	2.74	2.85	2.71	2.72	2.79	2.91	0.04
Final wt, lb	286.2	278.0	293.1	291.8	278.5	276.8	2.85
Carcass characteristics[3]							
Carcass yield, %[4]	73.8	72.2	71.9	71.5	72.2	72.4	0.69
HCW, lb	209.3	201.0	210.9	209.4	202.1	200.5	2.53
Backfat depth, in.[3]	0.95	0.97	0.99	0.90	0.91	0.94	0.03
Loin depth, in.[3]	2.33	2.32	2.29	2.26	2.32	2.33	0.03
Lean, %[3]	50.98	50.75	50.47	51.09	51.28	50.98	0.38
Jowl iodine value (IV)	68.20	70.29	74.56	76.99	73.39	76.60	0.42

[1] A total of 288 pigs (TR4 × 1050, Initial BW= 83.6 lb) were used in this 87-d study with 8 pigs per pen and 6 pens per treatment.
[2] Dried distillers grains with solubles.
[3] Carcass characteristics other than yield and IV were adjusted using HCW as a covariate.
[4] Percentage yield was calculated by dividing HCW by live weight obtained at the farm before transport to the packing plant.

Table 6. Main effects of dietary NDF on finishing pig growth performance and carcass characteristics[1]

	Probability, P <								
	Main effects			Wheat middlings (midds)		DDGS[2]		NDF	
	Interaction[3]	Midds[4]	DDGS[5]	Linear[6]	Quadratic[6]	Linear[7]	Quadratic[7]	Linear[8]	Quadratic[8]
Initial wt, lb	1.00	1.00	0.99	1.00	0.96	0.99	0.96	0.98	0.99
Day 0 to 87									
ADG, lb	0.12	<0.001	0.16	<0.001	0.28	0.90	0.48	0.04	0.07
ADFI, lb	0.71	0.49	0.19	0.45	0.57	0.50	0.46	0.89	0.88
F/G	0.28	<0.001	0.68	0.001	0.06	0.29	0.08	0.02	0.10
Final wt, lb	0.16	<0.001	0.32	<0.001	0.06	0.77	0.74	0.07	0.08
Carcass characteristics[9]									
Carcass yield, %[10]	0.09	0.37	0.17	0.52	0.29	0.78	0.89	0.06	0.07
HCW, lb	0.68	<0.001	0.82	0.007	0.24	0.89	0.66	0.04	0.49
Backfat depth, in.[9]	0.35	0.76	0.86	0.42	0.10	0.59	0.25	0.40	0.65
Loin depth, in.[9]	0.36	0.65	0.52	0.36	0.15	0.85	0.98	0.65	0.27
Lean, %[9]	0.32	0.76	0.71	0.39	0.43	0.66	0.36	0.68	0.49
Jowl iodine value (IV)	0.95	<0.001	<0.001	0.002	0.01	<0.001	0.91	<0.001	0.78

[1] A total of 288 pigs (TR4 × 1050, initial BW= 83.6 lb) were used in an 87-d study.
[2] Dried distillers grains with solubles.
[3] Interaction effect of midds × DDGS was tested using treatments 1 and 6 vs. 2 and 3.
[4] Main effect of adding midds was tested using treatments 1 and 3 vs. 2 and 6.
[5] Main effect of adding DDGS was tested using treatments 1 and 2 vs. 3 and 6.
[6] Linear and quadratic effects of midds level (0%, 9.5%, and 19%) were tested using treatments 3, 4, and 6.
[7] Linear and quadratic effects of DDGS level (0%, 15%, and 30%) were tested using treatments 2, 5, and 6.
[8] Linear and quadratic effects of NDF level (9.2%, 14.0%, 16.4%, and 18.8%) were tested using treatment 1, an average of 2 and 3, an average of 4 and 5, and 6.
[9] Carcass characteristics other than yield and IV were adjusted using HCW as a covariate.
[10] Percentage yield was calculated by dividing HCW by live weight obtained at the farm before transport to the packing plant.