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Effects of a Dried Distillers Grains with Solubles Withdrawal Strategy on Grow-Finish Growth Performance, Carcass Characteristics, and Economics

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Summary

A study was conducted to evaluate the effects of a DDGS withdrawal strategy on grow-finish pig growth performance and carcass characteristics. A total of 2,133 pigs (PIC 337 × 1050; initially 52.4 ± 0.88 lb) were used in a 120-d trial. Pens of pigs (27 pigs/pen) were blocked by body weight (BW) and randomly assigned to one of four dietary treatments in a randomized complete block design. The four treatments consisted of varying DDGS inclusion and withdrawal strategies across six dietary phases: A) corn-soybean meal-based diet with no DDGS in phases 1 to 6; B) 20% DDGS in phases 1 to 4, and no DDGS (corn-soybean meal) in phases 5 and 6 (20%-0%); C) 20% DDGS in phases 1 to 3, and 10% DDGS in phases 4 to 6 (20%-10%); and D) 30% DDGS in phases 1 and 2, 20% DDGS in phases 3 and 4, and 5% DDGS in phases 5 and 6 (30%-20%-5%). Experimental diets were formulated to maintain a constant SID Lys:NE ratio across treatments. Overall (d 0 to 120), pigs fed a corn-soybean meal-based diet had greater ($P < 0.05$) ADG than pigs fed 30%-20%-5% DDGS, with pigs fed 20%-0% and 20%-10% intermediate. No differences were observed for ADFI across treatments. Feed efficiency improved for pigs fed the corn-soybean meal diet compared with the three withdrawal strategies ($P < 0.05$). Final BW tended to differ among treatments ($P = 0.051$), with pigs fed a corn-soybean meal-based diet having the numerically greatest final BW and pigs fed 30%-20%-5% DDGS the lowest. No differences were observed for removals, mortality, hot carcass weight, carcass yield, backfat depth, loin depth, percentage lean, or revenue across different treatments. Feed cost per pound of gain was lower ($P < 0.05$) for pigs fed the 20%-10% DDGS diet compared with pigs fed the corn-soybean meal diet, with the 20%-0% and 30%-20%-5% DDGS strategies being intermediate. Income over feed cost on a per pig placed basis tended ($P = 0.091$) to be greater for pigs fed the 20%-10% DDGS program compared with pigs fed 30%-20%-5% DDGS, with the corn-soybean meal-based diet and the 20%-0% DDGS diet intermediate. In conclusion, although pigs fed a corn-soybean meal diet had the greatest final BW and best F/G, DDGS withdrawal strategies reduced feed costs while

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maintaining comparable economic outcomes and carcass characteristics under the ingredient prices used in this study.

Introduction

Distillers' dried grains with solubles (DDGS), a co-product of the ethanol industry, have been widely used in swine diets due to their nutritional value and relatively low cost. Corn DDGS contains relatively high concentrations of crude protein and digestible phosphorus, making it a valuable alternative feed ingredient that can partially replace corn, soybean meal, and supplemental phosphorus in swine diets.

Despite its nutritional and economic benefits, feeding high levels of DDGS throughout the finishing period has been associated with negative effects on growth performance and carcass characteristics. One of the primary concerns with DDGS is the elevated neutral detergent fiber concentration, which increases gut fill and visceral mass, ultimately reducing carcass yield[3]. In addition, DDGS is rich in polyunsaturated fatty acids, which can increase carcass iodine value and reduce fat firmness, negatively affecting pork fat quality.

To mitigate these negative effects while maintaining the economic advantages of DDGS, producers commonly implement withdrawal strategies during the late finishing period. Reducing or removing DDGS before marketing increases carcass yield and allows pigs to deposit firmer, more saturated fat, improving iodine value. However, differences in the degree and timing of withdrawal can potentially influence growth performance, carcass characteristics, and economic return. Therefore, the objective of this study was to evaluate the effects of four different DDGS withdrawal strategies on growth performance and carcass characteristics of grow-finish pigs.

Procedures

The protocol used in this experiment was approved by the Kansas State University Institutional Animal Care and Use Committee. The experiment was conducted at a commercial research site in southwest Minnesota. The barns were naturally ventilated and double-curtain-sided with totally slatted floors. Each pen (10 × 18 ft) was equipped with a five-hole stainless steel dry self-feeder (Thorp Equipment, Thorp, WI) and a bowl waterer to provide ad libitum access to feed and water throughout the experiment. Diets were manufactured and fed in mash form (Hord Farms West Feed Mill, Pipestone, MN). Daily feed additions to each pen were accomplished using a robotic feeding system (FeedPro; Feedlogic Corp., Willmar, MN) that recorded feed deliveries for individual pens.

Animals and diets

A total of 2,133 pigs (PIC 337 × 1050, initially 52.4 ± 0.88 lb) were used in a 120-d study. Pigs were housed in mixed-gender pens with 27 pigs per pen across two barns, for a total of 79 pens used in the experiment. Pens of pigs were blocked by initial BW and allotted to one of four dietary treatments in a randomized complete block design. The corn-soybean meal-based control treatment had 19 pens/treatment, whereas all other treatments had 20 pens/treatment.

[3] Wang, C., X. Huang, X. Liu, R. Wang, J. Li, Q. Meng, and A. Shan. 2025. Strategies for efficient utilization of corn distillers dried grains with solubles in diets of pigs: A review. Animals. 15(12):1727. doi:10.3390/ani15121727.

Samples of the DDGS were collected and analyzed for dry matter, crude protein, ether extract, acid detergent fiber, neutral detergent fiber, ash, and starch (Ward Laboratories, Inc., Kearney, NE). Amino acid analysis was conducted at the University of Missouri (Columbia, MO). The NE content of DDGS was calculated based on its chemical composition using equations adapted from NRC (2012)[4] and was estimated to be 862 kcal/lb (Table 1).

Diets were fed across six phases based on BW: phase 1 from approximately 50 to 65 lb, phase 2 from 65 to 125 lb, phase 3 from 125 to 155 lb, phase 4 from 155 to 195 lb, phase 5 from 195 to 240 lb, and phase 6 from 240 lb to market weight (approximately 285 lb). The dietary treatments differed in the level of DDGS (Tables 2, 3, and 4). The treatments were: A) corn-soybean meal-based diet with no DDGS in phases 1 to 6; B) 20% DDGS in phases 1 to 4, and no DDGS (corn-soybean meal) in phases 5 and 6 (20%-0%); C) 20% DDGS in phases 1 to 3, and 10% DDGS in phases 4 to 6 (20%-10%); and D) 30% DDGS in phases 1 and 2, 20% DDGS in phases 3 and 4, and 5% DDGS in phases 5 and 6 (30%-20%-5%). Experimental diets were formulated to maintain a constant SID Lys:NE ratio across treatments. Therefore, SID lysine, NE and phosphorus concentrations varied among diets. Diet phase changes were implemented based on the estimated average BW of each barn. At each phase transition, new diets were added on top of the remaining feed in the feeder to ensure a smooth transition between diets.

Pens of pigs were weighed, and feed delivery and disappearance were recorded at the start of the trial and approximately every 14 d thereafter. These measurements were used to calculate average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F/G).

When the average pen weight reached approximately 240 lb, the three heaviest pigs per pen were selected and marketed at a USDA-inspected facility (JBS Foods, Worthington, MN). No carcass data was collected at this first marketing event. At the end of the study, the remaining pigs were marketed. Standard carcass measurements, including backfat, loin depth, percentage lean, and carcass weight, were collected individually and summarized by pen. Mortality and removals were recorded throughout the trial. If a pig died or was removed due to inability to recover from sickness or injury, its BW was recorded.

Economic responses were calculated for each feeding program. Feed cost per pig placed was determined by dividing the total feed cost per pen by the number of pigs placed at the beginning of the study. Feed cost per lb of gain was calculated by dividing the total feed cost per pen by the total BW gain of pigs within the pen over the entire experimental period. Revenue per pig was calculated by multiplying total pen weight gain (including pigs that were removed or died) by the average treatment carcass yield and a market price of $0.82/lb carcass, and then dividing by the number of pigs initially placed in the pen. Income over feed cost (IOFC) was calculated by subtracting total feed cost per pen from total revenue per pen and dividing the result by the number of pigs placed at the beginning of the study.

Economics were also calculated on a closeout basis. Closeout calculations were based on the BW of pigs present at the conclusion of the trial for marketing and did not include weight gain from pigs that died or were removed during the study. Closeout BW gain

[4] NRC. 2012. Nutrient requirements of swine. 11th rev. ed. Natl. Acad. Press, Washington, DC

was calculated as the final pen weight minus the initial pen weight, plus the BW of pigs that were marketed at the initial marketing event during the study. Feed cost, revenue, and IOFC on a closeout basis were calculated as previously described; however, calculations were based on closeout BW gain.

Prices used in the economic calculations were carcass weight price at $0.82/lb, corn at $3.80/bu, soybean meal at $290/ton, DDGS at $135/ton, liquid lysine at $0.58/lb, DL-Met at $1.38/lb, ThrPro at $0.81/lb, and L-Trp at $3.18/lb.

Statistical analysis

Data were analyzed as a randomized complete block design for one-way ANOVA using the lmer function from the lme4 package in R (version 4.5.1, R Core Team, Vienna, Austria). Pen was considered the experimental unit and treatment was considered a fixed effect in the statistical model. Mortality data were analyzed using a binomial distribution. Carcass data were analyzed using the pen as experimental unit. Hot carcass weight was used as a covariate for analysis of backfat depth, loin depth, and percentage lean. Treatment differences were considered statistically significant at $P \leq 0.05$, and marginally significant at $0.05 < P \leq 0.10$.

Results and Discussion

Results are presented for two periods: d 0 to 57 and d 57 to 120 (Table 5). Day 57 corresponded to the end of phase 3 for all treatments.

From d 0 to 57, pigs fed the corn-soybean meal-based diet had greater ($P < 0.05$) ADG compared with pigs fed 20% DDGS (B) and 30%-20% DDGS (D) in the first three dietary phases, with pigs fed 20% DDGS (C) having intermediate performance (although the two treatments with 20% DDGS, B and C, had nearly identical performance during the first three phases). No differences were observed for ADFI. Feed efficiency was improved ($P < 0.05$) for pigs fed the corn-soybean meal-based diet compared with pigs fed the other three DDGS withdrawal strategies. Pigs fed 20% DDGS (B) had improved ($P < 0.05$) F/G compared with pigs fed 30% DDGS (treatment D), with pigs fed the other 20% DDGS treatment (C) intermediate. On d 57, pigs fed the corn-soybean meal-based diet had greater ($P < 0.05$) BW than pigs fed the three DDGS withdrawal treatments (B, C, and D).

From d 57 to 120, no differences were observed for ADG or ADFI. However, pigs fed the corn-soybean meal-based diet had improved ($P < 0.05$) F/G compared with those fed 30%-20%-5% DDGS diets, whereas pigs fed the 20%-0% DDGS and 20%-10% DDGS were intermediate.

Overall (d 0 to 120), pigs fed the corn-soybean meal-based diet had greater ($P < 0.05$) ADG than pigs fed the 30%-20%-5% DDGS diet, whereas pigs fed the 20%-0% and 20%-10% DDGS had intermediate ADG. No difference was observed among treatments for ADFI. Feed efficiency was improved ($P < 0.05$) for pigs fed the corn-soybean meal-based diet compared with pigs fed the three DDGS withdrawal strategies. Final BW at d 120 tended to differ among treatments ($P = 0.051$), with pigs fed the 30%-20%-5% DDGS diet having the numerically lowest final BW and pigs fed the diet without DDGS having the greatest final BW. No differences were observed among treatments for removals, mortality, or total removals and mortality.

No differences were observed for HCW, carcass yield, backfat depth, loin depth, or percentage lean across treatments.

For economics based on total pen weight gain, feed cost tended ($P = 0.077$) to be decreased for pigs fed 30%-20%-5% DDGS compared with pigs fed the corn-soybean meal-based diet, with pigs fed 20%-0% and 20%-10% intermediate. Feed cost per pound of gain was lower ($P < 0.05$) for pigs fed the 20%-10% DDGS diet compared with pigs fed the corn-soybean meal-based diet, whereas the 20%-0% and 30%-20%-5% DDGS strategies resulted in intermediate feed costs. No difference was observed for revenue on a pig placed basis. However, IOFC tended ($P = 0.091$) to be greater for pigs fed the 20%-10% DDGS compared with pigs fed 30%-20%-5% DDGS, with those fed the corn-soybean meal-based diet and the diet containing 20%-0% DDGS being intermediate.

For economics using the closeout calculation method, no difference was observed for feed cost, revenue, or IOFC among treatments.

In conclusion, inclusion of DDGS in finishing pig diets worsened feed efficiency compared with pigs fed the corn-soybean meal diet, and the highest inclusion of DDGS (30%-20%-5% withdrawal strategy) also reduced ADG and final BW. Carcass characteristics were not affected, thus indicating the DDGS withdrawal strategies evaluated resulted in similar outcomes as pigs fed the corn-soybean meal-based diet. Although feeding DDGS reduced feed cost in some withdrawal strategies, improvements in economic outcomes were limited, with few differences observed for revenue or IOFC. These results suggest that although pigs fed a corn-soybean meal-based diet had the greatest final weight and best F/G, with the ingredient prices at the time of this study, DDGS withdrawal strategies may help reduce feed costs while minimizing negative effects on growth performance and carcass characteristics in finishing pigs.

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Table 1. Chemical composition of corn DDGS (as-fed basis)[1]

Nutrient, %	Corn DDGS
Estimated NE, kcal/lb[2]	862
Dry matter	89.65
Crude protein	28.90
Ether extract	7.70
Acid detergent fiber	11.25
Neutral detergent fiber	30.90
Ash	6.07
Starch	1.85
Total AA	
Lys	1.06
Ile	1.08
Leu	3.18
Met	0.50
Cys	0.60
Thr	1.03
Trp	0.20
Val	1.40

[1] Values represent the mean of two DDGS samples analyzed in duplicate. Proximate analysis was performed at Ward Laboratories, Inc. (Kearney, NE), and total AA content was determined at the University of Missouri (Columbia, MO).

[2] The NE content of DDGS was calculated based on its chemical composition using equations adapted from NRC (2012).

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

	Phase 1			Phase 2		
DDGS, %:	0	20	30	0	20	30
Ingredient, %						
Corn	69.43	60.85	54.06	75.38	65.82	59.38
Soybean meal, 47.1% CP	27.19	15.60	12.56	22.00	11.48	7.85
DDGS, 7.7% oil	---	20.00	30.00	---	20.00	30.00
Monocalcium phosphate, 21% P	0.49	0.12	---	0.37	---	---
Calcium carbonate	0.92	1.10	1.18	0.84	1.02	1.11
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Liquid Lys, 55% Lys[2]	0.48	0.77	0.78	0.48	0.73	0.77
DL-Met[2]	0.17	0.13	0.07	0.14	0.09	0.05
L-Thr	0.20	0.22	0.18	0.18	0.19	0.16
L-Trp	0.04	0.08	0.08	0.04	0.07	0.08
L-Val	0.03	0.06	0.02	0.03	0.05	0.05
Vitamin and trace mineral premix	0.11	0.11	0.11	0.11	0.11	0.11
Phytase[3]	0.05	0.05	0.05	0.05	0.05	0.05
Copper sulfate	0.05	0.05	0.05	0.05	0.05	0.05
Chlortetracycline[4]	0.18	0.18	0.18	---	---	---
Tiamulin[5]	0.20	0.20	0.20	---	---	---
Feed Aid[6]	0.15	0.15	0.15	---	---	---
Calculated analysis						
SID amino acids, %						
Lys	1.13	1.09	1.06	1.00	0.96	0.94
Ile:Lys	61	55	57	59	54	55
Leu:Lys	115	130	145	118	137	152
Met:Lys	35	33	31	34	32	30
Met and Cys:Lys	56	56	56	56	56	56
Thr:Lys	62	62	62	62	62	62
Trp:Lys	20.2	20.3	20.1	20.4	20.1	20.5
Val:Lys	67	68	68	67	68	71
CP, %	18.1	18.1	19.0	16.0	16.4	17.1
SID Lys:NE, g/Mcal	4.60	4.60	4.60	3.99	3.99	3.99
NE, kcal/lb	1,111	1,074	1,046	1,133	1,093	1,066
STTD P, %	0.41	0.37	0.37	0.37	0.33	0.35

[1] Phases 1 and 2 were fed from approximately 52 to 65 lb, and 65 to 125 lb, respectively.

[2] CJ Bio (Seoul, Korea).

[3] Quantum Blue 2G (AB Vista, Marlborough, Wiltshire, England), 1,000 FTU/kg, and assumed release of 0.15% STTD P.

[4] Aureomycin 100 (Phibro Animal Health Corporation, Teaneck, NJ).

[5] Denagard 10 (Elanco, Indianapolis, IN).

[6] FeedAID (Elanco, Indianapolis, IN), a blend of sodium metabisulfite, bentonite, and mineral oil, containing 21.8% Na.

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

	Phase 3		Phase 4		
DDGS, %:	0	20	0	10	20
Ingredient, %					
Corn	80.66	69.80	82.60	76.66	70.48
Soybean meal, 47.1% CP	16.92	7.76	14.99	11.04	7.16
DDGS, 7.7% oil	---	20.00	---	10.00	20.00
Monocalcium phosphate, 21% P	0.26	---	0.17	---	---
Calcium carbonate	0.79	0.95	0.77	0.82	0.89
Salt	0.35	0.35	0.35	0.35	0.35
Liquid Lys, 55% Lys[2]	0.47	0.66	0.53	0.59	0.65
DL-Met[2]	0.11	0.05	0.13	0.09	0.06
L-Thr	0.17	0.16	0.20	0.18	0.16
L-Trp	0.04	0.07	0.05	0.06	0.07
L-Val	0.04	0.03	0.06	0.05	0.03
Vitamin and trace mineral premix	0.10	0.10	0.08	0.08	0.08
Copper sulfate	0.05	0.05	0.05	0.05	0.05
Phytase[3]	0.05	0.05	0.05	0.05	0.05
Calculated analysis					
SID amino acids, %					
Lys	0.87	0.83	0.85	0.83	0.81
Ile:Lys	57	54	54	54	54
Leu:Lys	121	147	118	133	149
Met:Lys	34	30	35	33	31
Met and Cys:Lys	56	56	57	57	58
Thr:Lys	63	63	64	64	64
Trp:Lys	20.2	20.1	20.4	20.6	20.1
Val:Lys	67	68	67	68	69
CP, %	13.9	14.8	13.3	13.9	14.5
SID Lys:NE, g/Mcal	3.42	3.42	3.33	3.33	3.33
NE, kcal/lb	1,148	1,104	1,155	1,132	1,106
STTD P, %	0.33	0.32	0.30	0.29	0.31

[1] Phases 3 and 4 were fed from approximately 125 to 155 lb, and 155 to 195 lb, respectively.

[2] CJ Bio (Seoul, Korea).

[3] Quantum Blue 2G (AB Vista, Marlborough, Wiltshire, England), 1,000 FTU/kg, and assumed release of 0.15% STTD P.

Table 4. Phases 5 and 6 diet composition (as-fed basis)[1]

	Phase 5			Phase 6		
DDGS, %:	0	5	10	0	5	10
Ingredient, %						
Corn	83.07	81.01	78.70	83.07	80.86	78.54
Soybean meal, 47.1% CP	15.00	11.98	9.17	15.30	12.39	9.61
DDGS, 7.7% oil	---	5.00	10.00	---	5.00	10.00
Monocalcium phosphate, 21% P	0.05	---	---	---	---	---
Calcium carbonate	0.76	0.78	0.81	0.76	0.79	0.81
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Liquid Lys, 55% Lys[2]	0.36	0.44	0.52	0.22	0.30	0.38
DL-Met[2]	0.08	0.07	0.07	0.04	0.03	0.02
L-Thr	0.14	0.15	0.15	0.08	0.09	0.10
L-Trp	0.03	0.04	0.05	0.02	0.03	0.04
L-Val	---	0.02	0.02	---	---	---
Vitamin and trace mineral premix	0.08	0.08	0.08	0.08	0.08	0.08
Copper sulfate	0.05	0.05	0.05	0.05	0.05	0.05
Phytase[3]	0.05	0.05	0.05	0.05	0.05	0.05
Calculated analysis						
SID amino acids, %						
Lys	0.76	0.75	0.74	0.69	0.68	0.68
Ile:Lys	61	58	56	67	65	62
Leu:Lys	133	137	142	147	152	158
Met:Lys	34	33	33	31	30	30
Met and Cys:Lys	58	58	59	58	58	58
Thr:Lys	65	65	65	65	65	66
Trp:Lys	20.4	20.2	20.3	20.5	20.4	20.4
Val:Lys	68	69	68	76	74	73
CP, %	13.0	13.0	13.0	13.0	13.0	13.0
SID Lys:NE, g/Mcal	2.96	2.96	2.96	2.70	2.70	2.70
NE, kcal/lb	1,156	1,147	1,137	1,156	1,146	1,135
STTD P, %	0.28	0.28	0.29	0.28	0.28	0.29

[1] Phases 5 and 6 were fed from approximately 195 to 240 lb, and 240 to marketing, respectively.

[2] CJ Bio (Seoul, Korea).

[3] Quantum Blue 2G (AB Vista, Marlborough, Wiltshire, England), 1,000 FTU/kg, and assumed release of 0.15% STTD P.

Table 5. Effects of a DDGS withdrawal strategy on growth performance, carcass characteristics, and economic outcomes of growing-finishing pigs[1]

	DDGS inclusion, %[2]					
	A	B	C	D		
Phase 1	0	20	20	30		
Phase 2	0	20	20	30		
Phase 3	0	20	20	20		
Phase 4	0	20	10	20		
Phase 5	0	0	10	5		
Item Phase 6	0	0	10	5	SEM	*P* =
BW, lb						
d 0	52.3	52.5	52.5	52.4	0.88	0.710
d 57	163.7[a]	159.6[b]	160.3[b]	159.0[b]	1.68	< 0.001
d 120	285.0	280.5	280.6	279.1	2.04	0.051
Phases 1 to 3, d 0 to 57						
ADG, lb	1.92[a]	1.86[b]	1.87[ab]	1.82[b]	0.018	< 0.001
ADFI, lb	4.10	4.15	4.20	4.18	0.051	0.276
F/G	2.14[c]	2.24[b]	2.25[ab]	2.29[a]	0.013	< 0.001
Phases 4 to 6, d 57 to 120						
ADG, lb	2.14	2.13	2.12	2.12	0.038	0.802
ADFI, lb	6.31	6.43	6.39	6.45	0.053	0.107
F/G	2.97[b]	3.03[ab]	3.03[ab]	3.05[a]	0.041	0.004
Overall, d 0 to 120						
ADG, lb	2.02[a]	1.99[ab]	1.99[ab]	1.96[b]	0.019	0.009
ADFI, lb	5.16	5.26	5.25	5.27	0.043	0.120
F/G	2.56[b]	2.65[a]	2.65[a]	2.69[a]	0.023	< 0.001
Removals, %	9.6	8.0	7.2	9.6	1.30	0.412
Mortality, %	1.9	0.6	1.1	1.7	0.61	0.232
Total removals and mortality, %	11.5	8.5	8.3	11.3	1.41	0.156
Carcass characteristics						
Count, n	317	375	382	325		
HCW, lb	210.9	207.5	206.7	207.3	1.74	0.119
Carcass yield, %	73.4	73.3	73.4	73.7	0.31	0.775
Backfat depth, in[3]	0.67	0.67	0.66	0.69	0.02	0.192
Loin depth, in[3]	2.54	2.51	2.56	2.52	0.08	0.708
Lean, %	56.9	56.8	56.8	56.4	0.21	0.263
Economics, $/pig placed						
Feed cost	53.40	53.25	53.07	51.35	0.867	0.077
Feed cost/lb gain[4]	0.250[a]	0.248[ab]	0.245[b]	0.247[ab]	0.002	0.020
Revenue[5]	128.28	128.86	129.98	125.38	1.440	0.118
IOFC[6]	74.77	75.61	76.91	74.03	0.844	0.091
Closeout, $/pig placed[7]						

Feed cost/lb gain[8]	0.268	0.261	0.258	0.263	0.004	0.127
Revenue[9]	120.21	122.55	123.68	117.97	2.198	0.251
IOFC[6]	66.69	69.30	70.61	66.62	1.705	0.250

[1] A total of 2,133 pigs (PIC 337 × 1050) were used in a growing-finishing trial to determine the effect of four different DDGS withdrawal strategies on growth performance. Pigs were housed in mixed-gender pens with 27 pigs per pen across two barns. The corn-soybean meal-based control treatment had 19 pens/treatment, whereas all other treatments had 20 pens/treatment.

[2] Dietary phases 1 to 6 were fed from approximately 50 to 65 lb, 65 to 125 lb, 125 to 155 lb, 155 to 195 lb, 195 to 240 lb, and 240 lb to market, respectively.

[3] Adjusted using HCW as covariate.

[4] Feed cost/lb gain = total feed cost per pen divided by total gain of pigs within a pen.

[5] Revenue = (pen weight gain ′ treatment carcass yield ′ $0.82/lb carcass).

[6] Income over feed cost = revenue - feed cost.

[7] Closeout is based on the weight of pigs present at the conclusion of the trial for marketing, not including the weight gain of pigs that died or were removed.

[8] Feed cost/lb gain = total feed cost per pen divided by the gain of pigs remaining at the end of the study within a pen.

[9] Revenue = (gain of pigs remaining at the end of the study within a pen ′ treatment carcass yield ′ $0.82/lb carcass).