EFFECT OF DEOILED CORN DRIED DISTILLERS GRAINS WITH SOLUBLES (SOLVENT EXTRACTED) ON GROWTH PERFORMANCE, CARCASS CHARACTERISTICS, AND CARCASS FAT QUALITY OF GROWING AND FINISHING PIGS[1]

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Summary

A total of 1,215 pigs (initially 65.2 lb) were used in a 99-d study to determine the effects of deoiled corn dried distillers grains with solubles, solvent extracted (dDGS) on growing and finishing pig growth performance, carcass characteristics, and carcass fat quality. Pigs were blocked on the basis of pen weight and randomly allotted to 1 of 5 dietary treatments containing either 0, 5, 10, 20, or 30% dDGS. Pigs were fed in 4 phases; all dietary treatments were formulated to similar dietary ME and standardized ileal digestible (SID) lysine concentrations within each phase. Choice white grease (CWG) was included at increasing amounts as dDGS increased in the diet to maintain uniform dietary ME. Overall (d 0 to 99), ADG and ADFI decreased (linear, $P < 0.01$) with increasing dDGS in the diet. This reduction was especially pronounced when pigs were fed more than 20% dDGS. However, there was no difference in F/G ($P > 0.12$) for pigs fed increasing dDGS. For carcass characteristics, carcass weight and percent yield were reduced (linear, $P < 0.01$) and loin depth tended to decrease ($P < 0.09$) with increasing dDGS. However, there were no differences in backfat ($P < 0.26$), percent lean ($P < 0.16$) or fat-free lean index ($P < 0.20$). Jowl, backfat, and belly fat iodine values increased (linear, $P < 0.01$) with increasing dDGS. These increases were expected because of the increasing CWG in diets with increasing dDGS. In summary, feeding increasing levels of dDGS lowered ADG and ADFI but did not affect F/G as a result of the added fat in the diet. These data confirm the accuracy of the previously determined ME (1,137 kcal/lb) and SID amino acid values for dDGS; however, reasons for the reduced ADFI need further investigation.

Key words: deoiled corn dried distillers grains with solubles, feed ingredient, growth, pork quality

Introduction

The U.S. ethanol industry has experienced rapid growth over the last several years. In January 2008, there were 139 plants that accounted for 7.9 billion gal of ethanol produced, and more plants are being built to meet the increasing demand for ethanol. This

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rapid growth has led to an increased availability of ethanol manufacturing coproducts such as dried distillers grains with solubles (DDGS). Although the cattle industry historically has been the major market for this coproduct, its use as a feed ingredient in the swine industry has increased because improved manufacturing processes allow for a high quality coproduct with greater nutrient digestibility.

As the amount of DDGS increases and technologies improve, new coproducts are also being developed. One such product is deoiled corn DDGS, solvent extracted (dDGS), which is traditional DDGS with a majority of the oil removed. The deoiling process increases the CP, fiber, and mineral content of this coproduct. Because dDGS is a new coproduct that has the potential to be used in swine diets, an evaluation of its use in a commercial swine environment is necessary. We have previously determined the digestibility of amino acids and energy in dDGS; however, the effect on growth performance and carcass parameters has not been determined. Therefore, the objectives of this trial were to determine the effect of dDGS on the growth performance, carcass characteristics, and carcass fat quality of growing and finishing pigs.

Procedures

Procedures for this trial were approved by the Kansas State University Institutional Animal Care and Use Committee. The trial was conducted in a commercial research finishing barn in southwest Minnesota. The barns were double curtain sided with 18-ft × 10-ft pens that have completely slatted flooring and deep pits for manure storage. Each pen contained 1 self-feeder and 1 cup waterer. A robotic feeding system was utilized to provide feed on an individual pen basis.

A total of 1,215 pigs were used in a 99-d growth study. Pigs were blocked on the basis of pen weights and randomly allotted to 1 of 5 dietary treatments in meal form. There were initially 27 pigs in each pen. The 5 treatments consisted of diets containing 0, 5, 10, 20, or 30% dDGS. Pigs were fed in 4 phases with phase 1 fed from approximately 65 to 120 lb BW, phase 2 fed from 120 to 170 lb, phase 3 fed from 170 to 220 lb, and phase 4 fed from 220 to 265 lb (Tables 1 and 2). Diets were formulated to 0.94, 0.80, 0.69, and 0.95% standardized ileal digestible (SID) lysine and to maintain available P concentration of at least 0.27, 0.24, 0.22, and 0.21% for phases 1 to 4, respectively. All dietary treatments were formulated to similar dietary ME and SID lysine concentrations within each phase. The SID and energy content of dDGS were determined in a previous research study (Jaycela et al., 2007 Swine Day Report, p. 137; Table 3). Choice white grease (CWG) increased as dDGS increased in the diet to maintain uniform dietary ME levels.

Pen weights were obtained on d 0; every 14 d until d 70; and on d 78, 93, and 99 to determine ADG. Two middle-weight pigs from each pen were selected and slaughtered on d 93 to collect jowl, belly, and backfat (BF) samples for fatty acid analysis. Feed intake and F/G were determined on the basis of the feed delivery data generated through an automated feeding system and the amount of feed remaining in each pen's feeder on each weigh date.

Pigs from each pen were individually tattooed with the pen numbers at the end of the trial and transported to the JBS Swift & Company processing plant (Worthington, MN). Standard carcass criteria of loin and BF depth, HCW, percent lean, and yield were collected. Fat-free lean index (FFLI) was determined by using the equation 50.767 + (0.035 × HCW) – (8.979 × BF).

Fatty acids from each of the fat samples were expressed as a percentage of the total fatty acids. Iodine value was calculated by using the fatty acid profile of each sample according to the following equation (AOCS, 1998).

$$C16{:}1\ (0.95) + C18{:}1\ (0.86) + C18{:}2\ (1.732) + C18{:}3\ (2.616) + C20{:}1\ (0.785) + C22{:}1\ (0.723).$$

Statistical analysis was performed by analysis of variance by using the MIXED procedure of SAS. Data were analyzed as a randomized complete block design with pen as the experimental unit. Carcass weight was used as a covariate for BF, loin depth, percent lean, and FFLI. Linear and polynomial contrasts were used to determine the effects of increasing dDGS. Contrast coefficients were determined for unequally spaced treatments by using the IML procedure of SAS.

Results and Discussion

Overall (d 0 to 99), ADG and ADFI decreased (linear, $P < 0.01$; Table 4) with increasing dDGS in the diet. These effects were due to a modest reduction in ADG and ADFI at low levels of dDGS inclusion and a large reduction when dDGS were fed at 30% of the diet. However, F/G was not affected ($P > 0.12$) by increasing dDGS in the diet.

As dDGS increased, carcass weight and percent yield decreased (linear, $P < 0.01$), and loin depth tended to decrease (linear, $P < 0.09$). There was no difference in BF ($P > 0.25$), percent lean ($P > 0.16$), or FFLI ($P > 0.19$). The reduction in carcass weight can be attributed to the decreased ADG and yield as pigs were fed increasing dDGS.

Increasing dDGS in pig diets also increased (linear, $P < 0.01$) the iodine values of jowl, BF, and belly fat depots in pigs (Table 5). These increases were expected because of the increasing levels of CWG in diets with increasing dDGS. Iodine values from the 3 fat stores increased between 5.0 and 6.6 g/100 g in pigs fed 30% dDGS in the diet compared with the control pigs. This translates into an approximate 1.7 to 2.2 g/100 g increase for every 10% dDGS inclusion in the diet when fed in combination with CWG. In a previous study at Kansas State University in which growing-finishing pigs were fed diets with traditional DDGS, iodine values of various fat stores (jowl, BF, and belly fat) increased by similar levels when level of CWG was constant for all dietary treatments. The increase in iodine values herein, however, would not be expected to be nearly as large without the increase in added CWG needed to maintain isocaloric diets within each phase.

We hypothesize that the reduction in percent yield is related to the higher fiber content of the dDGS diets. Diets containing higher levels of fiber have been shown to increase basal metabolic rate, which could account for the lower percent yield in pigs that were fed diets containing dDGS. Previous studies have also shown that diets high in fiber increase rate of passage in the gastrointestinal tract, resulting in increased gut cell proliferation and intestinal growth. The higher fiber could have led to a greater volume of intestinal fluid and increased weight of digesta, intestines, and other visceral organs. Because visceral organs are excluded from the carcass, percent yield is negatively affected in pigs fed the dDGS diets because of the higher volume and weight of entrails removed during slaughter. In addition, the majority of the energy required for maintenance is used by visceral organs like the liver and the gastrointestinal tract. Thus, the resulting increase in weight of the visceral organs could have resulted in a further increase in maintenance requirement and diverted the utilization of nutrients away from the production of edible carcass. The reduction in carcass yield is not unexpected; this effect has been consistently reported in finishing pigs fed traditional DDGS.

Results from this trial appear similar to previous research evaluating traditional DDGS in which feed intake was reduced when DDGS were fed at more than 20% of the diet. The addition of dDGS to growing and finishing diets appears to negatively affect palatability, but reasons for the decrease in feed intake are not clear. However, these data validate the accuracy of the previously determined ME (1,137 kcal/lb) and SID amino acid values for dDGS because there were no changes in F/G when dDGS were fed at increasing levels in the diet.

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

	dDGS[2], %									
	Phase 1 diet					Phase 2 diet				
Item	0	5	10	20	30	0	5	10	20	30
Ingredient, %										
Corn	73.11	68.36	63.61	54.13	44.50	78.78	74.06	69.28	59.81	50.09
Soybean meal (46.5% CP)	24.79	23.62	22.44	20.09	17.75	19.22	18.04	16.87	14.52	12.18
dDGS	---	5.00	10.00	20.00	30.00	---	5.00	10.00	20.00	30.00
Choice white grease	---	0.95	1.93	3.80	5.75	---	0.95	1.93	3.80	5.80
Monocalcium phosphate (21% P)	0.60	0.48	0.35	0.13	---	0.50	0.35	0.25	---	---
Limestone	0.85	0.93	0.98	1.10	1.20	0.85	0.93	0.98	1.13	1.13
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix with phytase[3]	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
Trace mineral premix	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08	0.08
L-lysine HCl	0.15	0.18	0.20	0.25	0.30	0.15	0.18	0.20	0.25	0.30
Total	100	100	100	100	100	100	100	100	100	100
Calculated analysis										
Standardized ileal digestible amino acids										
Lysine, %	0.94	0.94	0.94	0.94	0.94	0.80	0.80	0.80	0.80	0.80
Methionine:lysine ratio, %	28	29	30	32	34	30	31	32	34	36
Met & Cys:lysine ratio, %	58	59	60	62	64	61	62	64	66	68
Threonine:lysine ratio, %	61	62	62	64	65	62	63	64	65	67
Tryptophan:lysine ratio, %	19	19	19	19	18	19	19	19	18	18
Total lysine, %	1.06	1.07	1.09	1.12	1.15	0.90	0.92	0.93	0.96	0.99
CP, %	17.89	18.52	19.15	20.42	21.68	15.78	16.41	17.04	18.31	19.57
ME, kcal/lb	1,517	1,517	1,517	1,517	1,517	1,520	1,520	1,520	1,520	1,520
SID Lysine:calorie ratio, g/Mcal ME	2.81	2.81	2.81	2.81	2.81	2.39	2.39	2.39	2.39	2.39
Ca, %	0.54	0.54	0.54	0.54	0.54	0.50	0.50	0.50	0.50	0.50
P, %	0.50	0.49	0.48	0.47	0.48	0.46	0.44	0.44	0.42	0.45
Available P, %	0.27	0.27	0.27	0.27	0.30	0.24	0.24	0.24	0.24	0.29
Dietary fat iodine value	121.4	108.4	97.8	98.1	88.4	117.2	108.0	100.9	94.2	88.7
Iodine value product[4]	25.5	36.8	42.1	55.9	69.8	16.4	30.2	39.3	57.5	70.9

[1] Phase 1 fed from approximately 65 to 120 lb and phase 2 fed from 120 to 170 lb.
[2] Deoiled corn dried distillers grains with solubles, solvent extracted.
[3] Provided 450 FTU/kg phytase with an expected phytate P release of 0.08% in phases 1 and 2.
[4] Iodine value of diet oil × % diet oil × 0.10.

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

	dDGS[2], %									
	Phase 3 diet					Phase 4 diet				
Item	0	5	10	20	30	0	5	10	20	30
Ingredient, %										
Corn	83.21	78.47	73.71	64.21	54.49	73.03	68.26	63.53	53.93	44.07
Soybean meal (46.5% CP)	14.84	13.66	12.49	10.14	7.81	25.17	23.99	22.82	20.47	18.15
dDGS	---	5.00	10.00	20.00	30.00	---	5.00	10.00	20.00	30.00
Choice white grease	---	0.95	1.90	3.80	5.80	---	0.98	1.90	3.85	5.90
Monocalcium phosphate (21% P)	0.45	0.34	0.23	---	---	0.35	0.23	0.1	---	---
Limestone	0.88	0.93	1.00	1.13	1.13	0.8	0.88	0.95	1.00	1.08
Salt	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix with phytase[3]	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Trace mineral premix	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06	0.06
L-lysine HCl	0.15	0.18	0.20	0.25	0.30	0.15	0.18	0.20	0.25	0.30
Paylean (9 g/lb)	---	---	---	---	---	0.025	0.025	0.025	0.025	0.025
Total	100	100	100	100	100	100	100	100	100	100
Calculated analysis										
Standardized ileal digestible amino acids										
Lysine, %	0.69	0.69	0.69	0.69	0.69	0.95	0.95	0.95	0.95	0.95
Methionine:lysine ratio, %	32	33	34	37	39	28	29	30	32	33
Met & Cys:lysine ratio, %	65	66	68	70	73	58	58	59	61	63
Threonine:lysine ratio, %	63	64	65	67	69	61	62	62	64	65
Tryptophan:lysine ratio, %	19	18	18	18	17	19	19	19	19	18
Total lysine, %	0.78	0.8	0.81	0.84	0.87	1.07	1.08	1.10	1.13	1.16
CP, %	14.12	14.75	15.38	16.65	17.91	18.05	18.69	19.32	20.58	21.83
ME, kcal/lb	1,521	1,521	1,521	1,521	1,521	1,522	1,522	1,522	1,522	1,522
SID Lysine:calorie ratio, g/Mcal ME	2.06	2.06	2.06	2.06	2.06	2.83	2.83	2.83	2.83	2.83
Ca, %	0.49	0.49	0.49	0.49	0.49	0.48	0.48	0.48	0.48	0.50
P, %	0.43	0.42	0.42	0.4	0.43	0.45	0.44	0.43	0.44	0.48
Available P, %	0.22	0.22	0.22	0.23	0.28	0.21	0.21	0.21	0.24	0.29
Dietary fat iodine value	116.1	107.5	100.8	94.2	89.4	121.6	107.8	100.2	94.7	88.2
Iodine value product[4]	19.7	33.3	41.3	59.3	69.8	26.8	31.3	40.1	54.9	67.9

[1] Phase 3 fed from 170 to 220 lb and phase 4 fed from 220 to 265 lb.
[2] Deoiled corn dried distillers grains with solubles, solvent extracted.
[3] Provided 375 FTU/kg phytase with an expected phytate P release of 0.07% in phases 3 and 4.
[4] Iodine value of diet oil × % diet oil × 0.10.

Table 3. Analyzed nutrient composition and standardized ileal digestible (SID) amino acids and energy content of deoiled corn dried distillers grains with solubles, solvent extracted (dDGS)[1]

	dDGS	
Item	Nutrient composition[2]	SID, %
Proximate analysis, %		
DM	87.69	
CP	31.20	
Crude fat	4.00	
ADF	16.10	
NDF	34.60	
Ca	0.05	
P	0.76	
Ash	4.64	
Metabolizable energy, kcal/lb[3]	1,137	
Amino acids, %		
Arginine	1.31	82.70
Histidine	0.82	74.63
Isoleucine	1.21	74.52
Leucine	3.64	83.79
Lysine	0.87	50.38
Methionine	0.58	80.41
Phenylalanine	1.69	80.77
Threonine	1.10	68.91
Tryptophan	0.19	77.96
Valine	1.54	73.75
Alanine	2.13	79.12
Aspartic acid	1.84	64.58
Cysteine	0.54	66.94
Glutamic acid	4.26	79.01
Glycine	1.18	64.63
Proline	2.11	87.79
Serine	1.30	76.86
Tyrosine	1.13	82.35

[1] Values were determined in a previous study (Jacela et al., 2007 KSU Swine Day Report of Progress, p. 137).
[2] As-fed basis.
[3] Calculated.

Table 4. Effects of increasing deoiled corn dried distillers grains with solubles, solvent extracted (dDGS) on growth performance and carcass characteristics[1]

	dDGS, %					Probability, $P <$		
Item	0	5	10	20	30	Linear	Quadratic	SE
Weight, lb								
d 0	65.2	65.2	65.2	65.3	65.3	0.94	0.99	1.0
d 99	267.6	262.9	262.0	260.5	256.3	0.001	0.68	2.1
d 0 to 99								
ADG, lb	2.00	1.97	1.96	1.96	1.93	0.01	0.61	0.02
ADFI, lb	4.76	4.78	4.64	4.65	4.49	0.003	0.72	0.07
F/G	2.38	2.43	2.37	2.38	2.33	0.12	0.44	0.03
Slaughter wt, lb	265.8	261.9	262.1	259.2	255.7	0.001	0.89	2.1
Carcass wt, lb	200.9	196.2	196.5	193.4	190.2	0.0001	0.66	1.8
Yield, %	75.5	75.0	75.0	74.7	74.3	0.01	0.73	0.3
Backfat, in[2]	0.65	0.65	0.65	0.65	0.67	0.26	0.25	0.01
Loin depth, mm[2]	2.50	2.45	2.46	2.48	2.39	0.09	0.55	0.03
Lean, %[2]	56.5	55.9	56.3	56.4	55.8	0.16	0.28	0.2
FFLI, %[2,3]	50.4	50.4	50.4	50.5	50.2	0.20	0.19	0.1

[1] A total of 1,215 pigs (initially 65.2 lb, 27 pigs per pen) were used in this study; there were 9 replications per treatment.
[2] Data analyzed using carcass weight as a covariate.
[3] Fat-free lean index.

Table 5. Effects of increasing deoiled corn dried distillers grains with solubles, solvent extracted (dDGS) on fat quality

	dDGS[1], %					Gender[2]		Probability, $P <$			SE	
Item	0	5	10	20	30	Barrow	Gilt	Linear	Quadratic	Gender	Trt	Gender
Iodine value, g/100g												
Jowl	67.5	68.1	69.0	71.1	73.3	68.9	70.7	0.01	0.41	0.01	0.45	0.30
Backfat	68.5	68.4	69.2	73.0	73.5	69.2	71.9	0.01	0.99	0.01	0.63	0.42
Belly fat	67.1	68.0	69.1	72.4	73.7	68.7	71.5	0.01	0.64	0.01	0.60	0.40
C 18:2 fatty acids, %												
Jowl	13.6	13.7	14.7	15.9	17.1	14.5	15.4	0.01	0.75	0.01	0.31	0.20
Backfat	16.5	16.3	17.0	18.9	18.4	16.5	18.3	0.01	0.40	0.01	0.43	0.29
Belly fat	15.3	15.4	16.3	17.8	18.2	15.7	17.5	0.01	0.50	0.01	0.39	0.26
Saturated fatty acids, %												
Jowl	35.7	35.1	35.0	33.8	32.3	34.9	33.9	0.01	0.34	0.01	0.34	0.22
Backfat	37.6	37.5	37.2	34.8	33.6	36.7	35.5	0.01	0.34	0.01	0.39	0.26
Belly fat	37.9	36.9	36.5	34.3	33.0	36.4	35.0	0.01	0.85	0.01	0.40	0.26

[1] Values are means of 18 observations per treatment.
[2] Values are means of 45 observations.