EFFECTS OF DRIED DISTILLERS GRAIN WITH SOLUBLES ON GROWING-FINISHING PIG PERFORMANCE

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Summary

Three experiments were conducted to determine the effects of increasing dried distiller's grains with solubles (DDGS) on growth performance and palatability in growing-finishing pigs. In Exp. 1, a total of 1,050 pigs (initially 104.9 lb) were used in a 28-d study in May 2002. Pigs were fed diets with either 0 or 15% DDGS and 0, 3, or 6% added fat, for a 2 × 3 factorial arrangement. Overall, there were no DDGS × fat content interactions (P = 0.20). There was an improvement (linear, P<0.01) in ADG and F/G with increasing added fat and no difference in growth performance between pigs fed 0 or 15% DDGS. In Exp. 2, a total of 1,038 pigs (initially 102.1 lb) were used in a 56-d study in August 2005. Pigs were fed diets with either 0, 10, 20, or 30% DDGS from the same ethanol plant as in Exp. 1. Overall (d 0 to 56), there was a trend for decreased ADG (linear, P<0.10) and ADFI (linear, P<0.06) as DDGS increased. The greatest reduction occurred in pigs fed more than 10% DDGS. In Exp. 3, a total of 120 growing pigs (initially 48.7 lb) were used in a 21-d feed preference study in October 2005. Pigs were randomly allotted to a pen with 4 feeders, each containing a separate dietary treatment. Pigs were offered diets based on corn-soybean meal, with 0, 10, 20, or 30% DDGS from the same source as in Exp. 1 and 2. For all periods (d 0 to 7, 7 to 21, and 0 to 21), there was a decrease in ADFI (quadratic, P<0.01) as DDGS increased in the diet. The most dramatic decrease was observed between 0 and 10% DDGS. Experiment 1 showed no difference in growth performance in pigs fed 0 or 15% DDGS. In Exp 2, at DDGS contents higher than 10%, there were trends for decreased ADG and ADFI; in Exp. 3, ADFI decreased with increasing DDGS in the diet. In summary, DDGS from the ethanol plant tested can be used at 10 to 15% in finishing diets without reducing pig performance. Higher percentages of DDGS in the diet decreased ADFI in growing and finishing pigs.

(Key Words: Dried Distillers Grains, Growing-Finishing Pigs.)

Introduction

The use of DDGS in swine diets has increased because of increases in ethanol production. Research has shown variable results when pigs are fed various amounts of DDGS. This has been partly attributed to variation between manufacturing processes at different plants, and to batch variation at a single plant. Potential sources of variation that have been proposed to explain batch variation over time within a single plant include drying method, particle size, regional grain quality variation, and amounts of residual sugars. There is little information available about potential variation of DDGS from an individual ethanol production plant. Therefore, the objective of the ex-

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periments were: 1) To evaluate feeding DDGS over time from the same ethanol manufacturing plant to determine potential DDGS quality variation within plant: and 2) Determine the efficacy of a preference test to predict DDGS palatability in commercial settings.

Procedures

General. Procedures used in these experiments were approved by the Kansas State University Animal Care and Use Committee. Experiments 1 and 2 were conducted at a commercial research facility in southwestern Minnesota. The facility had totally slatted floors with approximately 10 × 18 ft pens that contained a five-hole feeder and one bowl drinker. The facility was a double curtain-sided, deep-pit barn that operated on minimal ventilation during the summer and on automatic ventilation during the winter. Experiment 1 was conducted in May 2002 and Exp. 2 was conducted in August 2005. Experiment 3 was performed at the Kansas State Swine Teaching and Research Center in October 2005. Dried distiller grains with solubles for all three experiments were from different batches from Agri-Energy, Luverne, Minnesota.

Experiment 1. A total of 1,050 pigs (initial BW of 104.9) were used in a 28-d growth assay evaluating the effects of DDGS and increasing added fat on growth performance. Pigs were randomly blocked by weight, and were allotted to one of 6 dietary treatments, with 7 pens per treatment. Each pen contained 24 to 26 pigs.

Experimental diets were based on corn-soybean meal and were fed in meal form (Table 1). Diets contained either 0 or 15% DDGS, in combination with 0, 3, or 6% added fat, and were formulated by using DDGS values from 1998 NRC. Pigs and feeders were weighed on d 0, 14, and 28 to determine the response criteria of ADG, ADFI, and F/G.

Data were analyzed as a 2 × 3 factorial, with pen as the experimental unit. Fixed model effects included with or without DDGS, fat content (0, 3, or 6%), and their interaction. Analysis of variance was performed by using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC). Linear and polynomial contrasts were used to determine the effects of increasing DDGS.

Experiment 2. A total of 1,038 gilts (initial BW of 102.1 lb) were used in a 56-d growth assay evaluating the effect of increasing DDGS (0, 10, 20, and 30%) in the diet on pig growth performance. Pigs were randomly blocked and were allotted to one of four dietary treatments, with 10 replications per treatment. Each pen contained 24 to 26 pigs.

The four experimental diets were based on corn-soybean meal and contained 0, 10, 20, or 30% DDGS. All diets contained 6% added fat and were fed in meal form. Dietary treatments were fed in two phases, with Phase 1 from d 0 to 28 (Table 2) and Phase 2 from d 28 to 56 (Table 3). The Phase 1 and Phase 2 diets were formulated to 0.95 and 0.78% true ileal digestible (TID) lysine with values from the 1998 NRC and to 0.55 and 0.54% calcium, respectively. Diets were formulated to maintain a minimum available phosphorus concentration of 0.29 and 0.26% in Phase 1 and Phase 2, respectively. The diet containing 30% DDGS did not need any supplemental phosphorus, and exceeded the minimum requirement. Pigs and feeders were weighed on d 0, 14, 28, 42, and 56 to determine the response criteria of ADG, ADFI, and F/G.

Analysis of variance was performed by using the MIXED procedure of SAS (SAS Institute Inc., Cary, NC), with pen as the experimental unit. Linear and polynomial contrasts were used to determine the effects of increasing DDGS.

Experiment 3. A total of 120 growing pigs (initial BW of 48.7 lb) were used in a 21-

d study evaluating the effects on palatability of increasing DDGS from 0 to 30%. Pigs were randomly blocked by sex and allotted to a pen. There were 15 pigs/pen and 8 pens. Each pen used in this experiment was 10.5 × 10.2 ft. and contained one nipple waterer. Each pen contained 4 feeders and each feeder supplied one of the treatment diets. Feeders were randomly rotated within pens twice daily. *Ad libitum* access to feed and water was provided.

Diets were based on corn-soybean meal and contained 0, 10, 20, or 30% DDGS (Table 4). Experimental diets were formulated to 1.07% TID lysine and contained 0.29% available phosphorus. Diets were formulated by using an average of DDGS high and low values from Stein et al. (2005) and were fed in meal form. The only response criterion measured was ADFI, which was determined by weighing the feeders at d 0, 7, 14, and 21.

Data were analyzed by using the MIXED procedures of SAS as a completely randomized block design with feeder as the experimental unit. Linear and quadratic polynomial contrasts, as well as least squares means, were used to determine differences in treatment preference.

Results and Discussion

Experiment 1. Overall, there were no DDGS × added fat interactions (P = 0.20, Table 5). There was improvement (linear, P<0.01) in ADG and F/G as amount of added fat increased. There was no difference (P = 0.79) in pig growth performance between pigs fed 0 or 15% DDGS.

Experiment 2. For Phase 1 (d 0 to 28), pigs fed diets containing DDGS had decreased ADFI and improved (linear, P<0.01) F/G (Table 6). During this same period, there was no difference in ADG among treatments (P = 0.77). For Phase 2 (d 28 to 56), pigs fed diets with increasing DDGS tended to have decreased (linear, P<0.14) ADG and poorer F/G. Overall (d 0 to 56), pigs fed diets with increasing DDGS had a tendency for decreased ADG (linear, P<0.10) and ADFI (linear, P<0.06). This was due to reductions in intake and gain when DDGS was fed at 20 or 30% of the diet.

Experiment 3. For all periods (d 0 to 7, 7 to 21, and 0 to 21), pigs offered DDGS had decreased ADFI as the amount of DDGS in the diet increased (linear and quadratic, P<0.01, Table 7). The response was primarily due to a decrease in ADFI between 0 and 10% DDGS and a further reduction between 10 and 20% DDGS. Feed intake was similar for 20 and 30% DDGS.

Results from the commercial trials indicate that increasing the energy density of the diet by adding fat improved pig performance whether dietary DDGS was used or not. Also, feeding this DDGS source up to 15% in the growing and finishing diets did not affect pig performance (Exp. 1). But dietary DDGS at 20 or 30% of the diet reduced growth performance (Exp. 2). In contrast, a similar response was not seen in Exp. 3 when pigs were given a choice of diets consisting of the same dietary percentages of DDGS as in Exp. 2.

Pigs preferred to eat diets without DDGS, compared with diets that contained DDGS, even when only 10% was added to the diet. A research preference model provides valuable information in demonstrating that palatability is a concern when feeding high percentages of DDGS in the diet. Although the research model does not fully replicate responses observed in the commercial environment, Exp. 2 supports the concern with decreased palatability, especially at higher percentages of DDGS. In consequence, producers can use added fat to improve growth performance with confidence. If a producer or feed mill can obtain from a single ethanol plant DDGS demonstrated not to negatively affect feed intake, data from these trials indicate that 10 to 15% can be used in finishing diets.

Table 1. Composition of Diets (Exp. 1; As-fed Basis)[a]

	Without DDGS			With DDGS		
Item Added Fat, %:	0	3	6	0	3	6
Ingredient, %						
Corn	72.4	67.65	62.81	59.62	54.80	50.00
Soybean meal (46.5%)	25.2	26.98	28.80	23.30	25.10	27.00
DDGS	-	-	-	15.00	15.00	15.00
Choice white grease	-	3.00	6.00	-	3.00	6.00
Monocalcium P (21% P)	0.80	0.85	0.90	0.45	0.48	0.50
Limestone	0.90	0.85	0.85	0.95	0.95	0.95
Salt	0.35	0.35	0.35	0.35	0.35	0.35
Vitamin premix	0.08	0.08	0.08	0.08	0.08	0.08
Trace mineral premix	0.10	0.10	0.10	0.10	0.10	0.10
L-lysine HCl	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
Calculated values						
Total lysine, %	1.07	1.11	1.15	1.07	1.11	1.15
True ileal digestible amino acids[b]						
Lysine, %	0.95	0.99	1.03	0.93	0.97	1.00
Methionine:lysine ratio, %	0.27	0.27	0.26	0.31	0.30	0.30
Met & cys:lysine ratio, %	0.58	0.56	0.55	0.65	0.63	0.62
Threonine:lysine ratio, %	0.63	0.63	0.62	0.70	0.69	0.68
Tryptophan:lysine ratio, %	0.19	0.19	0.20	0.21	0.21	0.21
ME, kcal/lb	1,510	1,571	1,632	1,474	1,535	1,596
Calcium, %	0.60	0.59	0.61	0.57	0.58	0.59
Phosphorus, %	0.54	0.55	0.56	0.54	0.54	0.55
Available phosphorus, %	0.24	0.25	0.26	0.24	0.25	0.26
Lysine:calorie ratio, g/, mcal	3.21	3.21	3.21	3.21	3.21	3.21

[a]Diets fed in meal form from d 0 to 28.

[b]DDGS nutrient values for diet formulation derived from 1998 NRC.

Table 2. Composition of Diets (Exp. 2. Phase 1; As-fed Basis)[a]

	DDGS, %			
Item	0	10	20	30
Ingredient, %				
Corn	64.60	55.45	46.30	37.10
Soybean meal (46.5 %)	27.25	26.60	25.90	25.25
DDGS	-	10.00	20.00	30.00
Choice white grease	6.00	6.00	6.00	6.00
Monocalcium P (21% P)	0.70	0.40	0.15	-
Limestone	0.83	0.93	1.00	1.03
Salt	0.35	0.35	0.35	0.35
Vitamin premix with phytase	0.08	0.08	0.08	0.08
Trace mineral premix	0.10	0.10	0.10	0.10
L-lysine HCl	0.10	0.10	0.10	0.10
Total	100.00	100.00	100.00	100.00
Calculated values				
Total lysine, %	1.07	1.09	1.11	1.12
True ileal digestible amino acids[b]				
Lysine, %	0.95	0.95	0.95	0.95
Methionine:lysine ratio, %	0.28	0.30	0.32	0.34
Met & cys:lysine ratio, %	0.57	0.61	0.64	0.67
Threonine:lysine ratio, %	0.62	0.65	0.68	0.71
Tryptophan:lysine ratio, %	0.20	0.19	0.18	0.18
ME, kcal/lb	1,638	1,614	1,590	1,565
Calcium, %	0.55	0.55	0.55	0.55
Phosphorus, %	0.52	0.50	0.49	0.51
Available phosphorus equiv, %[c]	0.29	0.29	0.29	0.31
TID Lysine:calorie ratio, g/mcal	2.50	2.50	2.50	2.50

[a]Diets fed in meal form from d 0 to 28.

[b]DDGS nutrient values for diet formulation derived from 1998 NRC.

[c]Includes expected phytase phosphorus release from added phytase.

Table 3. Composition of Diets (Exp. 2. Phase 2; As-fed Basis)[a]

	DDGS, %			
Item	0	10	20	30
Ingredient, %				
Corn	70.70	61.50	52.35	43.10
Soybean meal (46.5%)	21.25	20.60	19.95	19.25
DDGS	-	10.00	20.00	30.00
Choice white grease	6.00	6.00	6.00	6.00
Monocalcium P (21% P)	0.60	0.35	0.10	-
Limestone	0.88	0.98	1.05	1.05
Salt	0.35	0.35	0.35	0.35
Vitamin premix with phytase	0.06	0.06	0.06	0.06
Trace mineral premix	0.08	0.08	0.08	0.08
L-lysine HCL	0.08	0.08	0.08	0.08
Total	100.00	100.00	100.00	100.00
Calculated values				
Total lysine, %	0.88	0.90	0.92	0.94
True ileal digestible amino acids[b]				
Lysine, %	0.78	0.78	0.78	0.78
Methionine:lysine ratio, %	0.30	0.33	0.35	0.38
Met & cys:lysine ratio, %	0.63	0.67	0.71	0.75
Threonine:lysine ratio, %	0.65	0.69	0.73	0.76
Tryptophan:lysine ratio, %	0.21	0.19	0.18	0.17
ME, kcal/lb	1,641	1,616	1,592	1,566
Calcium, %	0.54	0.54	0.54	0.54
Phosphorus, %	0.47	0.46	0.46	0.48
Available phosphorus equiv, %[c]	0.26	0.26	0.26	0.29
TID Lysine:calorie ratio, g/mcal	2.08	2.08	2.08	2.08

[a]Diets fed in meal form from d 28 to 56.

[b]DDGS nutrient values for diet formulation from 1998 NRC.

[c]Includes expected phytase phosphorus release from added phytase.

Table 4. Composition of Diets (Exp. 3; As-fed Basis)[a]

	DDGS, %			
Item	0	10	20	30
Ingredient, %				
Corn	67.05	59.00	50.85	42.75
Soybean meal (46.5%)	30.05	28.40	26.80	25.20
DDGS	-	10.00	20.00	30.00
Monocalcium P (21% P)	1.05	0.79	0.53	0.27
Limestone	1.00	1.00	1.00	1.00
Salt	0.35	0.35	0.35	0.35
Vitamin premix	0.15	0.15	0.15	0.15
Trace mineral premix	0.15	0.15	0.15	0.15
L-lysine HCl	0.15	0.15	0.15	0.15
DL-methoinine	0.05	0.02	-	-
L-threonine	0.02	-	-	-
Total	100.00	100.00	100.00	100.00
Calculated values				
Total lysine, %	1.20	1.22	1.24	1.26
True ileal digestible amino acids[b]				
Lysine, %	1.07	1.07	1.07	1.07
Methionine:lysine ratio, %	0.31	0.31	0.32	0.25
Met & cys:lysine ratio, %	0.60	0.63	0.67	0.74
Threonine:lysine ratio, %	0.62	0.62	0.65	0.67
Tryptophan:lysine ratio, %	0.20	0.20	0.20	0.20
ME, kcal/lb	1,505	1,522	1,538	1,555
Calcium, %	0.70	0.66	0.62	0.59
Phosphorus, %	0.62	0.60	0.59	0.58
Available phosphorus, %	0.29	0.29	0.29	0.29
TID Lysine:calorie ratio, g/mcal	3.02	3.02	3.02	3.02

[a]Diets fed in meal form from d 0 to 21.
[b]DDGS nutrient values for diet formulation from H.H. Stein, C. Pederson, and M.G. Boersma. 2005. Energy and nutrient digestibility in dried distillers grain with solubles by growing pigs. *Journal of Animal Science* 83 (Suppl. 2): p. 79 (Abstr. 199).

Table 5. Effects of DDGS with Added Fat on Finishing Pig Performance (Exp. 1)[a]

	Without DDGS			With DDGS				Probability, P<			
										Added Fat	
Item Added Fat, %:	0	3	6	0	3	6	SE	DDGS × Fat	DDGS	Level	Linear
D 0 to 28											
ADG, lb	1.98	2.12	2.12	2.02	2.03	2.17	0.041	0.20	0.99	0.01	0.01
ADFI, lb	4.68	4.76	4.68	4.79	4.66	4.72	0.081	0.43	0.79	0.92	0.68
F/G	2.37	2.25	2.21	2.38	2.30	2.18	0.038	0.57	0.92	0.01	0.01

[a]A total of 1,050 pigs initially 104.9 lb were used in this study, with 7 replications per treatment.

Table 6. Effects of Increasing Percentages of DDGS on Grower Pig Performance (Exp. 2)[a]

Item	DDGS, %				Probability, P <			SE
	0	10	20	30	Treatment	Linear	Quadratic	
D 0 to 28								
ADG, lb	1.75	1.76	1.74	1.72	0.77	0.40	0.59	0.040
ADFI, lb	3.66	3.68	3.52	3.47	0.03	0.01	0.49	0.076
F/G	2.10	2.09	2.03	2.02	0.02	0.01	0.99	0.028
D 28 to 56								
ADG, lb	1.99	2.02	1.93	1.96	0.14	0.14	0.96	0.036
ADFI, lb	4.91	5.02	4.91	4.90	0.40	0.62	0.31	0.084
F/G	2.47	2.49	2.54	2.50	0.21	0.14	0.22	0.032
D 0 to 56								
ADG, lb	1.87	1.89	1.83	1.84	0.17	0.10	0.68	0.026
ADFI, lb	4.28	4.35	4.21	4.18	0.10	0.06	0.35	0.069
F/G	2.29	2.30	2.29	2.28	0.71	0.42	0.40	0.023
Total Removals	3	10	9	8				

[a]A total of 1,038 growing pigs, initially 102.1 lb, were used in this study, with 10 replications per treatment.

Table 7. Effects of Increasing Dried Distiller Grains with Solubles on Feed Intake (Exp. 3)[a]

		DDGS, %			Probability, P<			
ADFI	Control	10	20	30	Trt	Linear	Quadratic	SED
D 0 to 7	1.01[b]	0.69[c]	0.49[d]	0.58[cd]	0.01	0.01	0.01	0.057
D 7 to 21	1.33[b]	0.86[c]	0.45[e]	0.53[d]	0.01	0.01	0.01	0.062
D 0 to 21	1.22[b]	0.80[c]	0.46[d]	0.55[d]	0.01	0.01	0.01	0.044

[a]A total of 120 pigs, initially 48.7 lb, were used in this study, with 8 replications per treatment. Pigs given the choice of one of four diets in the same pen; corn-soybean meal control or control with DDGS replacing corn.

[bcde]Means within a row with different subscripts differ ($P<0.05$).