EFFECTS OF DRIED DISTILLERS GRAINS WITH SOLUBLES ON GROWTH PERFORMANCE AND FAT QUALITY OF FINISHING PIGS[1]

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Summary

A total of 1,112 pigs were used in a 78-d growth assay evaluating the effects of increasing dried distillers grains with solubles (DDGS, 0, 5, 10, 15, or 20%) on pig growth performance and carcass characteristics. At the end of the trial, jowl fat, belly fat, and backfat samples were collected and analyzed for fatty acid profile and iodine value (IV). From d 0 to 78, ADG and ADFI decreased (linear; P<0.04) with increasing DDGS with the greatest reduction occurring between pigs fed 15 and 20% DDGS. Feed efficiency tended to improve (P<0.06) for pigs fed 5% DDGS compared with those fed other dietary treatments. Increasing DDGS decreased (P<0.04) carcass weight and percent yield. There was no difference (P>0.22) in loin depth, but increasing DDGS tended to decrease (P<0.09) backfat and fat-free lean index (FFLI). Backfat, jowl fat, and belly fat iodine values and percentage C 18:2 fatty acids increased (linear, P<0.02) with increasing DDGS in both the "topped" pigs marketed 21 d before trial conclusion and pigs marketed at trial completion. Increasing DDGS decreased (linear, P<0.05) percentage saturated fatty acids in backfat and belly fat in both marketing groups and percentage saturated fatty acids in jowl fat with increasing DDGS in the diet in the pigs marketed at trial completion. Barrows had decreased (P<0.04) belly fat iodine values and percentage 18:2 fatty acids when compared to gilts. Barrows also had increased (P<0.05) jowl fat and belly fat percentage 18:2 fatty acids when compared to gilts. Based on these results and previous research trials, dried distillers grain with solubles from this source can be fed up to 15% before seeing reductions in ADG; however, the increase in iodine value and decrease in dressing percentage must be considered in determining the economic value of DDGS.

(Key words; DDGS, feed ingredients, pork quality.)

Introduction

Demands in fuel ethanol production have led to an increase in dried distillers grains with solubles (DDGS), which is the major by-product of dry corn milling from fuel ethanol production. The swine industry has the opportunity to incorporate DDGS into diets because of increased availability. Newer ethanol plants, built after 1990, have improved processing techniques that can increase amino acid digestibility and make DDGS more applicable to swine industry use.

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When fed to livestock, the impact of DDGS on growth performance has been inconsistent due to product variability in drying methods, levels of residual sugars, or grain quality with respect to batch-to-batch variation. Research has shown that DDGS levels anywhere from 0% to 30% of the diet could be fed before growth performance was reduced. It has been theorized that variation in DDGS palatability between sources can influence performance.

Dried distillers grain with solubles also has been shown to impact carcass quality and characteristics when fed to grow-finish pigs. Specifically, feeding DDGS has been shown to reduce percent yield and carcass weight, increase carcass fat softness, and reduce belly firmness. Therefore, the objective of this research was to test the effect of DDGS on grow-finish pig performance, carcass characteristics and iodine value of belly fat and backfat.

Procedures

A total of 1,112 pigs were used in a 78-d growth assay evaluating the effects of increasing DDGS in the diet on pig growth performance and carcass characteristics. Dietary treatments were fed in meal form and contained 0, 5, 10, 15, or 20% DDGS. All diets contained 6% added fat with choice white grease as the fat source. Treatments were fed in four phases with Phase 1 fed from 110 to 130 lb, Phase 2 from 130 to 181 lb, Phase 3 from 181 to 232 lb, and Phase 4 from 232 to 271 lb (Tables 1 to 4).

Diets were formulated to 0.98, 0.83, 0.73, and 0.66% true ileal digestible (TID) lysine and to maintain minimum available P concentrations of 0.28, 0.25, 0.23, and 0.22% for phases 1 to 4, respectively. The diet containing 20% DDGS in phase 4 did not include supplemental phosphorus and exceeded the minimum requirement. There were 9 replicates per treatment with 25 to 28 pigs per pen. There was an equal distribution of barrows and gilts in each pen. The experiment was conducted in a commercial research finishing barn in southwestern Minnesota. Pens were 18 × 10 feet. The barns were double curtain sided, with completely slatted flooring and a deep pit for manure storage. Each pen contained one self feeder and one cup waterer.

Pigs and feeders were weighed on d 0, 15, 29, 43, 57, and 78 to determine the response criteria of ADG, ADFI, and F/G. On d 57, the barn was "topped" to simulate normal pig marketing under commercial production practices. The three heaviest pigs from all pens were visually selected, removed, and marketed. From the tops, six barrows were randomly chosen from each treatment to collect jowl, backfat, and belly samples and analyze them for fatty acid analysis.

At the end of the experiment, pigs from each pen were individually tattooed with pen number and shipped to Swift processing plant (Worthington, MN) where standard carcass criteria of body weight (BW), loin and backfat (BF) depth, hot carcass weight, lean percentage, and yield were collected. Fat-free lean index (FFLI) was also measured using the equation 50.767 + (0.035 × hot carcass weight) – (8.979 × BF). Jowl, backfat, and belly samples were collected on one barrow and one gilt randomly chosen from each pen to analyze fat for fatty acid analysis. Samples were collected and frozen until further processing and analysis.

Iodine value was calculated from 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).

The fatty acids are represented as a percentage of the total fatty acids in the sample.

Data were analyzed by Analysis of Variance using the MIXED procedure of SAS

(SAS Inst., Inc., Cary, NC). Pigs from all experiments were blocked based on initial weight. Linear and polynomial contrasts were used to determine the effects of increasing DDGS. Pen was the experimental unit, except for data analyzing "topped" pigs, where pig was the experimental unit. All growth data were analyzed as randomized complete block design. The "topped" pig fat analysis data was evaluated as a completely random design. The fat analysis data from the closeout pigs were analyzed as a split plot with DDGS treatments as a whole plot and gender as the subplot. Carcass weight was used as a covariate for the responses of BF, FFLI, and loin depth.

Results and Discussion

Overall (d 0 to 78), ADG and ADFI decreased (linear; $P<0.04$) with increasing DDGS (Table 5); however, the greatest difference in ADG occurred when DDGS in the diet was increased from 15 to 20%. Pigs fed 5% DDGS tended ($P<0.06$) to have improved F/G compared with pigs fed other dietary treatments. There were no differences ($P>0.17$) in live slaughter weight or loin depth. Carcass weight and percent yield decreased ($P<0.04$) with increasing DDGS in the diet. Increasing DDGS tended to decrease ($P<0.09$) backfat and FFLI.

Backfat, jowl fat, and belly fat iodine values and percentage C 18:2 fatty acids increased (linear, $P<0.02$) with increasing DDGS in both the "topped" pigs (Table 6) and pigs marketed at trial completion (Table 7). Percentage saturated fatty acids in backfat and belly fat decreased (linear, $P<0.05$) with increasing DDGS in the "topped" pigs and pigs marketed at trial completion. Percentage of saturated fatty acids in jowl fat also decreased (linear, $P<0.03$) with increasing DDGS in the pigs marketed at trial completion.

There were no gender by treatment interactions observed. Barrows had decreased ($P<0.04$) belly fat iodine values and percentage 18:2 fatty acids compared to gilts. Barrows also had increased ($P<0.05$) jowl fat and belly fat percentage 18:2 fatty acids compared to gilts.

Increasing DDGS reduced ADG, carcass weights and percent yield. The reduction in ADG was driven by a reduction in ADFI as DDGS level increased in the diet. The reduced carcass weights equated to a reduction of 4 lb per pig fed 20% DDGS. This reduction was caused by the combination of lower ADG and decreased percent yield as DDGS increased. First, the reduction in percent yield may be explained by the fact that visceral organ weights are not included in percent yield. Further, increased dietary protein, which caused increased metabolic activity may have contributed to percent yield reduction. Secondly, the reduction in percent yield could also be contributed to an increase in dietary fiber for pigs fed diets containing DDGS because of its high fiber content. Feeding fiber increases the rate of passage causing increased intestinal growth and gut cell proliferation. The weight of digesta is increased causing reduced percent yield. It has been well documented that feeding pigs diets high in fiber reduces percent yield, as is potentially the case when pigs consume diets containing DDGS.

Iodine values were also increased by feeding increasing DDGS, showing an increase of 3 to 4 g/100g in the various fat stores in pigs fed 20% DDGS. This increase caused jowl fat samples to exceed the maximum level of 73 g/100g for jowl fat set by Triumph Foods, St. Joseph, MO. Based on these results and previously conducted research trials, dried distillers grain with solubles from this source can be fed up to 15% before seeing reductions in growth performance. The linear reduction in yield and increase in iodine value must be considered when determining the economic value of DDGS.

Table 1. Phase 1 Diet Composition (Fed from 108 to 130 lb; as-fed basis)

	DDGS, %				
Item	0	5	10	15	20
Ingredient, %					
Corn	65.00	60.65	56.30	51.95	47.60
Soybean meal (46.5 % CP)	26.85	26.30	25.75	25.15	24.60
DDGS	---	5.00	10.00	15.00	20.00
Choice white grease	6.00	6.00	6.00	6.00	6.00
Monocalcium P (21% P)	0.63	0.50	0.38	0.25	0.13
Limestone	0.85	0.90	0.94	0.99	1.03
Salt	0.35	0.35	0.35	0.35	0.35
L-lysine HCl	0.150	0.150	0.150	0.150	0.150
Vitamin premix with phytase	0.075	0.075	0.075	0.075	0.075
Trace mineral premix	0.075	0.075	0.075	0.075	0.075
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
True ileal digestible amino acids					
Lysine, %	0.98	0.98	0.98	0.98	0.98
Methionine:lysine ratio, %	27	28	29	31	32
Met & cys:lysine ratio, %	55	58	60	63	65
Threonine:lysine ratio, %	60	62	64	66	68
Tryptophan:lysine ratio, %	19	20	20	21	21
Total lysine, %	1.10	1.10	1.10	1.11	1.11
CP, %	18.2	18.9	19.7	20.4	21.2
TID lysine:calorie ratio, g/Mcal	2.71	2.71	2.71	2.70	2.70
ME, kcal/kg	3,616	3,618	3,622	3,624	3,627
Ca, %	0.55	0.55	0.55	0.55	0.55
P, %	0.50	0.49	0.49	0.49	0.48
Available P, %	0.28	0.28	0.28	0.28	0.28
Analyzed values					
Dietary fat IV	80.9	83.9	88.0	87.5	89.1
Dietary IV	78.5	82.2	91.5	95.4	99.8

Table 2. Phase 2 Diet Composition (Fed from 130 to 181 lb; as-fed basis)

	DDGS, %				
Item	0	5	10	15	20
Ingredient, %					
Corn	71.05	66.70	62.35	58.00	53.65
Soybean meal (46.5 % CP)	20.90	20.35	19.75	19.20	18.65
DDGS	---	5.00	10.00	15.00	20.00
Choice white grease	6.00	6.00	6.00	6.00	6.00
Monocalcium P (21% P)	0.58	0.45	0.33	0.20	0.08
Limestone	0.85	0.89	0.92	0.98	1.03
Salt	0.35	0.35	0.35	0.35	0.35
L-lysine HCl	0.150	0.150	0.150	0.150	0.150
Vitamin premix with phytase	0.063	0.063	0.063	0.063	0.063
Trace mineral premix	0.063	0.063	0.063	0.063	0.063
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
True ileal digestible amino acids					
Lysine, %	0.83	0.83	0.83	0.83	0.83
Methionine:lysine ratio, %	28	30	31	33	34
Met & cys:lysine ratio, %	59	62	64	67	70
Threonine:lysine ratio, %	61	63	65	68	70
Tryptophan:lysine ratio, %	19	20	20	21	22
Total lysine, %	0.93	0.94	0.94	0.94	0.94
CP, %	15.9	16.7	17.4	18.2	18.9
TID lysine:calorie ratio, g/Mcal	2.29	2.29	2.29	2.29	2.29
ME, kcal/kg	3,620	3,622	3,627	3,629	3,633
Ca, %	0.52	0.52	0.52	0.52	0.52
P, %	0.46	0.46	0.46	0.45	0.45
Available P, %	0.25	0.25	0.25	0.25	0.25
Analyzed values					
Dietary fat IV	84.2	86.4	86.2	87.3	88.6
Dietary IV	78.3	86.4	87.9	96.9	97.4

Table 3. Phase 3 Diet Composition (Fed from 181 to 231 lb; as-fed basis)

	DDGS, %				
Item	0	5	10	15	20
Ingredient, %					
Corn	75.15	70.80	66.45	62.10	57.75
Soybean meal (46.5 % CP)	16.90	16.35	15.80	15.20	14.65
DDGS	---	5.00	10.00	15.00	20.00
Choice white grease	6.00	6.00	6.00	6.00	6.00
Monocalcium P (21% P)	0.53	0.40	0.27	0.14	0.01
Limestone	0.80	0.84	0.89	0.93	0.97
Salt	0.35	0.35	0.35	0.35	0.35
L-lysine HCl	0.150	0.150	0.150	0.150	0.150
Vitamin premix with phytase	0.063	0.063	0.063	0.063	0.063
Trace mineral premix	0.063	0.063	0.063	0.063	0.063
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
True ileal digestible amino acids					
Lysine, %	0.73	0.73	0.73	0.73	0.73
Methionine:lysine ratio, %	30	32	33	35	37
Met & cys:lysine ratio, %	62	65	68	71	75
Threonine:lysine ratio, %	62	64	67	70	72
Tryptophan:lysine ratio, %	19	19	20	21	22
Total lysine, %	0.82	0.83	0.83	0.83	0.83
CP, %	14.4	15.1	15.9	16.7	17.4
TID lysine:calorie ratio, g/Mcal	2.01	2.01	2.01	2.01	2.01
ME, kcal/kg	3,628	3,629	3,631	3,635	3,638
Ca, %	0.48	0.48	0.48	0.48	0.48
P, %	0.44	0.43	0.43	0.42	0.42
Available P, %[e]	0.23	0.23	0.23	0.23	0.23
Analyzed values					
Dietary fat IV	84.9	86.7	87.0	90.6	89.7
Dietary IV	74.7	83.3	84.4	91.5	97.8

[a]Dietary treatments fed in meal form from 181 to 231 lb.

Table 4. Phase 4 Diet Composition (Fed from 231 to 271 lb; as-fed basis)

	DDGS, %				
Item	0	5	10	15	20
Ingredient, %					
Corn	77.90	73.55	69.20	64.90	60.55
Soybean meal (46.5 % CP)	14.15	13.55	13.00	12.45	11.85
DDGS	-	5.00	10.00	15.00	20.00
Choice white grease	6.00	6.00	6.00	6.00	6.00
Monocalcium P (21% P)	0.53	0.39	0.26	0.13	-
Limestone	0.83	0.87	0.91	0.96	1.00
Salt	0.35	0.35	0.35	0.35	0.35
L-lysine HCl	0.150	0.150	0.150	0.150	0.150
Vitamin premix with phytase	0.050	0.050	0.050	0.050	0.050
Trace mineral premix	0.050	0.050	0.050	0.050	0.050
Total	100.00	100.00	100.00	100.00	100.00
Calculated analysis					
True ileal digestible amino acids					
Lysine, %	0.66	0.66	0.66	0.66	0.66
Methionine:lysine ratio, %	31	33	35	37	39
Met & cys:lysine ratio, %	64	68	71	75	79
Threonine:lysine ratio, %	63	65	68	71	74
Tryptophan:lysine ratio, %	18	19	20	21	22
Total lysine, %	0.75	0.75	0.75	0.76	0.76
CP, %	13.3	14.1	14.8	15.6	16.4
TID lysine:calorie ratio, g/Mcal	1.82	1.82	1.82	1.82	1.81
ME, kcal/kg	3,626	3,629	3,633	3,636	3,639
Ca, %	0.48	0.48	0.48	0.48	0.48
P, %	0.43	0.42	0.42	0.41	0.41
Available P, %[e]	0.22	0.22	0.22	0.22	0.22
Analyzed values					
Dietary fat IV	86.9	90.0	86.9	86.6	87.1
Dietary IV	86.0	91.8	89.5	94.4	95.0

Table 5. Effects of Increasing DDGS on Growing-finishing Pig Performance and Carcass Characteristics (Exp. 3)[a]

	DDGS, %					Probability, $P <$			
Item	0	5	10	15	20	Treatment	Linear	Quadratic	SE
D 0 to 78									
ADG, lb	2.03	2.02	2.02	1.98	1.95	0.0003	0.02	0.43	11.9
ADFI, lb	5.27	5.11	5.22	5.09	5.05	0.0003	0.04	0.98	31.4
F/G	2.60	2.53	2.59	2.58	2.59	0.06	0.46	0.14	0.003
Slaughter wt, lb[b]	259.9	259.7	259.6	256.7	256.7	0.68	0.17	0.85	1.03
Carcass wt, lb	196.7	195.9	195.4	193.1	192.7	0.7	0.04	0.86	0.83
Yield, %	75.67	75.46	75.39	75.22	75.06	0.24	0.02	1.00	0.002
Backfat, in[c]	0.733	0.741	0.717	0.713	0.705	0.016	0.07	0.97	0.35
Loin depth, mm[c]	2.31	2.30	2.29	2.26	2.27	0.03	0.22	0.98	0.81
FFLI, %[cd]	49.34	49.45	49.53	49.70	49.65	0.48	0.09	0.67	0.15

[a]A total of 1,112 pigs (initially 49.67 kg) with 25 to 28 pigs per pen and 9 replications per treatment.
[b]Weight determined at slaughter plant.
[c]Data analyzed using carcass weight as a covariate.
[d]Fat-free lean index.

Table 6. Effects of Increasing DDGS on Fat Quality of Topped Pigs (Exp. 3)[a]

	DDGS, %					Probability, $P <$			
Item	0	5	10	15	20	Treatment	Linear	Quadratic	SE
Iodine value, g/100 g									
Backfat	67.9	69.3	71.8	72.3	72.3	0.01	0.01	0.15	0.94
Jowl fat	69.3	70.3	70.3	71.3	72.9	0.11	0.02	0.53	1.00
Belly fat	67.5	69.6	70.8	72.0	73.8	0.02	0.01	0.92	1.20
C 18:2 fatty acids, %									
Backfat	13.7	15.2	16.5	17.5	17.6	0.01	0.01	0.24	0.69
Jowl fat	13.0	13.9	14.1	15.4	15.8	0.01	0.01	0.99	0.57
Belly fat	13.3	14.8	15.8	17.3	17.9	0.01	0.01	0.60	0.64
Saturated fatty acids, %									
Backfat	36.1	35.1	34.4	34.6	33.7	0.21	0.03	0.62	0.73
Jowl fat	33.8	33.6	33.9	33.9	32.5	0.47	0.27	0.28	0.68
Belly fat	36.2	35.4	35.1	35.1	33.7	0.30	0.05	0.76	0.83

[a]Means represent 6 observations (pigs) per treatment.

Table 7. Effects of Increasing DDGS on Fat Quality[a]

	DDGS, %					Gender		Probability, *P* <				Treatment	Gender
Item	0	5	10	15	20	Barrows	Gilts	Treatment	Linear	Quadratic	Gender	SE	SE
Iodine value, g/100 g													
Backfat	68.3	70.0	71.2	72.4	72.8	70.7	71.1	0.01	0.01	0.33	0.52	0.76	0.46
Jowl fat	70.7	70.8	71.9	72.6	73.8	71.6	72.3	0.01	0.01	0.49	0.25	0.74	0.46
Belly fat	70.2	71.5	72.4	73.3	74.5	71.8	72.9	0.01	0.01	0.95	0.03	0.61	0.44
C 18:2 fatty acids, %													
Backfat	14.0	14.9	15.8	17.1	17.6	15.6	16.2	0.01	0.01	0.75	0.17	0.45	0.28
Jowl fat	14.1	14.0	14.9	15.6	16.5	15.0	15.1	0.01	0.01	0.34	0.85	0.55	0.36
Belly fat	14.5	15.3	16.3	16.8	17.9	15.9	16.5	0.01	0.01	0.89	0.04	0.38	0.22
Saturated fatty acids, %													
Backfat	36.0	35.0	34.5	34.4	34.5	34.9	34.9	0.16	0.03	0.19	0.97	0.53	0.34
Jowl fat	33.3	33.1	32.8	32.7	32.3	33.2	32.5	0.25	0.03	0.91	0.02	0.38	0.22
Belly fat	34.4	33.8	33.7	33.2	32.9	33.9	33.3	0.03	0.01	0.81	0.05	0.42	0.33

[a]Means represent 9 observations per treatment.