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Abstract

A total of 288 pigs (Line 600 × 241, DNA, Columbus, NE; initially 91.5 lb) were used in an 82-d trial to determine if replacing conventional yellow dent corn with high amylase corn (Enogen®, Syngenta Seeds, LLC) in diets with or without distillers dried grains with solubles (DDGS) influences growth performance and carcass characteristics. Pens contained 8 pigs with an equal number of barrows and gilts. There were 9 pens per treatment with pens assigned randomly to treatments balancing for initial body weight. Diets were arranged in a 2 × 2 factorial with two corn sources (conventional or high amylase) and two levels of DDGS (0 or 25%). Experimental diets were fed in meal form in 3 phases: d 0 to 29, d 29 to 47, and d 47 to 82. Pigs were weighed approximately every 2 weeks and at the start of each phase. On d 82, pigs were transported to a commercial packing plant for processing and carcass data collection. Overall, average daily gain (ADG) was marginally greater ($P < 0.089$) for pigs fed high amylase corn than conventional corn with no evidence for difference in feed intake, feed efficiency (F/G), hot carcass weight (HCW), or other carcass traits. Added DDGS resulted in decreased ($P < 0.026$) overall ADG and poorer ($P < 0.047$) F/G compared to pigs fed no DDGS. Pigs fed DDGS had marginally lower ($P < 0.086$) HCW, less ($P < 0.045$) backfat, and marginally greater ($P < 0.054$) loin depth, ($P < 0.017$) percentage lean, and ($P < 0.0001$) iodine values than pigs not consuming DDGS. The results of this trial suggest that high amylase corn tended to improve overall ADG; however, F/G and carcass characteristics were unchanged between corn sources. Further research is needed to determine if this hybrid has positive effects on growth of younger pigs or pigs fed pelleted diets.

Keywords

amylase, high amylase corn, yellow dent corn, swine

Cover Page Footnote

Appreciation is expressed to Syngenta Seeds, LLC, for financial support and Triumph Foods for collection of carcass data.

Authors

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Evaluation of High Amylase Corn on Growth Performance and Carcass Characteristics of Finishing Pigs[1]

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Summary

A total of 288 pigs (Line 600 × 241, DNA, Columbus, NE; initially 91.5 lb) were used in an 82-d trial to determine if replacing conventional yellow dent corn with high amylase corn (Enogen®, Syngenta Seeds, LLC) in diets with or without distillers dried grains with solubles (DDGS) influences growth performance and carcass characteristics. Pens contained 8 pigs with an equal number of barrows and gilts. There were 9 pens per treatment with pens assigned randomly to treatments balancing for initial body weight. Diets were arranged in a 2 × 2 factorial with two corn sources (conventional or high amylase) and two levels of DDGS (0 or 25%). Experimental diets were fed in meal form in 3 phases: d 0 to 29, d 29 to 47, and d 47 to 82. Pigs were weighed approximately every 2 weeks and at the start of each phase. On d 82, pigs were transported to a commercial packing plant for processing and carcass data collection. Overall, average daily gain (ADG) was marginally greater ($P < 0.089$) for pigs fed high amylase corn than conventional corn with no evidence for difference in feed intake, feed efficiency (F/G), hot carcass weight (HCW), or other carcass traits. Added DDGS resulted in decreased ($P < 0.026$) overall ADG and poorer ($P < 0.047$) F/G compared to pigs fed no DDGS. Pigs fed DDGS had marginally lower ($P < 0.086$) HCW, less ($P < 0.045$) backfat, and marginally greater ($P < 0.054$) loin depth, ($P < 0.017$) percentage lean, and ($P < 0.0001$) iodine values than pigs not consuming DDGS. The results of this trial suggest that high amylase corn tended to improve overall ADG; however, F/G and carcass characteristics were unchanged between corn sources. Further research is needed to determine if this hybrid has positive effects on growth of younger pigs or pigs fed pelleted diets.

[1] Appreciation is expressed to Syngenta Seeds, LLC, for financial support and Triumph Foods for collection of carcass data.

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Introduction

Starch from cereal grains is the greatest source of energy in swine diets, thus increasing digestibility of starch can potentially have a positive impact on growth performance. Initially developed for ethanol production, Enogen® Feed Corn (Syngenta Seeds, LLC) is a corn hybrid with increased expression of heat-stable alpha-amylase. Feeding Enogen® corn to both growing and finishing beef cattle resulted in improved feed efficiency; however, there is limited research on the effect of feeding this hybrid to swine and poultry.[4,5] Production of ethanol has also resulted in availability of low-cost byproducts, such as DDGS, which are commonly added to swine diets in an effort to reduce feed costs. Research on adding DDGS in swine diets, and its impact on growth performance and carcass characteristics, has yielded varying results.[6,7,8] Due to DDGS being included in swine diets at the expense of corn, it is important to assess whether any interaction exists between corn variety and DDGS inclusion rate. Therefore, the objective of this trial was to determine whether replacing conventional corn with Enogen® high amylase corn in diets with or without DDGS influences growth performance and carcass characteristics of finishing pigs.

Procedures

All procedures used in this study were approved by the Kansas State University Institutional Animal Care and Use Committee. This study was conducted at the Kansas State University Swine Teaching and Research Center, Manhattan, KS, from September to December 2018.

Pigs were housed in a fully enclosed, environmentally regulated barn containing 36 pens with slatted concrete floors. Pens were equipped with a two-space single sided feeder (Farmweld, Teutopolis, IL) and a cup waterer, and pigs were allowed access to feed and water *ad libitum*. The floor space allowance per pig was maintained at 7.83 ft^2. An automated feeding system (FeedPro; Feedlogic Corp., Wilmar, MN) was used to deliver and record feed to each pen.

Corn samples were collected at time of feed manufacturing, and feed samples were collected approximately two days after each feed delivery. Samples were stored at -20°C until sent for analysis. Pooled samples for each phase were sent to a commercial labora-

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[8] Lineen, S.K., J.M. DeRouchey, S.S. Dritz, R.D. Goodband, M.D. Tokach, and J.L. Nelssen. 2008. Effects of dried distillers grains with solubles on growing and finishing pig performance in a commercial environment. J. Anim. Sci. 86:1579-1587.

tory (Ward Laboratories, Inc., Kearney, NE) for analysis of dry matter (DM), starch, crude protein (CP), crude fiber (CF), fat, calcium, and phosphorus (Tables 1 and 2).

A total of 288 pigs (DNA 600 × 241; initial BW 91.5 ± 4.3 lb) were enrolled in an 82-d trial. There were 9 pens per treatment and 8 pigs per pen with an equal number of barrows and gilts per pen. Pens were randomly assigned to dietary treatments and balanced based on pen weight at the start of the study. Dietary treatments (Table 3) were arranged in a 2 × 2 factorial with two corn sources (conventional or high amylase) and two levels of DDGS (0 or 25%). The experimental diets were fed in 3 phases: d 0 to 29, d 29 to 47, and d 47 to 82. Diets were fed in meal form and both corn sources were ground to a similar particle size for the experiment (Table 3).

Pen and feeder weights were obtained approximately every 2 weeks and at the end of each phase change in order to calculate ADG, average daily feed intake (ADFI), and F/G (Tables 4 and 5). During the study, 6 pigs died or were removed due to health related issues. On d 82, 282 pigs were individually weighed, ear tagged with a radio frequency identification (RFID) tag, and tattooed for individual carcass data measurements. Pigs were transported to a commercial packing plant (Triumph Foods, St. Joseph, MO) for processing and collection of hot carcass weight (HCW), loin depth, backfat depth, and percentage lean. Carcass yield was calculated as HCW divided by individual live animal weight. Iodine values (IV) were measured on 2 barrows randomly selected from each pen (Tables 6 and 7).

Data were analyzed using the PROC GLIMMIX procedure of SAS (v. 9.4, SAS Institute, Inc., Cary, NC) with pen serving as the experimental unit. The main effects of corn source, DDGS, and their interactions were tested using orthogonal contrasts. For analyses of loin depth, backfat depth, and percentage lean, HCW was used as a covariate. Results were considered significant at $P \leq 0.05$ and marginally significant at $P \leq 0.10$.

Results

Minor interactions were observed for ADG during phases 1 and 3. During phase 1, pigs fed the diet containing high amylase corn without DDGS had greater ($P < 0.019$) ADG and greater ($P < 0.035$) ADFI than pigs fed the high amylase with 25% DDGS; whereas there were no differences between the conventional corn treatments. During phase 3, ADG was greater ($P < 0.041$) for pigs fed the high amylase corn containing 25% DDGS compared to the 25% DDGS conventional corn diet, with no differences between corn sources if the diet did not contain DDGS.

There were no interactions ($P > 0.05$) between corn source and DDGS for overall performance or any of the carcass measurements. Pigs fed high amylase corn had a marginally greater ($P < 0.089$) ADG during phase 3 and for the overall experiment than pigs fed conventional corn. There was no evidence for differences in ADFI, F/G, HCW, and other carcass characteristics between corn sources. There was a marginally significant interaction for iodine value where adding DDGS to the conventional corn diets increased iodine value slightly more than when DDGS were added to the high amylase corn diets.

There was a DDGS main effect for growth performance, with pigs fed 25% DDGS having decreased ($P < 0.005$) ADG during phase 1, phase 2, and overall. There was no difference ($P > 0.151$) during any phases or overall for ADFI between pigs fed 0 and 25% DDGS. Overall, pigs fed diets containing 25% DDGS had poorer ($P < 0.047$) F/G. Pigs fed 25% DDGS had a marginally lower ($P < 0.071$) HCW, marginally less ($P < 0.050$) backfat, greater ($P < 0.026$) loin depth, and greater ($P < 0.020$) percentage lean and IV ($P < 0.0001$) than pigs fed diets without DDGS.

The results of this trial suggest that the high amylase corn hybrid tended to improve overall ADG; however, feed efficiency and carcass characteristics were unchanged between corn sources. Consistent with previous research, the addition of DDGS decreased ADG and increased IV. The marginally lower backfat, greater loin depth, and percentage lean for pigs fed 25% DDGS may be attributed to their lower HCW and overall decreased ADG. Further research should be conducted to understand if addition of high amylase corn to swine diets could be beneficial in other phases of growth or whether heat treatment of diets, such as pelleting, may influence the response to high amylase corn.

Table 1. Chemical analysis of corn varieties (as-fed basis)[1]

Item, %	Conventional[2]	High amylase[3]
Dry matter	87.1	87.4
Starch	60.6	60.8
Crude protein	7.2	7.9
Crude fat	3.1	3.1
Crude fiber	1.7	1.4
Calcium	0.05	0.06
Phosphorus	0.20	0.22

[1]Corn samples were collected at time of feed manufacturing and pooled for analysis (Ward Laboratories, Inc., Kearney, NE).
[2]Yellow dent corn.
[3]High amylase corn (Enogen®, Syngenta Seeds, LLC).

Table 2. Chemical analysis of experimental diets (as-fed basis)[1]

	Phase 1[2]				Phase 2				Phase 3			
	Conventional[3]		High amylase[4]		Conventional		High amylase		Conventional		High amylase	
Item, % DDGS,[5] %:	0	25	0	25	0	25	0	25	0	25	0	25
Dry matter	88.6	88.9	88.1	88.1	87.8	88.3	87.6	88.4	89.2	89.5	86.9	88.2
Starch	48.4	37.5	44.1	36.3	48.3	38.4	46.5	39.0	46.5	41.5	53.1	39.9
Crude protein	16.2	18.9	16.3	18.6	13.4	16.6	14.2	16.5	13.6	15.7	11.3	15.8
Crude fat	2.3	4.3	2.6	4.1	3.0	4.6	3.4	4.4	3.3	4.4	1.8	4.3
Crude fiber	1.4	3.7	2.2	3.4	2.2	3.4	2.2	3.6	2.9	3.6	1.7	3.5
Calcium	0.59	0.68	0.78	0.63	0.64	0.60	0.54	0.53	0.55	0.47	0.61	0.64
Phosphorus	0.38	0.46	0.43	0.44	0.36	0.44	0.39	0.39	0.36	0.39	0.33	0.40

[1]Feed samples were collected approximately 2 days after each feed delivery, pooled within treatment for each phase, and analyzed. (Ward Laboratories, Inc., Kearney, NE).
[2]The experimental diets were fed in 3 phases: d 0 to 29, d 29 to 47, and d 47 to 82.
[3]Yellow dent corn.
[4]High amylase corn (Enogen®, Syngenta Seeds, LLC).
[5]DDGS = distillers dried grains with solubles.

Table 3. Composition of experimental diets (as-fed basis)[1]

	0% DDGS[2]			25% DDGS		
Item	Phase 1	Phase 2	Phase 3	Phase 1	Phase 2	Phase 3
Ingredient, %						
Corn (high amylase or conventional)[3]	75.45	81.90	85.25	59.95	65.65	68.20
Soybean meal, 46% crude protein	21.80	15.65	12.35	12.30	6.95	4.50
Corn DDGS, 7.5% Oil	---	---	---	25.00	25.00	25.00
Calcium carbonate	0.93	0.85	0.85	1.08	1.03	1.03
Monocalcium phosphate, 21% P	0.55	0.40	0.35	0.20	---	---
Sodium chloride	0.50	0.50	0.50	0.50	0.50	0.50
L-Lysine-HCl	0.30	0.30	0.30	0.50	0.48	0.45
DL-Methionine	0.07	0.03	0.02	0.02	---	---
L-Threonine	0.09	0.10	0.11	0.09	0.09	0.09
L-Tryptophan	0.01	0.02	0.02	0.04	0.04	0.04
Trace mineral premix	0.15	0.13	0.10	0.15	0.13	0.10
Vitamin premix	0.15	0.13	0.10	0.15	0.13	0.10
Phytase[4]	0.02	0.02	0.02	0.02	0.02	0.02
Total	100	100	100	100	100	100
Calculated analysis						
Standardized ileal digestible (SID) amino acids, %						
Lysine	0.95	0.80	0.72	0.95	0.80	0.72
Isoleucine:lysine	62	61	60	60	60	61
Leucine:lysine	139	148	154	165	181	193
Methionine:lysine	32	31	30	31	32	34
Methionine and cysteine:lysine	58	58	58	58	62	65
Threonine:lysine	63	65	68	63	65	68
Tryptophan:lysine	18.6	18.5	18.8	18.5	18.3	18.4
Valine:lysine	69	70	70	72	75	78
Histidine:lysine	42	43	43	43	44	46
Total lysine, %	1.07	0.90	0.82	1.11	0.94	0.86
Net energy, kcal/lb	1,128	1,147	1,157	1,124	1,141	1,149
SID lysine:net energy, g/Mcal	3.82	3.16	2.82	3.83	3.18	2.84
Crude protein, %	17.0	14.6	13.3	18.4	16.3	15.3
Calcium, %	0.59	0.51	0.48	0.59	0.51	0.49
Phosphorus, %	0.47	0.41	0.38	0.47	0.40	0.39
STTD[5] phosphorus, %	0.33	0.28	0.26	0.33	0.28	0.27

[1]The experimental diets were fed in 3 phases: d 0 to 29, d 29 to 47, and d 47 to 82.
[2]DDGS = distillers dried grains with solubles.
[3]High amylase corn (Enogen®, Syngenta Seeds, LLC) or conventional (yellow dent corn).
[4]HiPhos 2700 (DSM Nutritional Products, Inc., Parsippany, NJ) providing 405 phytase units (FTU)/lb and an estimated release of 0.08% available P.
[5]STTD = standardized total tract digestible.

Table 4. Effects of corn variety and dried distillers grains with solubles (DDGS) on growth performance of finishing pigs[1]

		Conventional[2]		High amylase[3]			Probability, $P<$
Item	DDGS, %:	0	25	0	25	SEM	Corn × DDGS
Body weight, lb							
d 0		91.5	91.4	91.5	91.4	1.50	0.924
d 29		156.6[ab]	156.9[ab]	157.9[a]	154.9[b]	1.96	0.036
d 47		198.4	196.7	199.3	195.7	2.02	0.403
d 82		286.8	282.9	286.6	285.7	1.92	0.305
d 0 to 29 (Phase 1)[4]							
ADG,[5] lb		2.25[ab]	2.26[ab]	2.29[a]	2.19[b]	0.024	0.019
ADFI,[5] lb		5.07	5.24	5.29	5.14	0.095	0.035
F/G[5]		2.26	2.32	2.31	2.35	0.033	0.664
d 29 to 47 (Phase 2)							
ADG, lb		2.33	2.21	2.35	2.27	0.031	0.571
ADFI, lb		6.61	6.51	6.69	6.52	0.109	0.652
F/G		2.84	2.95	2.85	2.87	0.056	0.385
d 47 to 82 (Phase 3)							
ADG, lb		2.53[ab]	2.42[a]	2.51[ab]	2.57[b]	0.039	0.041
ADFI, lb		7.94	7.75	7.78	8.16	0.160	0.081
F/G		3.14	3.21	3.10	3.18	0.069	0.971
d 0 to 82 (Overall)							
ADG, lb		2.38	2.31	2.40	2.37	0.020	0.304
ADFI, lb		6.62	6.59	6.64	6.73	0.097	0.444
F/G		2.78	2.85	2.77	2.84	0.040	0.999

[1]A total of 288 pigs (DNA 600 × 241; initially 91.5 ± 4.3 lb) were enrolled in an 82-d trial. There were 9 pens per treatment with 4 barrows and 4 gilts per pen.
[2]Yellow dent corn.
[3]High amylase corn (Enogen®, Syngenta Seeds, LLC).
[4]The experimental diets were fed in 3 phases: d 0 to 29, d 29 to 47, and d 47 to 82.
[5]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed efficiency.

Table 5. Main effects of corn variety and dried distillers grains with solubles (DDGS) on growth performance of finishing pigs[1]

	Corn				DDGS, %			
Item	Conventional[2]	High amylase[3]	SEM	Probability, *P*<	0	25	SEM	Probability, *P*<
Body weight, lb								
d 0	91.5	91.5	1.49	1.000	91.5	91.4	1.49	0.887
d 29	156.7	156.4	1.89	0.632	157.3	155.9	1.89	0.071
d 47	197.5	197.5	1.88	0.956	198.8	196.2	1.88	0.020
d 82	284.9	286.2	1.65	0.353	286.7	284.3	1.65	0.097
d 0 to 29 (Phase 1)[4]								
ADG,[5] lb	2.25	2.24	0.018	0.580	2.27	2.22	0.018	0.045
ADFI,[5] lb	5.15	5.21	0.080	0.434	5.18	5.18	0.080	0.879
F/G[5]	2.29	2.33	0.026	0.224	2.28	2.33	0.026	0.092
d 29 to 47 (Phase 2)								
ADG, lb	2.27	2.31	0.022	0.204	2.34	2.24	0.022	0.005
ADFI, lb	6.56	6.61	0.089	0.606	6.65	6.52	0.089	0.151
F/G	2.90	2.86	0.043	0.527	2.85	2.91	0.043	0.206
d 47 to 82 (Phase 3)								
ADG, lb	2.47	2.54	0.028	0.077	2.52	2.49	0.028	0.541
ADFI, lb	7.84	7.97	0.114	0.430	7.86	7.95	0.114	0.566
F/G	3.18	3.14	0.051	0.547	3.12	3.20	0.051	0.277
d 0 to 82 (Overall)								
ADG, lb	2.35	2.38	0.014	0.089	2.39	2.34	0.014	0.026
ADFI, lb	6.60	6.68	0.078	0.328	6.63	6.66	0.078	0.760
F/G	2.81	2.81	0.033	0.814	2.78	2.84	0.033	0.047

[1]A total of 288 pigs (DNA 600 × 241; initially 91.5 ± 4.3 lb) were enrolled in an 82-d trial. There were 9 pens per treatment with 4 barrows and 4 gilts per pen.
[2]Yellow dent corn.
[3]High amylase corn (Enogen®, Syngenta Seeds, LLC).
[4]The experimental diets were fed in 3 phases: d 0 to 29, d 29 to 47, and d 47 to 82.
[5]ADG = average daily gain. ADFI = average daily feed intake. F/G = feed efficiency.

Table 6. Effects of corn variety and dried distillers grains with solubles (DDGS) inclusion on carcass characteristics of finishing pigs[1]

	Conventional[2]		High amylase[3]			Probability, *P*<
Item DDGS, %:	0	25	0	25	SEM	Corn × DDGS
HCW,[4] lb	215.5	210.9	214.4	212.5	1.76	0.448
Carcass yield, %	75.1	74.7	74.9	74.6	0.23	0.863
Backfat,[5] in	0.64	0.61	0.64	0.63	0.011	0.448
Loin depth,[5] in	2.53	2.56	2.51	2.57	0.023	0.420
Lean,[5] %	54.4	54.8	54.2	54.7	0.16	0.951
Iodine value	64.4	72.5	66.1	71.8	0.60	0.053

[1]On d 82, 282 pigs were individually weighed, ear tagged with a radio frequency identification (RFID) tag, and tattooed for individual carcass data measurements. Pigs were transported to a commercial packing plant (Triumph Foods, St. Joseph, MO) for processing and collection of carcass data.
[2]Yellow dent corn.
[3]High amylase corn (Enogen®, Syngenta Seeds, LLC).
[4]HCW = hot carcass weight.
[5]HCW used as a covariate in statistical analysis.

Table 7. Effects of corn variety and dried distillers grains with solubles (DDGS) inclusion on carcass characteristics of finishing pigs[1]

	Corn				DDGS, %			
Item	Conventional[2]	High amylase[3]	SEM	Probability, *P*<	0	25	SEM	Probability, *P*<
HCW,[4] lb	213.2	213.4	1.61	0.883	215.0	211.7	1.61	0.071
Carcass yield, %	74.9	74.8	0.17	0.651	75.0	74.7	0.17	0.139
Backfat,[5] in	0.62	0.64	0.008	0.196	0.64	0.62	0.008	0.050
Loin depth,[5] in	2.55	2.54	0.034	0.767	2.52	2.57	0.034	0.026
Lean,[5] %	54.6	54.5	0.12	0.400	54.3	54.7	0.12	0.020
Iodine value	68.4	69.0	0.42	0.400	65.3	72.1	0.42	<0.0001

[1]On d 82, 282 pigs were individually weighed, ear tagged with a radio frequency identification (RFID) tag, and tattooed for individual carcass data measurements. Pigs were transported to a commercial packing plant (Triumph Foods, St. Joseph, MO) for processing and collection of carcass data.
[2]Yellow dent corn.
[3]High amylase corn (Enogen®, Syngenta Seeds, LLC).
[4]HCW = hot carcass weight.
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