Grower-Finisher Performance and Carcass Characteristics of Pigs Fed Genetically Modified "Bt" Corn

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Introduction

The USDA estimated that 30% of the US corn planted in 1999 was of the Bt variety (USDA, 2000), which leads to a high probability that transgenic Bt corn is finding its way into swine diets. Limited research has been conducted as to the effects of using Bt corn and other transgenic-derived feed ingredients on livestock growth performance and carcass quality. Research in poultry has shown that feeding diets containing transgenic Bt corn had no deleterious effects on performance or carcass yield of broilers (Brake and Vlachos, 1998). This is the first trial in which Bt corn has been evaluated as an ingredient in grower-finisher swine diets.

Materials and Methods

Experimental Design

One hundred eighty pigs (initially 66 lb and 62 days of age; Dekalb 45 by EB) were blocked by sex and weight and allotted in a randomized complete block design to one of three dietary treatments, consisting of phase fed diets containing: 1) the isogenic control, non-genetically modified parent corn hybrid; 2) the transgenic Bt corn hybrid; or 3) commingled nontransgenic corn of different varieties. Initially, pigs were weaned at 12 to 16 days of age and reared in a segregated early weaning (SEW) nursery for a period of 5 weeks prior to entering the separate site, grow-finish facility. Once moved to the grow-finish facility, the pigs were allowed to acclimate and were fed a common diet for a period of 10 days before starting on the experimental diets.

Pigs were housed in a curtain sided confinement facility and reared in groups of six per pen (10 ft^2/pig). All pigs had *ad libitum* access to a one-hole self-feeder and a nipple waterer.

Diets and Data Collection

All diets were formulated to meet or exceed requirements proposed by the NRC (NRC, 1998). Pigs were split sex fed in four dietary phases, with phase changes occurring after 4 weeks for phases I and II, and after 2 weeks for phase III; phase IV was fed from week 11 to market. Each corn type was included at equal percentages within each dietary phase treatment group. Dietary treatments within each phase were formulated to be isolysinic and isocaloric (Tables 1 and 2). Weights and feed intake were recorded every two weeks to monitor average daily gain (ADG), average daily feed intake (ADFI), and feed efficiency (F/G). When the pigs reached an average body weight of approximately 266 lb, they were transported to a commercial processing facility where carcass data was collected. Measurements taken on the ribbed carcasses included: hot carcass weight (HCW), carcass length, backfat depths at the last rib and last lumbar vertebrae, and 10^{th} rib fat depth and loin eye area. Subjective measurements of color, marbling, and firmness were also taken on the carcasses (NPPC, 1999). P2 fat depth was measured via real-

time ultrasound. Percentage lean was calculated using the procedure for ribbed carcasses (NPPC, 1991).

The data were analyzed as a 2 x 3 factorial arrangement of sex and dietary treatment using the GLM procedure of SAS (1996). The pen served as the experimental unit. Carcass length, backfat measurements, loin eye area, and percent lean were adjusted for hot carcass weight. Mean separation was carried out using the PDIFF option of SAS for adjusted means and the least significant difference test for weight and subjective quality data.

Results

Performance Data

Mean nursery performance was: .95 lb ADG, 1.57 lb ADFI, and 1.65 F/G. Corn type did not affect (P>.10) ADG, ADFI, or feed efficiency during any of the dietary phases (Table 3). Sex affected ADG and ADFI during phases I, II, III, and overall (P<.05), with gilts consuming less feed per day and therefore gaining less body weight per day. Gilts were more feed efficient during phases II, III, and IV and for the overall duration of the trial (P<.05).

Carcass Characteristics

Dietary corn treatment affected HCW (P=.09), with pigs fed the conventional commingled corn varieties having heavier carcasses than pigs fed Bt corn or the isogenic control (Table 4). Pigs fed conventional corn had higher dressing percentages than pigs fed Bt or isogenic control corn (P<.05). Corn had an effect on calculated percent lean, with pigs fed diets containing the isogenic control corn having less percent lean than pigs fed diets containing Bt or conventional corn (P<.05). Pigs fed diets containing isogenic control corn had greater backfat depths at the 10^{th} (P<.05) and last rib (P=.11) as well as the P2 location (P<.05) than pigs fed diets containing Bt or conventional corn. Isogenic control-fed pigs had greater backfat depths at the last lumbar vertebrae than pigs fed conventional corn (P<.05). Corn treatment affected subjective marbling scores, with pigs fed the conventional corn having lower marbling scores (P<.05) than pigs fed either isogenic control or Bt corn diets.

Sex had an effect on slaughter weight and HCW (P<.05), with gilts weighing less at time of slaughter and therefore having lighter carcass weights than barrows. Gilts had a greater calculated percent lean than barrows (P<.05). Sex impacted 10^{th} rib LEA and backfat, with gilts having greater LEA and less backfat than barrows (P<.05). Gilts also had lower backfat depths at the last rib, last lumbar vertebrae, and P2 location than barrows (P<.05). Sex had an effect on subjective marbling scores, with barrows having higher scores than gilts (P<.01).

Discussion

Feeding diets containing transgenic Bt corn had no deleterious effects on growth performance or carcass quality characteristics. The type of corn fed in the diet had no impact on performance, but it did significantly affect measures of carcass composition and quality. While the diets were formulated to the same nutrient specifications, differences in carcass composition could arise due to differences in the bioavailability of the nutrients in the corn. Additionally, there was a numerical increase of .10 lb/day in feed intake for the pigs fed the isogenic control

corn. This increased feed intake equated to 9 lbs more feed consumed with identical body weight gain. This increased feed intake may partially explain the increased carcass fat depths and marbling. This phenomenon was also realized in broilers fed Bt corn, in that birds fed Bt corn had improved breast muscle yield over birds fed nontransgenic control corn (Brake and Vlachos, 1998). This warrants further research, such as digestibility studies comparing Bt corn to the other corn types used in this trial.

Implications

Feeding Bt corn to grower-finisher pigs does not hinder growth performance or pork quality when compared to its isogenic control or commingled conventional corn.

References

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Table 1. Basal diet compositions (as fed basis) for barrows[a].

Item	Phase I 66.6 to 122 lb	Phase II 122 to 183 lb	Phase III 183 to 215 lb	Phase IV 215 to 262 lb
Ingredient, %				
Corn	67.80	74.69	79.09	84.68
Soybean meal (46.5% CP)	28.07	21.17	16.29-17.07	9.76-11.16
Dicalcium phosphate	1.54	1.41	1.14-1.21	1.03-1.19
Limestone	.70	.79	.86-.96	.85-.95
Salt	.35	.35	.25	.15
Vitamin Premix[b]	.15	.15	.15	.10
Trace mineral premix[c]	.09	.09	.09	.05
Selenium premix[d]	.05	.05	.05	.025
Medication[e]	.05	.05	.05	.05
Micro-Aid	.10	.10	.10	.10
Choice white grease	1.00	1.00	1.00-1.30	1.00-1.50
Corn starch	--	--	0.00-0.50	0.00-1.95
Calculated analysis				
Lysine, %	1.10	.95	.80	.65
ME, Mcal/kg	3.34	3.35	3.37	3.38
Ca, %	.75	.70	.65	.60
P, %	.65	.60	.55	.50

[a] Diets were formulated within each phase to contain equal percentages of each corn type. Therefore, due to inherent differences in nutrient concentrations between corn varieties, it was sometimes necessary to modify the concentrations of other dietary ingredients in order to maintain the same nutrient concentrations (isocaloric, isolysinic) between dietary treatment regimens.

[b] Provided per lb of complete diet: vitamin A, 1650 IU; vitamin D_3, 165 IU; vitamin E, 12 IU; menadione, .55 mg; vitamin B_{12}, .01 mg; riboflavin, 1.9 mg; pantothenic acid, 6.0 mg; and niacin, 9.0 mg.

[c] Provided per lb of complete diet: Zn, 39 mg; Fe, 39 mg; Mn, 4.8 mg; Cu, 3.6 mg; and I, .13 mg.

[d] Provided .14 mg selenium/lb of complete diet.

[e] To provide 20 mg tylosin/lb of complete diet.

Table 2. Basal diet compositions for growing and finishing gilts[a].

Item	Phase I 65.3 to 118 lb	Phase II 118 to 174 lb	Phase III 174 to 203 lb	Phase IV 203 to 249 lb
Ingredient, %				
Corn	64.13	71.14	74.95	81.17
Soybean meal (46.5% CP)	31.70	24.80	20.24-21.26	13.40-14.74
Dicalcium phosphate	1.47	1.33	1.04-1.23	.96-1.10
Limestone	.68	.79	.88-.98	.87-.96
Salt	.35	.35	.25	.15
Vitamin Premix[b]	.15	.15	.15	.10
Trace mineral premix[c]	.09	.09	.09	.05
Selenium premix[d]	.05	.05	.05	.025
Medication[e]	.05	.05	.05	.05
Micro-Aid	.10	.10	.10	.10
Choice white grease	1.00	1.00	1.00-1.20	1.00-1.50
Corn starch	--	--	0.00-1.02	0.00-1.89
Calculated analysis				
Lysine, %	1.20	1.05	.90	.75
ME, Mcal/kg	3.34	3.35	3.36	3.38
Ca, %	.75	.70	.65	.60
P, %	.65	.60	.55	.50

[a] Diets were formulated within each phase to contain equal percentages of each corn type. Therefore, due to inherent differences in nutrient concentrations between corn varieties, it was sometimes necessary to modify the concentrations of other dietary ingredients in order to maintain the same nutrient concentrations (isocaloric, isolysinic) between dietary treatment regimens.

[b] Provided per lb of complete diet: vitamin A, 1650 IU; vitamin D_3, 165 IU; vitamin E, 12 IU; menadione, .55 mg; vitamin B_{12}, .01 mg; riboflavin, 1.9 mg; pantothenic acid, 6.0 mg; and niacin, 9.0 mg.

[c] Provided per lb of complete diet: Zn, 39 mg; Fe, 39 mg; Mn, 4.8 mg; Cu, 3.6 mg; and I, .13 mg.

[d] Provided .14 mg selenium/lb of complete diet.

[e] To provide 20 mg tylosin/lb of complete diet.

Table 3. Effects of feeding grower-finisher diets containing transgenic "Bt" corn on swine growth performance traits[a].

Item	Corn type			Sex		CV	Significance[b]	
	Isogenic	Bt	Conventional	Barrow	Gilt		Corn	Sex
Phase I, 66-121 lb								
ADG, lb	1.92	1.92	1.92	1.97	1.87	5.8	.99	.03
ADFI, lb	4.29	4.22	4.25	4.38	4.11	5.6	.89	.01
F/G	2.22	2.20	2.21	2.22	2.20	3.6	.75	.40
Phase II, 121-178 lb								
ADG, lb	2.08	2.08	2.12	2.20	1.99	3.9	.37	.01
ADFI, lb	5.72	5.57	5.70	6.12	5.21	4.1	.37	.01
F/G	2.74	2.67	2.67	2.78	2.61	4.0	.22	.01
Phase III, 178-209 lb								
ADG, lb	2.20	2.18	2.17	2.29	2.08	5.5	.73	.01
ADFI, lb	6.71	6.53	6.51	7.13	6.05	4.5	.32	.01
F/G	3.02	2.98	2.99	3.11	2.90	5.6	.87	.01
Phase IV, 209-255 lb								
ADG, lb	2.20	2.22	2.20	2.24	2.17	5.8	.97	.09
ADFI, lb	7.24	7.15	7.02	7.63	6.64	4.7	.35	.01
F/G	3.27	3.22	3.16	3.39	3.06	5.2	.39	.01
Overall, 66-266 lb								
ADG, lb	2.08	2.08	2.09	2.15	2.01	3.0	.95	.01
ADFI, lb	5.78	5.68	5.68	6.09	5.34	3.7	.51	.01
F/G	2.77	2.72	2.72	2.82	2.65	2.7	.22	.01

[a] A total of 180 pigs were used, six pigs/pen, ten pens/treatment. Pigs were fed diets containing isogenic parental corn, Bt corn, or blended conventional nontransgenic corn of different varieties. Corn varieties were incorporated into the diets as a fixed percentage for each of the three treatment groups.

[b] There were no significant (P>.10) interactions occurring between corn and sex for any of the response criteria.

Table 4. Effects of feeding grower-finisher diets containing transgenic "Bt" corn on pork carcass quality[a].

Item	Corn type			Sex		CV	Significance	
	Isogenic	Bt	Conventional	Barrow	Gilt		Corn	Sex
Market weight, lb	264.9	264.9	268.1	272.1	259.9	2.6	.50	.01
Hot carcass wt., lb	194.7^{xy}	194.2^{x}	199.1^{y}	198.9	193.1	2.7	.09	.01
Dressing, %	73.9^{x}	73.9^{x}	74.7^{y}	74.0	74.3	1.1	.05	.31
Carcass lean[bc], %	54.6^{x}	55.5^{xy}	56.1^{y}	54.2	56.6	2.1	.04	.01
Carcass length[b], in	32.9	32.9	32.9	32.9	32.9	.95	.46	.98
LEA[b], in^2	7.60	7.78	7.92	7.57	7.96	5.6	.34	.05
10th rib fat depth[b], in	.86^{x}	.78^{y}	.79^{y}	.93	.68	7.7	.02	.01
Last rib fat depth[b], in	1.02	.97	.97	1.05	.92	6.1	.11	.01
Last lumbar fat depth[b], in	.76^{x}	.71^{xy}	.68^{y}	.78	.66	9.1	.03	.01
P2 fat depth[b], in	.68^{x}	.63^{y}	.61^{y}	.71	.57	8.7	.02	.01
Color[d]	2.45	2.45	2.35	2.32	2.51	13	.70	.12
Marbling[e]	1.32^{x}	1.27^{x}	1.12^{y}	1.31	1.16	10	.01	.01
Firmness[f]	2.55	2.32	2.30	2.28	2.50	13	.17	.07

[a] A total of 180 pigs were used, six pigs/pen, ten pens/treatment. Pigs were fed diets containing isogenic parental corn, Bt corn, or blended conventional nontransgenic corn of different varieties. Corn varieties were incorporated into the diets as a fixed percentage for each of the three treatment groups. Data are reported as least square means.

[b] Means are adjusted for hot carcass weight.

[c] Carcass lean was calculated using the equation for ribbed carcasses (NPPC, 1991).

[d] Subjective scores were used to evaluate color (1= pale, pinkish gray; 6=dark, purplish red).

[e] Subjective scores were used to evaluate marbling (1= devoid to practically devoid; 6 = moderately abundant or greater).

[f] Carcass firmness was evaluated using subjective scores (1= very soft; 5 = very firm).

[x,y] Means in a row with different superscripts differ (P<.05). No significant interactions were detected between sex and corn type (P>.10).