Comparison of Broiler Performance When Fed Diets Containing Grain from Roundup Ready (NK603), YieldGard × Roundup Ready (MON810 × NK603), Non-transgenic Control, or Commercial Corn[1]

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ABSTRACT Two 42-d experiments compared the nutritional value of the glyphosate-tolerant corn event NK603 (Roundup Ready corn) (experiment 1) and the combined traits, insect-protected corn event MON 810 (YieldGard corn) × glyphosate-tolerant corn event NK603 (experiment 2) to their respective non-transgenic controls and to commercial reference corn, when fed to growing broilers. For each experiment, a randomized complete block design was used with eight dietary treatments in each of five replicated blocks of pens (eight pens for males and eight pens for females per block). Final live weights and feed conversion were not different ($P > 0.05$) across all treatments in both experiments. In experiment 1, broilers fed diets containing Roundup Ready corn had similar feed conversion adjusted for mortalities to those fed the non-transgenic control and one of the commercial corn diets. Chill weights and thigh, drum, and wing weights were not affected by diets. Differences ($P < 0.05$) were noted for breast meat and fat pad weights across treatments. In experiment 2, the adjusted feed conversion and carcass parameters were not affected by diets. Differences ($P < 0.05$) were noted only for protein content of breast meat. Differences observed in both experiments were consistent with natural variability. Broilers in general performed consistently and had similar carcass yields and meat compositions when fed diets containing Roundup Ready corn or YieldGard × Roundup Ready corn as compared with their respective non-transgenic control and commercial diets supporting similar feeding values among diets.

(*Key words*: broiler performance, carcass yield, *Bacillus thuringiensis*, Cry1A(b), CP4 EPSPS)

2003 Poultry Science 82:443–453

INTRODUCTION

Traits such as herbicide tolerance and insect protection have been introduced into corn to provide efficacious, environmentally compatible methods of weed and insect control. Roundup Ready corn event NK603 was produced by the stable insertion of two gene cassettes expressing 5-enolpyruvylshikimate-3-phosphate synthases from *Agrobacterium sp.* strain CP4 (CP4 EPSPS) that confer tolerance to glyphosate, the active ingredient in Roundup herbicide. Event NK603 differs from Roundup Ready corn event GA21 that expresses a modified corn EPSPS (mEPSPS) (Sidhu et al., 2000). The *cp4 epsps genes* from *Agrobacterium sp.* strain CP4 have been completely sequenced and encode ~47.6 kDa proteins consisting of a single polypeptide of 455 amino acids (Padgette et al., 1996). The CP4 EPSPS proteins are functionally similar to plant EPSPS enzymes but have a much-reduced affinity for glyphosate. A comprehensive safety assessment of CP4 EPSPS protein has been described in the literature (Harrison et al., 1996).

The combined trait, YieldGard (event MON810) × Roundup Ready (event NK603) corn, also produces the Cry1A(b) protein that confers insect protection from the European corn borer (*Ostrinia numbilalis*) in addition to Roundup tolerance. YieldGard corn was modified to produce the Cry1A(b) protein from *Bacillus thuringienisis* subsp. *kurstaki* strain HD-1 (Sanders et al., 1998). YieldGard × Roundup Ready corn were combined by conventionally breeding the two transgenically derived single-trait products.

Data are systematically collected to assess the safety of foods and feed derived from genetically modified crops. This process involves evaluation of the introduced trait (often a gene expressing a protein) by comparison of the agronomic characteristics of the new plant to traditionally bred plants and nutritional and biochemical compositions of the new food to traditional food or feed, also called compositional equivalence (WHO, 1991, 1995; FAO, 1996).

Received for publication May 15, 2002.
Accepted for publication November 1, 2002.
[1]YieldGard, Roundup, and Roundup Ready are registered trademarks of Monsanto Technology LLC.
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Previous experiments have concluded that YieldGard corn and the other variety of Roundup Ready corn containing event GA21 were substantially equivalent in composition to conventional corn (Sanders et al., 1998; Sidhu et al., 2000). In addition, confirmatory studies may include evaluation of the safety of the resulting food or feed established by comparative toxicology testing. In addition, nutritional wholesomeness of the new food or feed is established by testing in farm animals such as broilers (Astwood and Fuchs, 2001). Broiler studies such as these may detect potential effects resulting from the transformation event or from the expression of the new trait or traits by examining performance characteristics during a period of rapid growth.

In these current experiments, as in that of Sidhu et al. (2000), rapidly growing broilers were chosen as a useful model to evaluate the wholesomeness of transgenic corn to conventional corn because of their sensitivity to changes in nutrient quality and because corn is a major ingredient in broiler diets. These current experiments individually compared the nutritional value of Roundup Ready or YieldGard × Roundup Ready corn to conventional corn by measuring performance, carcass yield, and meat quality parameters in broilers.

MATERIALS AND METHODS

Birds and Housing

These experiments were conducted in accordance with the principles and guidelines for the care and use of agricultural animals in research (FASS, 2001) and in compliance with the Food and Drug Administration guidelines (FDA, 1979). For experiments 1 and 2, broiler chickens of a high-yielding commercial strain (Ross × Ross 508) were purchased[3] at 1 d of age. Broilers were vaccinated for Marek's disease at the hatchery and for Newcastle disease and infectious bronchitis at the test site at 7 d of age.

The broilers were randomly assigned by gender to pens and maintained under simulated commercial conditions for raising broilers. These conditions included clean pens with concrete floors (1.5 m × 0.9 m), providing approximately 0.3 m^2 per bird and containing 10 to 13 cm of clean wood shavings. Environmentally controlled incandescent lighting and temperature were used. Water and feed were available ad libitum throughout the experiment. Within each pen, water was provided via a hanging automatic bell drinker (36-cm diameter), and feed was provided via a hanging tube feeder (43-cm diameter). A chick feeder tray was also placed in each pen for the first 6 d. Environmental conditions (floor space, temperature, lighting, bird density, and feeder and water space) were similar for all treatments.

Experimental Design

For each experiment, a randomized complete block design was used with eight treatments (test, non-transgenic control, and commercial diets). For each of the eight treatment groups, there were 100 broilers in 10 pens, five pens of males (10 broilers per pen) and five pens of females (10 broilers per pen) for a total of 800 birds. Initially, there were two additional broilers in each pen to compensate for early chick mortality during the first few days posthatch. At experiment d 7, the group size was culled to a maximum of 10 broilers per pen. The primary criterion for removal was slower growing broilers, followed by random selection.

Grains

In Experiment 1, both Roundup Ready grain and the non-transgenic control grain (B73HT × LH82) were produced in Kaunakakai, Hawaii. Grain from five non-transgenic commercial hybrids grown during the 1999 and 2000 U.S. growing seasons were included in the experiment for reference purposes. The commercial hybrids were RX826 (St. Joseph, Illinois); LH235 × LH185 (Kaunakakai, Hawaii); MON 847 (Monmouth, Illinois), commercially known as RX670; RX770 (Monmouth, Illinois); and DK493 (Yuma County, Colorado). An additional test diet, unrelated to corn event NK603, was included in experiment 1, but individual data for this event are not reported.

In experiment 2, grain from both YieldGard × Roundup Ready corn and the non-transgenic control corn (RX730) were produced in Monmouth, Illinois, during the 2000 season. Grain from six commercial hybrids grown during 2000 was evaluated in the experiment for comparison to grain from the test hybrids. Six commercially available corn hybrids (grown in 2000) were obtained from US growers: SC1096, SC1087, and SC1140 (Fayette County, Ohio); Asgrow 740, Pioneer 34B23, and DEKALB 626 (Clinton County, Illinois).

Mycotoxin[4] and pesticide[5] screens of the corn grain used in these experiments were conducted prior to initiation of each experiment to verify that levels were below the limits of concern for broiler performance. Diets were formulated based on the individual nutrient analyses[5] for the grain from each test, control, and commercial hybrid.

Diets

Dietary protein was provided by the corn supplemented with commercial dehulled soybean meal. Synthetic methionine and lysine were added to the diets as needed to conform to industry standards. A coccidiostat, salinomycin (Sacox)[6] was mixed into diets at 60 g/ton. No growth promoters or other medications were added to the diets. For both experiments, diets were formulated such that the critical amino acid levels met NRC (1994) values for poultry to align them with broiler industry levels.

For both experiments, from d 1 to 20, chickens were fed a starter diet containing approximately 55% wt/wt corn.

[3]Hoover's Hatchery, Rudd, IA.
[4]Romer Laboratories, Union, MO.
[5]Covance Laboratories, Madison, WI.
[6]Intervet, Inc., Millsboro, DE.

TABLE 1. Experiment 1: ingredient composition of diets [Roundup Ready (NK603), control (B73HT × LH82), and commercial lines RX826, LH235 × LH185, DK493, MON847, and RX770]

	Treatment						
Ingredient	NK603	B73HT × LH82	RX826	LH235 × LH185	DK493	MON 847	RX770
Starter diet							
Corn (%)	57.10	57.90	56.34	55.30	55.17	58.44	57.06
Dehulled soybean meal (%)	36.05	35.40	36.70	37.55	37.65	34.95	36.15
Soy oil (%)	3.40	3.25	3.50	3.70	3.70	3.15	3.40
Deflourinated phosphate (%)	1.80	1.90	1.85	1.90	1.85	1.85	1.80
Limestone (%)	0.75	0.65	0.70	0.65	0.70	0.70	0.70
Salt (%)	0.28	0.27	0.27	0.27	0.28	0.28	0.28
DL-Methionine (%)	0.23	0.23	0.24	0.24	0.25	0.24	0.22
Choline chloride-60% (%)	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Trace minerals[1] (%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamins[2] (%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Sacox (coccidiostat) (%)	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Grower/finisher diet							
Corn (%)	62.70	63.50	61.80	60.70	60.58	64.23	62.67
Dehulled soybean meal (%)	30.80	30.10	31.55	32.45	32.60	29.60	30.90
Soy oil (%)	3.25	3.10	3.40	3.60	3.60	2.95	3.25
Deflourinated phosphate (%)	1.70	1.80	1.75	1.80	1.70	1.70	1.70
Limestone (%)	0.65	0.60	0.60	0.55	0.60	0.60	0.60
Salt (%)	0.30	0.29	0.29	0.28	0.29	0.30	0.30
DL-Methionine (%)	0.24	0.25	0.25	0.26	0.27	0.25	0.23
Choline chloride-60% (%)	0.11	0.12	0.11	0.10	0.10	0.12	0.11
Trace minerals[1] (%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamins[2] (%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lysine (%)	0.00	0.01	0.00	0.00	0.00	0.01	0.00
Sacox (coccidiostat) (%)	0.05	0.05	0.05	0.05	0.05	0.05	0.05

[1]Trace mineral premix (SEM Minerals, Quincy, IL) contained 0.003% calcium and provided the following in milligrams per kilogram of diet: Mn, 120; Zn, 100; Fe, 40; Cu, 10; I, 1.4; Se, 0.3, and Mg, 26.

[2]Vitamin premix (Roche Vitamins, Inc., Parsippany, NJ) provided the following per kilogram of diet: vitamin A, 9,350 IU from all *trans*-retinyl acetate; cholecalciferol D_3, 3,025 IU; vitamin E, 27.5 IU from DL-α-tocopherol; vitamin B_{12}, 13.75 μg; riboflavin, 7.7 mg; niacin, 49.5 mg; pantothenic acid, 12.1 mg; menadione, 1.925 mg; folic acid, 0.99 mg; ethoxyquin, 77 mg; biotin, 0.088 mg; thiamine, 1.925 mg; pyridoxine, 3.08 mg.

From d 20 to 42, chickens were fed a grower/finisher diet containing approximately 60% wt/wt corn (Tables 1 and 2). Analyses of formulated poultry diets[7] are summarized in Tables 3 and 4.

Measurements

Broilers were examined twice daily for general health. All mortalities and unhealthy birds killed were weighed and necropsied. Probable cause of death or reason for removal was documented. The broilers were weighed at d 0 (experiment start) and d 42 and individually at experiment termination (d 43 for males and d 44 for females). Average BW per pen and BW per bird values within each treatment group were calculated for each gender. The average feed conversion per pen was calculated for the entire duration of the experiment by using the total feed consumption during the experiment divided by the total BW of the surviving broilers in the pen. This result was averaged for each treatment group by gender. Adjusted feed conversion was calculated by using the total feed consumption per pen divided by the total BW of the surviving broilers and the BW of broilers that died or were removed from the pen. Carcass measurements for all birds were taken at experiment completion, and fat pads were collected from each bird and weighed. The first male and female birds processed from each pen were selected for breast and thigh tissue collection. Moisture, protein, and fat analyses were conducted on breast and thigh meat samples after in-life experiment termination.[8]

Statistical Analysis

Statistical analyses (ANOVA), using a randomized complete block design, were performed on starting and final live weights, feed consumption, feed conversion, adjusted feed conversion, live weight upon processing, carcass chill weight, percentage chill weight (chill weight/live weight), breast weight, percentage breast weight (breast weight/chill weight), wing weight, percentage wing weight (wing weight/chill weight), thigh weight, percentage thigh weight (thigh weight/chill weight), drum weight, percentage drum weight (drum weight/chill weight), fat pad weight, percentage fat pad (fat pad/live weight), and moisture, protein, and fat values for breast and thigh meats. The statistical analysis was carried out using a linear mixed model procedure of SAS software (SAS Institute, Inc., 2000).

The mean values obtained for the Roundup Ready and YieldGard × Roundup Ready diets were compared with

[7]Covance Laboratories, Madison, WI; Dairy One Laboratories, Ithaca, NY.

[8]University of Missouri, Experiment Stations Chemical Laboratories, Columbia, MO.

TABLE 2. Experiment 2: ingredient composition of diets [YieldGard × Roundup Ready (MON 810 × NK603), control (RX730), and commercial lines SC1087, SC1140, Asgrow 740, Pioneer 34B23, and DEKALB 626]

	Treatment						
Ingredient	MON 810 × NK603	RX730	SC1087	SC1140	Asgrow 740	Pioneer 34B23	DEKALB 626
Starter diet							
Corn (%)	55.16	55.36	53.89	55.18	54.44	55.55	54.99
Dehulled soybean meal (%)	37.65	37.45	38.70	37.60	38.25	37.35	37.80
Soy oil (%)	3.70	3.70	3.95	3.70	3.85	3.65	3.75
Deflourinated phosphate (%)	1.85	1.85	1.85	1.85	1.80	1.80	1.80
Limestone (%)	0.75	0.75	0.70	0.75	0.75	0.75	0.75
Salt (%)	0.26	0.26	0.26	0.26	0.27	0.26	0.26
DL-Methionine (%)	0.24	0.24	0.25	0.27	0.25	0.24	0.25
Choline chloride-60% (%)	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Trace minerals[1] (%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamins[2] (%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Sacox (coccidiostat) (%)	0.05	0.05	0.05	0.05	0.05	0.05	0.05
Grower/finisher diet							
Corn (%)	60.47	60.77	59.16	60.53	59.71	60.86	60.36
Dehulled soybean meal (%)	32.60	32.35	33.75	32.55	33.25	32.30	32.75
Soy oil (%)	3.65	3.60	3.85	3.60	3.75	3.55	3.65
Deflourinated phosphate (%)	1.75	1.75	1.75	1.75	1.70	1.70	1.70
Limestone (%)	0.65	0.65	0.60	0.65	0.70	0.70	0.65
Salt (%)	0.28	0.28	0.27	0.28	0.28	0.28	0.28
DL-Methionine (%)	0.25	0.25	0.27	0.28	0.26	0.25	0.26
Choline chloride-60% (%)	0.10	0.11	0.10	0.10	0.10	0.11	0.10
Trace minerals[1] (%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Vitamins[2] (%)	0.10	0.10	0.10	0.10	0.10	0.10	0.10
Lysine (%)	0.00	0.00	0.00	0.01	0.00	0.00	0.00
Sacox (coccidiostat) (%)	0.05	0.05	0.05	0.05	0.05	0.05	0.05

[1]Trace mineral premix (SEM Minerals, Quincy, IL) contained 0.003% calcium and provided the following in milligrams per kilogram of diet: Mn, 120; Zn, 100; Fe, 40; Cu, 10; I, 1.4; Se, 0.3, and Mg, 26.

[2]Vitamin premix (Roche Vitamins, Inc., Parsippany, NJ) provided the following per kilogram of diet: vitamin A, 9,350 IU from all *trans*-retinyl acetate; cholecalciferol D_3, 3,025 IU; vitamin E, 27.5 IU from DL-α-tocopherol; vitamin B_{12}, 13.75 μg; riboflavin, 7.7 mg; niacin, 49.5 mg; pantothenic acid, 12.1 mg; menadione, 1.925 mg; folic acid, 0.99 mg; ethoxyquin, 77 mg; biotin, 0.088 mg; thiamine, 1.925 mg; pyridoxine, 3.08 mg.

those for the respective non-transgenic control and commercial diets at the 5% level of significance using a protected Fisher's least significant difference test (Fisher, 1949). The statistical model included effects of treatments, gender, block, and gender-by-treatment interactions, with the experimental unit being the pen. An additional statistical analysis compared the fit of the Roundup Ready and YieldGard × Roundup Ready diets to the population of responses from the non-transgenic controls and commercial corn diets in the respective experiments to determine whether the values of the test parameters were consistent across treatments. When a statistically significant gender-by-treatment interaction was noted for any of the parameters, the means were also broken out by gender.

RESULTS

General Observations

Mycotoxin and pesticide levels in corn grain mixed into the diets were below the limits of concern for broiler performance. Levels of mycotoxins (fumonisins) in the grain ranged from nondetectable to less than 3 ppm. All values for the pesticide screen were below the assay limits of detection [organophosphates (0.050 ppm), organonitrogens (0.500 ppm), organochlorinates (0.200 ppm), and N-methylcarbamates (0.100 ppm)]. Diets were formulated based on the individual nutrient analyses of the grain, and nutrient assay results for the starter and grower/finisher diets met NRC (1994) recommendations (Tables 3 and 4).

In experiment 1, a total of 24 broilers (2.5% of total) died during the first 7 d with mortality spread out across treatments. In experiment 2, a total of 20 broilers (2.1% of total) died during this early period, again with mortality being random across treatments. The distribution of birds that died from d 7 to 42 was also random across treatments in both experiments. In experiment 1, deaths from d 7 to experiment termination averaged 1.14% and ranged from 0 to 3% across treatments. The average starting and final BW of all broilers were approximately 38 and 2,300 g, respectively, with no treatment differences ($P > 0.05$; Table 5). In Experiment 2, deaths from d 7 to experiment termination averaged 2.6% and ranged from 1 to 4% across treatments. The average starting BW of all broilers was approximately 42 g, and final BW ranged from 2,100 to 2,200 g with no treatment differences ($P > 0.05$; Table 6). In both experiments, most of the apparent causes of death between d 7 and 42 were attributed to sudden death and ascites, which occur commonly in chickens. Remaining broilers in all treatments for both experiments were in good health.

TABLE 3. Experiment 1: nutrient composition of diets [Roundup Ready (NK603), control (B73HT × LH82), and commercial lines RX826, LH235 × LH185, DK493, MON847, and RX770]

Nutrient (as is basis)	NK603	B73HT ×LH82	RX826	LH235 × LH185	DK493	MON 847	RX770
Starter diets							
ME[1] (kcal/kg)	3,080.88	3,080.42	3,079.41	3,081.01	3,079.69	3,079.80	3,081.43
Crude protein (%)	21.4	21.5	21.7	20.8	21.9	20.7	21.1
Crude fat (%)	6.3	6.4	5.7	6.2	5.8	5.8	6.0
Moisture (%)	9.8	9.8	10.0	9.5	10.2	10.1	10.4
Arginine (%)	1.35	1.27	1.32	1.28	1.25	1.33	1.19
Lysine (%)	1.34	1.19	1.38	1.22	1.22	1.24	1.22
Methionine (%)	0.58	0.57	0.52	0.48	0.62	0.58	0.54
Cystine (%)	0.36	0.35	0.32	0.30	0.36	0.38	0.33
Tryptophan (%)	0.21	0.20	0.21	0.20	0.21	0.19	0.20
Threonine (%)	0.79	0.74	0.77	0.71	0.73	0.74	0.70
Valine (%)	1.16	1.09	1.14	1.05	1.06	1.09	1.03
Calcium (%)	0.90	0.98	0.85	0.98	0.90	1.02	0.85
Phosphorus (%)	0.78	0.84	0.79	0.82	0.79	0.86	0.75
Grower/finisher diets							
ME[1] (kcal/kg)	3,134.71	3,133.00	3,134.82	3,136.10	3,135.99	3,135.42	3,135.26
Crude protein (%)	20.5	20.0	19.6	19.5	19.9	19.7	19.6
Crude fat (%)	6.0	5.5	5.9	5.8	6.5	5.5	5.9
Moisture (%)	10.7	10.0	11.0	9.8	11.1	10.3	10.5
Arginine (%)	1.17	1.14	1.17	1.12	1.16	1.00	1.15
Lysine (%)	1.17	1.03	1.15	1.16	1.16	1.00	1.09
Methionine (%)	0.53	0.53	0.54	0.60	0.60	0.51	0.54
Cystine (%)	0.35	0.32	0.34	0.34	0.34	0.34	0.34
Tryptophan (%)	0.19	0.17	0.20	0.20	0.18	0.18	0.19
Threonine (%)	0.70	0.66	0.69	0.68	0.67	0.66	0.67
Valine (%)	1.02	0.98	1.01	1.01	0.98	0.96	0.99
Calcium (%)	0.82	0.76	0.79	0.76	0.76	0.77	0.80
Phosphorus (%)	0.74	0.71	0.74	0.70	0.72	0.75	0.77

[1]Calculated value.

TABLE 4. Experiment 2: nutrient composition of diets [YieldGard × Roundup Ready (MON 810 × NK603), control (RX730), and commercial lines SC1087, SC1140, Asgrow 740, Pioneer 34B23, and DEKALB 626]

Nutrient (as is basis)	MON 810 × NK603	RX730	SC1087	SC1140	Asgrow 740	Pioneer 34B23	DEKALB 626
Starter diets							
ME[1] (kcal/kg)	3,078.42	3,080.46	3,082.05	3,079.21	3,081.41	3,080.59	3,081.01
Crude protein (%)	22.2	21.1	21.8	21.4	22.3	21.4	21.9
Crude fat (%)	6.4	6.0	6.4	6.6	6.5	6.2	6.4
Moisture (%)	13.3	13.0	13.2	13.7	13.0	13.6	13.4
Arginine (%)	1.32	1.42	1.41	1.23	1.40	1.42	1.33
Lysine (%)	1.16	1.23	1.24	1.19	1.24	1.20	1.23
Methionine (%)	0.53	0.54	0.60	0.57	0.60	0.60	0.60
Cystine (%)	0.34	0.36	0.37	0.34	0.34	0.34	0.33
Tryptophan (%)	0.19	0.21	0.19	0.19	0.19	0.19	0.19
Threonine (%)	0.71	0.77	0.74	0.71	0.76	0.78	0.73
Valine (%)	0.91	0.98	0.98	0.91	0.96	0.96	0.93
Calcium (%)	1.44	1.47	1.41	1.40	1.36	1.38	1.44
Phosphorus (%)	0.91	0.91	0.90	0.89	0.92	0.88	0.94
Grower/finisher diets							
ME[1] (kcal/kg)	3,135.53	3,135.53	3,135.79	3,134.03	3,133.86	3,133.39	3,135.62
Crude protein (%)	21.8	20.6	20.8	21.4	21.0	20.6	21.3
Crude fat (%)	6.1	6.1	6.7	5.5	7.0	5.9	6.7
Moisture (%)	13.2	13.0	13.3	13.3	13.4	13.1	13.1
Arginine (%)	1.25	1.33	1.25	1.36	1.41	1.31	1.39
Lysine (%)	1.14	1.13	1.20	1.17	1.23	1.24	1.27
Methionine (%)	0.54	0.53	0.54	0.55	0.54	0.54	0.53
Cystine (%)	0.34	0.35	0.32	0.35	0.36	0.34	0.34
Tryptophan (%)	0.20	0.18	0.18	0.17	0.17	0.16	0.18
Threonine (%)	0.71	0.74	0.73	0.75	0.77	0.74	0.76
Valine (%)	0.92	0.93	0.94	0.95	0.97	0.96	0.98
Calcium (%)	1.06	1.15	1.21	1.00	1.19	1.07	1.25
Phosphorus (%)	0.74	0.77	0.82	0.72	0.84	0.76	0.85

[1]Calculated value.

TABLE 5. Experiment 1: performance and carcass yield comparison of broilers fed Roundup Ready corn event NK603, non-transgenic control corn (B73HT × LH82), and commercial corn (mean values of combined males and females)

	Treatment[1]								
	8	6	1	4	3	5	2		
Item	NK603	B73HT × LH82	RX826	LH235 × LH185	DK 493	MON 847	RX770	Treatments SSD[2]	LSD[3] 5.0%
Performance									
Live weight (g/bird) d 0	38.18	38.42	38.50	38.10	38.38	38.33	38.25	NS	0.80
Live weight (kg/pen) d 0	0.46	0.46	0.46	0.46	0.46	0.46	0.46	NS	0.01
Live weight (kg/bird) d 42	2.30	2.31	2.34	2.35	2.33	2.32	2.25	NS	0.07
Live weight (kg/pen) d 42	22.77	22.85	23.37	22.72	22.76	22.48	22.53	NS	1.11
Feed intake (kg/bird)	3.55	3.59	3.69	3.71	3.69	3.67	3.54	NS	0.13
Feed intake (kg/pen)	35.09	35.47	36.94	35.87	36.04	35.57	35.43	NS	1.48
Feed conversion (kg/kg)	1.54	1.56	1.58	1.58	1.59	1.59	1.57	NS	0.03
Adjusted feed conversion (kg/kg)	1.53^{c}	1.55^{bc}	1.57^{a}	1.55^{bc}	1.56^{ab}	1.56^{ab}	1.56^{ab}	*	0.02
Carcass yield									
Live weight (kg)	2.25	2.22	2.30	2.29	2.26	2.25	2.20	NS	0.06
Chill weight (kg)	1.59	1.58	1.64	1.62	1.60	1.60	1.56	NS	0.05
Chill weight (% of live weight)	70.90	71.00	71.20	70.90	70.90	70.90	70.80	NS	0.46
Fat pad weight (kg)	0.034^{b}	0.037^{a}	0.036^{ab}	0.039^{a}	0.039^{a}	0.037^{a}	0.037^{a}	*	0.003
Fat pad weight (% of live weight)	1.5^{c}	1.7^{ab}	1.6^{bc}	1.7^{a}	1.7^{a}	1.7^{ab}	1.7^{ab}	**	0.11
Breast meat weight (kg)	0.41^{abcd}	0.39^{d}	0.42^{a}	0.42^{ab}	0.41^{abc}	0.40^{bcd}	0.39^{cd}	*	0.02
Breast meat weight (% of chill weight)	25.50	24.90	25.80	25.60	25.70	25.30	25.30	NS	0.54
Thigh weight (kg)	0.28	0.28	0.28	0.28	0.27	0.28	0.27	NS	0.01
Thigh weight (% of chill weight)	17.50	17.40	17.20	17.10	17.10	17.30	17.20	NS	0.29
Drum weight (kg)	0.23	0.22	0.23	0.23	0.22	0.23	0.22	NS	0.01
Drum weight (% of chill weight)	14.30	14.20	14.10	14.00	14.00	14.20	14.30	NS	0.25
Wing weight (kg)	0.19	0.18	0.19	0.19	0.19	0.18	0.18	NS	0.01
Wing weight (% of chill weight)	11.70	11.80	11.70	11.60	11.70	11.60	11.70	NS	0.14

[a–d]Individual treatment means with the same superscript letter in the same row are not statistically different ($P > 0.05$).

[1]Data for treatment 7 not reported.

[2]Statistical significance of overall F-test: NS at $P > 0.05$.

[3]Least significant difference between two means ($P < 0.05$).

*$P < 0.05$; **$P < 0.01$.

Experiment 1

Means across gender are reported for the individual treatment comparisons (Tables 5 and 7), and means are reported broken out by gender for the population comparisons (Tables 8 and 9). Data for the additional test event are not reported, and this test event was not included in the population statistical analyses.

Performance Parameters. Performance parameters measured were not different across broilers fed diets containing Roundup Ready corn, the non-transgenic control, and the commercial corn. Live weight at d 0 (g/bird or kg/pen), live weight at d 42 (kg/bird or kg/pen), total feed intake (kg/bird or kg/pen), and feed conversion (kg/kg) were not different across all treatments ($P > 0.05$, Table 5). Broilers fed diets containing Roundup Ready corn had similar adjusted feed conversions to those fed the non-transgenic control (B73HT × LH82) and one of the five commercial diets (LH235 × LH185). Broilers fed diets containing grain from the other four commercial hybrids had poorer adjusted feed conversions ($P < 0.05$) than those fed diets containing Roundup Ready corn.

Carcass Measurements. Final live weight (kg) and carcass measurements of chill weight (kg or % of live weight), breast meat (% of chill weight), thighs (kg or % of chill weight), drums (kg or % of chill weight), and wings (kg or % of chill weight) were not different ($P > 0.05$) across treatments (Table 5). Expressed as a weight or percentage chill weight basis, fat pad weights of the birds fed diets of Roundup Ready corn were not different from fat pad weights of birds fed the RX826 commercial corn. However, the fat pad weight of the birds fed diets containing Roundup Ready corn was less ($P < 0.05$) than those fed control and the other four commercial diets. Breast meat weight of birds fed diets containing Roundup Ready corn was not different ($P > 0.05$) from those fed the non-transgenic control and the five commercial diets. However, breast meat weights of birds fed the non-transgenic control diet were less ($P < 0.05$) than those of birds fed diets containing grain from commercial hybrids RX826, LH235 × LH185, and DK493.

No differences were observed in the percentages of moisture, protein, and fat in breast meat or in the percentage of protein or fat in thigh meat among treatment diets (Table 7). Percentage moisture content of the thigh meat was not different among broilers fed diets containing Roundup Ready corn, non-transgenic control corn, and three of the commercial corn lines. Birds fed two of the commercial corn diets (LH235 × LH185 and MON847) had thigh meat that was slightly higher in moisture compared to those fed the diet containing transgenic corn (Table 7).

Experiment 2

Means across gender are reported for the individual treatment (Tables 6 and 10) and population comparisons

TABLE 6. Experiment 2: performance and carcass yield of broilers fed YieldGard × Roundup Ready corn (event MON810 × event NK603), non-transgenic control corn RX730, and commercial corn (mean values of combined males and females)

	Treatment[1]								
	8	7	2	3	4	5	6		
	MON 810 × NK603	RX730	SC1087	SC1140	Asgrow 740	Pioneer 34B23	DEKALB 626	Treatments SSD[2]	LSD[3] 5.0%
Performance									
Live weight (g/bird) d 0	42.52	42.12	41.98	42.17	42.52	42.32	41.87	NS	0.98
Live weight (kg/pen) d 0	0.51	0.50	0.50	0.51	0.51	0.51	0.50	NS	0.01
Live weight (kg/bird) d 42	2.19	2.12	2.19	2.15	2.14	2.18	2.17	NS	0.08
Live weight (kg/pen) d 42	21.25	20.16	21.49	21.17	20.79	21.65	20.98	NS	1.31
Feed Intake (kg/bird)	3.68	3.54	3.59	3.50	3.51	3.54	3.63	NS	0.21
Feed intake (kg/pen)	35.17	33.83	35.05	34.58	33.99	35.02	34.68	NS	1.63
Feed conversion (kg/kg)	1.67	1.68	1.63	1.64	1.64	1.62	1.66	NS	0.06
Adjusted feed conversion (kg/kg)	1.60	1.63	1.60	1.61	1.61	1.61	1.62	NS	0.02
Carcass yield									
Live weight (kg)	2.21	2.10	2.20	2.14	2.14	2.19	2.19	NS	0.08
Chill weight (kg)	1.55	1.49	1.55	1.52	1.51	1.54	1.54	NS	0.07
Chill weight (% of live weight)	70.7	70.1	70.9	70.9	70.5	70.8	70.8	NS	0.01
Fat pad weight (kg)	0.036	0.035	0.035	0.038	0.035	0.037	0.037	NS	0.004
Fat pad weight (% of live weight)	1.6	1.6	1.6	1.8	1.6	1.7	1.7	NS	0.001
Breast meat weight (kg)	0.40	0.39	0.40	0.40	0.39	0.40	0.40	NS	0.02
Breast meat weight (% of chill weight)	26.1	25.9	25.9	26.1	25.6	26.0	25.9	NS	0.005
Thigh weight (kg)	0.27	0.26	0.28	0.27	0.27	0.28	0.27	NS	0.01
Thigh weight (% of chill weight)	17.6	17.5	17.7	17.5	17.6	17.9	17.8	NS	0.003
Drum weight (kg)	0.22	0.21	0.22	0.22	0.22	0.22	0.22	NS	0.01
Drum weight (% of chill weight)	14.4	14.3	14.5	14.3	14.4	14.3	14.4	NS	0.002
Wing weight (kg)	0.18	0.18	0.18	0.18	0.18	0.18	0.18	NS	0.01
Wing weight (% of chill weight)	11.8	11.8	11.7	11.8	11.8	11.7	11.7	NS	0.002

[1]Commercial treatment 1 dropped from analyses.
[2]Statistical significance of overall *F*-test: NS at $P > 0.05$.
[3]Least significant difference between two means ($P < 0.05$).

(Table 11). Data associated with commercial hybrid SC1096 were deleted from statistical analyses due to detection of the MON 810 event in the diets above a 1% threshold level.

Performance Parameters. All performance parameters of broilers were unaffected ($P > 0.05$) among diets of containing YieldGard × Roundup Ready corn, non-transgenic control corn, and commercial corn, and gender-by-treatment interactions were not significant. Live weight at d 0 (g/bird or kg/pen), live weight at d 42 (kg/bird or kg/pen), total feed intake (kg/bird or kg/pen), feed conversion (kg/kg), and adjusted feed conversion (kg/kg) were not different among treatments (Table 6).

Carcass Measurements. Final live weight (kg) and carcass measurements of chill weight (kg or % of live weight), fat pad weight (kg or % of live weight), breast meat weight (kg or % of chill weight), thigh weight (kg or % of chill

TABLE 7. Experiment 1: moisture, protein and fat composition of breast and thighs from broilers fed Roundup Ready corn event NK603, non-transgenic control corn B73HT × LH82, and commercial corn (mean values of combined males and females)

	Treatment[1]								
	8	6	1	4	3	5	2		
	NK603	B73HT × LH82	RX826	LH235 × LH185	DK 493	MON 847	RX770	Treatments SSD[2]	LSD[3] 5.0%
Breast meat analysis									
Moisture (%)	74.74	74.88	74.72	74.73	74.77	74.99	74.44	NS	0.47
Protein (%, as-is basis)	24.11	23.71	24.24	24.35	24.16	24.01	24.02	NS	0.54
Fat (%, as-is basis)	0.87	0.93	0.81	1.04	0.81	1.04	0.80	NS	0.20
Thigh meat analysis									
Moisture (%)	75.89[bc]	75.75[c]	76.36[ab]	76.61[a]	76.29[ab]	76.80[a]	76.04[bc]	**	0.52
Protein (%, as-is basis)	21.06	20.50	21.16	21.13	21.02	20.66	21.34	NS	0.55
Fat (%, as-is basis)	2.46	2.31	1.97	1.85	2.14	1.83	2.15	NS	0.57

[a–c]Individual treatment means with the same superscript letter in the same row are not statistically different ($P > 0.05$).
[1]Data for treatment 7 not reported.
[2]Statistical significance of overall *F*-test: NS at $P > 0.05$).
[3]Least significant difference between two means ($P < 0.05$).
**$P < 0.01$.

TABLE 8. Experiment 1: performance, carcass yield of male broilers, and compositional analyses of breast and thigh meat[1]

Parameter	Corn diets: Roundup Ready	Corn diets: Non-transgenic	Variety effect: SSD[2]	Variety effect: LSD[3] (5.0%)
Performance				
Live weight (g/bird), d 0	38.27	38.43	NS	0.76
Live weight (kg/pen), d 0	0.46	0.46	NS	0.01
Live weight (kg/bird), d 42	2.48	2.50	NS	0.12
Live weight (kg/pen), d 42	24.28	24.28	NS	1.54
Feed intake (kg/bird)	3.76	3.86	NS	0.22
Feed intake (kg/pen)	36.82	37.50	NS	1.94
Feed conversion (kg feed/kg gain)	1.52	1.55	NS	0.04
Adjusted feed conversion (kg feed/kg gain)	1.50	1.52	NS	0.03
Carcass yield				
Live weight (kg)	2.38	2.40	NS	0.13
Chill weight (kg)	1.68	1.70	NS	0.09
Chill weight (% of live weight)	70.8	70.8	NS	0.52
Fat pad weight (kg)	0.032	0.036	**	0.003
Fat pad weight (% of live weight)	1.3	1.5	NS	0.16
Breast meat weight (% of chill weight)	25.2	25.2	NS	1.29
Thigh weight (% of chill weight)	17.6	17.5	NS	0.54
Drum weight (% of chill weight)	14.5	14.4	NS	0.39
Wing weight (% of chill weight)	11.6	11.6	NS	0.16
Breast meat analysis				
Moisture (%)	74.68	74.49	NS	1.02
Protein (%, as-is basis)	24.10	24.34	NS	0.76
Fat (%, as-is basis)	0.86	0.93	NS	0.29
Thigh meat analysis				
Moisture (%)	75.79	76.38	NS	0.75
Protein (%, as-is basis)	20.93	20.96	NS	0.86
Fat (%, as-is basis)	2.67	2.06	NS	0.90

[1]Comparison of the Roundup Ready corn event NK603 with the non-transgenic population (variety effect; mean values of males).

[2]SSD = statistical significance of differences.

[3]LSD = least significant difference between two means.

**$P < 0.01$.

weight), drum weight (kg or % of chill weight), and wing weight (kg or % of chill weight) were not different ($P > 0.05$) across treatments (Table 6). No differences were observed in the percentage of moisture, protein, or fat in thigh meat or in the percentage of moisture and fat in breast meat across treatment diets (Table 10). Protein content of breast meat was not different between birds fed diets containing the YieldGard × Roundup Ready corn and four commercial corn lines, however the diets containing the transgenic corn resulted in lower ($P < 0.05$) protein content in breast meat than diets containing the non-transgenic control corn or the Asgrow 740 commercial corn. For all carcass parameters measured in this experiment, no significant gender-by-treatment interactions were observed.

Population Statistical Analysis

In experiment 1, comparison of the data from broilers fed corn containing Roundup Ready corn event NK603 to that of the combined population of non-transgenic control and commercial corn showed no differences in performance parameters or in most carcass yield and meat quality parameters measured. In general, no differences were observed for wing weight measurements between birds fed diets containing Roundup Ready corn, non-transgenic control corn, or commercial corn. Only when wing weight from females was expressed as a percentage of chill weight was a treatment-by-gender interaction significant ($P < 0.05$) among individual diet comparisons, and, therefore, within-gender comparisons were made. In comparing female broilers fed the Roundup Ready corn diets with those fed the population of non-transgenic diets, no differences ($P > 0.05$) were observed for wing weight (Table 9).

The fat pad weights were lower ($P < 0.05$) in the males and females when fed the diet containing Roundup Ready corn versus any of the remaining diets. The fad pad weights as a percentage of live weight among birds fed the diet containing Roundup Ready corn and the population of diets were not different for males ($P > 0.05$), but they were different for females (Tables 8 and 9). Also, the thigh weights as a percentage of chill weight in birds fed the diet containing Roundup Ready corn and the population of control and commercial diets were not different ($P > 0.05$) in the males but were different in the females.

In experiment 2, comparison of the data from broilers fed corn containing YieldGard × Roundup Ready corn to the population of non-transgenic control and commercial corn showed no differences in all performance, carcass yield, or meat quality parameters measured. For all parameters, there were no significant gender-by-treatment inter-

TABLE 9. Experiment 1: performance, carcass yield of female broilers, and compositional analysis in breast and thigh meat[1]

	Corn diets		Variety effect	
Parameter	Roundup Ready	Non-transgenic	SSD[2]	LSD[3] (5.0%)
Performance				
Live weight (g/bird), d 0	38.10	38.23	NS	0.97
Live weight (kg/pen), d 0	0.46	0.46	NS	0.01
Live weight (kg/bird), d 42	2.13	2.14	NS	0.08
Live weight (kg/pen), d 42	21.26	21.29	NS	0.92
Feed intake (kg/bird)	3.34	3.44	NS	0.14
Feed intake (kg/pen)	33.36	34.27	NS	1.54
Feed conversion (kg feed/kg gain)	1.57	1.61	NS	0.05
Adjusted feed conversion (kg feed/kg gain)	1.56	1.60	NS	0.04
Carcass yield				
Live weight (kg)	2.12	2.11	NS	0.10
Chill weight (kg)	1.50	1.50	NS	0.08
Chill weight (% of live weight)	70.9	71.1	NS	0.76
Fat pad weight (kg)	0.036	0.039	*	0.003
Fat pad weight (% of live weight)	1.7	1.9	*	0.13
Breast meat weight (% of chill weight)	25.9	25.7	NS	0.78
Thigh weight (% of chill weight)	17.5	16.9	**	0.35
Drum weight (% of chill weight)	14.1	13.9	NS	0.37
Wing weight (% of chill weight)	11.9	11.7	NS	0.37
Breast meat analysis				
Moisture (%)	74.80	75.02	NS	0.45
Protein (%, as-is basis)	24.12	23.82	NS	0.65
Fat (%, as-is basis)	0.87	0.88	NS	0.41
Thigh meat analysis				
Moisture (%)	76.00	76.24	NS	1.52
Protein (%, as-is basis)	21.20	20.98	NS	1.46
Fat (%, as-is basis)	2.24	2.02	NS	0.54

[1]Comparison of the Roundup Ready corn event NK603 with the non-transgenic population (variety effect; mean values of females).

[2]SSD = statistical significance of differences.

[3]LSD = least significant difference between two means.

$*P < 0.05$; $**P < 0.01$.

actions; therefore, within-gender comparisons were not made for the population comparison (Table 11).

DISCUSSION

The rapidly growing broiler is considered to be sensitive to changes in nutrient quality in diets and, therefore, is a useful model to evaluate the wholesomeness of corn in meal-form diets. The broilers underwent a weight gain of approximately 50- to 60-fold during the 6 wk of these experiments. Any deficiencies in the major dietary nutrients would be expected to reduce growth and carcass yields. Meat protein and fat composition are of key importance to the poultry industry, and changes in meat composition could be a direct effect of reduced bioavailability of the key nutrients in the diet. These experiments demonstrated no differences in nutritional value among diets containing Roundup Ready corn or the combined-trait corn, YieldGard × Roundup Ready, when compared with the respective control or to commercial corn in terms of broiler performance, meat composition, and health.

Clark and Ipharraguerre (2001) recently summarized multiple experiments that assessed the impact of diets containing transgenic corn or soybean on broiler growth and performance. These experiments concluded that the genetically enhanced corn or soybean provided comparable growth, performance, and carcass yields when compared with the conventional counterpart. One of these experiments included Roundup Ready corn event GA21 fed to broilers. It was concluded that final BW and fat pad weights were within the expected range for broilers, and feed conversion was similar to the U.S. industry average (Sidhu et al., 2000).

Results of these current broiler feeding experiments are in agreement with those of Sidhu et al. (2000) and support that there are no relevant differences in the feeding values of Roundup Ready corn containing event NK603 or YieldGard × Roundup Ready corn and their respective non-transgenic controls when fed to broilers. In the few cases for each experiment in which significant differences were observed, the values were not of biological significance because they were similar to variability reported in literature values. For example, in experiment 1, observed minor differences in fat pad weights among individual diets (Table 5) and in the population (Tables 8 and 9) were within ranges (24.2 to 63.2 g fat pad and 1.14 to 3.60% abdominal fat yield) of reported values (Esteve-Garcia and Llaurado, 1997; Kidd and Kerr, 1997; Lei and Van Beek, 1997; Smith et al., 1998; Farranet al., 2000; Peak et al., 2000).

TABLE 10. Experiment 2: moisture, protein, and fat composition of breast and thighs from broilers fed YieldGard × Roundup Ready corn (event MON810 × event NK603), non-transgenic control corn RX730, and commercial corn (mean values of combined males and females)

	Treatment[1]								
	8	7	2	3	4	5	6		
	MON 810 × NK603	RX730	SC1087	SC1140	Asgrow 740	Pioneer 34B23	DEKALB 626	Treatments SSD[2]	LSD[3] 5.0%
Breast meat analysis									
Moisture (%)	75.17	74.98	75.06	75.11	75.02	75.14	75.26	NS	0.27
Protein (%, as-is basis)	23.04[bc]	23.45[a]	23.38[ab]	23.18[abc]	23.43[a]	22.93[c]	23.05[bc]	*	0.38
Fat (%, as-is basis)	0.86	0.83	0.81	0.96	0.96	1.03	0.95	NS	0.22
Thigh meat analysis									
Moisture (%)	76.25	75.84	75.90	75.62	75.54	76.17	75.94	NS	0.58
Protein (%, as-is basis)	20.07	20.74	20.70	21.00	21.35	20.58	20.08	NS	1.23
Fat (%, as-is basis)	2.79	3.07	2.35	3.09	3.08	2.21	2.66	NS	0.96

[a–c]Individual treatment means with the same superscript letter in the same row are not statistically different ($P > 0.05$).

[2]Commercial treatment 1 dropped from analyses.

[2]Statistical significance of overall F-test: NS at $P > 0.05$.

[3]Least significant difference between two means ($P < 0.05$).

*$P < 0.05$.

All mean values for breast meat yield (Table 5) in Experiment 1 were within the reported literature ranges of 0.225 to 0.551 kg for Ross × Ross broilers (Esteve-Garcia and Llaurado, 1997; Kidd and Kerr, 1997; Lei and Van Beek, 1997; Smith et al., 1998). In addition, minor differences in the thigh weights of females (Table 9) in the population comparison of experiment 1 were well within reported ranges of 12.80 to 20.65% carcass yield (Kidd and Kerr, 1997; Peak et al., 2000). Mean values observed for percentage protein in breast meat (Table 10) in experiment 2 were within the range (22.9 to 24.3%) reported by Grey et al. (1983).

TABLE 11. Experiment 2: performance, carcass yield of the broilers and compositional analysis in breast and thigh meat. Comparison of the YieldGard × Roundup Ready (event MON 810 × event NK603) corn with non-transgenic population (variety effect; mean values of combined males and females)

	Corn diets		Variety effect	
Parameter	YieldGard × Roundup Ready	Non-transgenic	SSD[1]	LSD[2] (5.0%)
Performance				
Live weight (g/bird), d 0	42.52	42.16	NS	0.73
Live weight (kg/pen), d 0	0.51	0.51	NS	0.01
Live weight (kg/bird), d 42	2.19	2.16	NS	0.06
Live weight (kg/pen), d 42	21.25	21.04	NS	1.48
Feed intake (kg/bird)	3.68	3.55	NS	0.15
Feed intake (kg/pen)	35.17	34.52	NS	1.25
Feed conversion (kg feed/kg gain)	1.67	1.64	NS	0.06
Adjusted feed conversion (kg feed/kg gain)	1.60	1.61	NS	0.03
Carcass yield				
Live weight (kg)	2.21	2.16	NS	0.10
Chill weight (kg)	1.55	1.53	NS	0.07
Chill weight (% of live weight)	70.7	70.7	NS	0.86
Fat pad weight (kg)	0.036	0.036	NS	0.004
Fat pad weight (% of live weight)	1.6	1.7	NS	0.19
Breast meat weight (% of chill weight)	26.1	25.9	NS	0.36
Thigh weight (% of chill weight)	17.6	17.7	NS	0.44
Drum weight (% of chill weight)	14.4	14.4	NS	0.25
Wing weight (% of chill weight)	11.8	11.8	NS	0.14
Breast meat analysis				
Moisture (%)	75.17	75.09	NS	0.29
Protein (%, as-is basis)	23.04	23.24	NS	0.60
Fat (%, as-is basis)	0.86	0.92	NS	0.24
Thigh meat analysis				
Moisture (%)	76.25	75.84	NS	0.62
Protein (%, as-is basis)	20.07	20.73	NS	1.03
Fat (%, as-is basis)	2.79	2.74	NS	1.09

[1]SSD = statistical significance of differences.

[2]LSD = least significant difference between two means.

The rationale for including grain from numerous commercial corn hybrids in these experiments was to demonstrate the range of broiler performance and carcass characteristics when fed grain from different corn hybrids. For example, in experiment 1 comparing Roundup Ready corn to other corn, significant differences were observed in breast meat measurements among the birds fed the diets containing commercial corn. However, the comparison of the Roundup Ready corn to the commercial corn showed no significant differences (Table 5).

Pairwise comparisons indicated that broilers generally performed and had similar carcass yield and meat composition when fed diets containing Roundup Ready or YieldGard × Roundup Ready corn, their respective non-transgenic control corn, or commercially available corn included in each experiment. As a result, it was concluded that the genetically modified corn containing the glyphosate-tolerant trait or combined glyphosate-tolerant and insect-protected traits were as wholesome for broiler diets as those containing their respective non-transgenic control corn and commercially available corn because it supported rapid growth of broiler chickens consistent with the industry norm. This conclusion is consistent with the evaluation of the composition of the Roundup Ready corn event NK603, which showed that there were no relevant differences in nutritional and compositional properties relative to control and reference corn (Ridley et al., 2002). These data confirm and support the conclusion that genetically modified corn events evaluated are as safe and nutritious as traditional corn.

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