EFFECTS OF DIFFERENT CORN HYBRIDS ON PERFORMANCE PARAMETERS, CARCASS YIELD AND ORGANOLEPTIC CHARACTERISTICS OF BROILERS

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ABSTRACT

A total of 280 straight-run broiler chicks were used to evaluate the feeding value of insect-protected herbicide-tolerant corn. Birds were randomly distributed into four treatments following a completely randomized design. Treatments included were diets with commercial corn, insect-protected herbicide-tolerant corn, insect-protected corn and herbicide-tolerant corn. The results show that the ME content of genetically-modified (GM) corn and commercial corn used in this study were not statistically different. However, birds fed diets with the commercial corn performed better than those fed diets with GM corn. Birds fed diets with any of the GM corn – insect-protected, herbicide-tolerant or combined traits of insect-protected and herbicide-tolerant corn – elicited similar growth and efficiency on feed utilization. The carcass yield and organoleptic characteristics of cooked broiler meat, except for tendernesswere, were likewise similar in all groups . Results indicate that the feeding value of insect-protected herbicide-tolerant corn was equivalent to any of the single trait GM corn, though slightly lower compared to the commercial corn.

Keywords: broiler, genetically-modified corn, herbicide-tolerant corn, insect-protected corn

INTRODUCTION

In livestock and poultry feeding, corn is the primary cereal grain used as energy source due to its high feeding value and palatability. Corn is very rich in highly digestible and easily assimilated carbohydrates. Therefore, the growth and success of livestock and poultry industry depend largely on the availability of corn for feed production. In the Philippines, corn production for the past years has been very erratic. The inconsistent corn production caused by weather changes, soil

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fertility, pests and weeds was aggravated with rising cost of pesticides and herbicides (Querubin *et al.*, 2003). These factors resulted to high prices of corn and feeds, leading to unreasonably low profit of farmers. These led to interest on research and development of varieties of corn that could withstand the factors contributing to the reduction of corn yield.

Through biotechnology, *Bacillus thuringiensis* (Bt) corn is genetically modified to produce a protein that provides the plant protection against the Asian Corn Borer (*Ostrinia furnicalis*). This insect pest is known to cause reduction in the production of corn. In addition, the affected plants are highly susceptible to molds and may lead to production of mycotoxins linked to decreased performance in poultry. With Bt corn, better production and yield are expected to meet the increasing demand for both animal feed and food for humans. Querubin *et al.* (2003) indicated that the Bt corn varieties and the non-Bt corn varieties have the same feeding value or nutritionally equivalent. Morever, the performance parameters measured were not statistically different among broilers fed diets containing transgenic, non-transgenic or commercial corn (Taylor *et al.,* 2003b).

Another corn hybrid developed by Monsanto was the glyphosate tolerant corn. Glyphosate is the active ingredient in non-selective, broad spectrum herbicides that kills plants, thus, providing increased corn yield while lowering herbicide costs (Taylor *et al.*, 2007). Recently, Monsanto Philippines, Inc. combined these two traits, developing insect- protected glyphosate- tolerant corn.

The objectives of this study were to determine the feeding value of insect-protected herbicide-tolerant corn for broilers and to assess the organoleptic characteristics of cooked meat from broilers fed diets with insect-protected herbicide -tolerant corn compared with other genetically modified corn (GM).

MATERIALS AND METHODS

Acquisition of test materials

The genetically modified (GM) corn such as insect protected-herbicide tolerant (MON89034 x NK603), insect protected (MON89034) and herbicide tolerant (NK603), which are isogenic to DK818 were provided by Monsanto Philippines, Inc. The commercial corn and other feed ingredients were purchased from a feedmill in Lipa City, Batangas. The genetic make-up of commercial corn was not identified in this study.

Experimental design, birds and diets

A total of three hundred (300) day-old straight-run chicks (Cobb 500) were group-brooded. After 7 days of brooding, two hundred eighty (280) broiler chicks of almost similar body weight (127-128 g) and health condition were randomly selected and distributed to 28 cages. Four treatments were randomly assigned to the caged birds following a completely randomized design (CRD). Each treatment was replicated 7 times with 10 birds per cage and each cage represented a replicate. The dietary treatments were as follows:

Treatment	Description
1	Diets with commercial corn
2	Diets with insect-protected herbicide-tolerant corn (MON89034 x NK603)
3	Diets with insect-protected corn (MON89034)
4	Diets with herbicide-tolerant corn (NK603)

Diets were formulated to contain 21 and 19% crude protein (CP), and metabolizable energy (ME) of 3050 and 2950 kcal/kg for broiler starter and finisher diets, respectively (Table 1). Each dietary treatment contained 50% corn. The commercial corn in Treatment 1 was replaced with MON89034 x NK603, MON89034 and NK603 in Treatments 2, 3 and 4, respectively. The sources of dietary protein in all diets were primarily from corn and soybean meal. All diets were

Table 1. Feed ingredient composition and calculated nutrient content of diets used in the study.

Ingredients	Percentage in the diets, %		
	Chick booster	Broiler starter	Broiler finisher
Yellow corn	50.00	50.00	50.00
Soya, US	34.00	32.00	27.00
Rice bran D1	3.01	7.26	15.55
Fishmeal, US/analogue	5.00	3.00	2.00
Coco oil	5	4	2
Monodicalcium phosphate	1.10	1.40	1.45
Limestone	1	1.40	1.10
Salt	0.25	0.30	0.30
DL-methionine	0.15	0.15	0.13
Mineral concentrate regular	0.20	0.20	0.20
Vitamin concentrate regular	0.20	0.20	0.20
Coccidiostat	0.02	0.02	-
Polyenzyme	0.05	0.05	0.05
Enzyme for soya (Xylanase)	0.02	0.02	0.02
Total	100.00	100.00	100.00
Calculated nutrient content			
Crude protein, %	22.50	21.30	19.62
Ether extract, %	8.00	7.40	6.36
Crude fiber, %	3.85	4.74	5.45
Calcium (Ca), %	1.00	1.01	0.85
Avail. Phosphorus (AP), %	0.50	0.50	0.50
ME kcal/kg	3150	3050	2950
Lysine, %	1.37	1.25	1.10
Meth + Cystine, %	0.95	0.87	0.79
Threonine, %	1.00	0.88	0.80
Tryptophan	0.27	0.24	0.22

fortified with vitamins, minerals and amino acids to provide the minimum nutrients required by the birds (PHILSAN, 2003).

The chicks were fed commercial chick booster for the first 7 days. Starter diet was provided to birds from 8-28 days of age, and shifted to finisher diet until 42 days of age. A 3-gallon capacity tube feeder was provided in each cage. Birds were fed their respective dietary treatments continuously during the study, water was made available at all times and all cages were provided with 18 h of continuous light daily. The total amount of feed consumed was determined at 28 and 42 days. Birds were weighed by lot at 7, 28 and 42 days of age. The cumulative body weight gain at 28 and 42 days was determined by subtracting the initial body weight from the body weight at each stage of growth. The cumulative feed efficiency was calculated and expressed as the amount of feed required for a kilogram gain in body weight.

Carcass and sensory evaluation

After the feeding trial, representative birds (one male, one female) from each cage were sacrificed. Carcass yield (%) or dressing percentage (%) was expressed as percentage relative to the live weight (g) of bird whereas the abdominal fat (g) was relative to the dressed weight. Two carcasses from each treatment were processed at a time. Organoleptic characteristics of cooked broiler meat were evaluated by 12 trained sensory panelists following the 7-point criteria for sensory evaluation of cooked meat established by the Animal Production and Product Utilization Division, Animal and Dairy Sciences Cluster (ADSC), College of Agriculture (CA), University of the Philippines Los Baños (UPLB).

Metabolism trial

A total of 44 twenty-one day-old male broilers (Cobb 500) were used to determine the ME of broiler starter diets, GM corn and the commercial corn. Birds were randomly distributed to 44 metabolism cages with each cage representing a replicate. Each treatment was replicated 7 times while each kind of corn was replicated 4 times only, due to lack of GM corn. Birds were fed their respective diet with 0.20% Cr_2O_3 for 7 days. Collection of fecal samples commenced on the 4th day. Fecal samples were collected for 4 consecutive days, cleaned from scales and feathers, dried at 70ºC, and ground to pass a 20 mm mesh. Aliquot samples of feeds and feces were subjected to gross energy (GE) and Cr_2O_3 analyses. ME was calculated as follows (Cheeke, 1999):

$$\text{Digestibility} = 100 - \left(\frac{Cr_2O_3 \text{ in feeds}}{Cr_2O_3 \text{ in feces}} \times \frac{\text{GE in feces}}{\text{GE in feeds}} \right) \times 100$$

$$\text{ME} = \text{Digestibility} \times \text{GE of feeds}$$

Chemical analyses

Feed/fecal samples were assayed for proximate analysis, calcium and phosphorus using standard methods described by AOAC (1995). Cr_2O_3 was analyzed using methods described by Stevenson (1962). Gross energy was determined using isoperibol bomb calorimeter (Parr 6200 Calorimeter) standardized with benzoic acid. Assays were conducted at the Animal Nutrition Analytical Service Laboratory, ADSC, CA, UPLB.

Statistical analysis

All data gathered were subjected to analysis of variance (ANOVA) using the general linear model procedures of SAS Software.

RESULTS AND DISCUSSION

Nutrient composition of corn and diets

There were slight variations observed on the components of proximate analysis of corn. As shown in Table 2, proximate analysis showed that both the herbicide-tolerant (NK603) and commercial corn had higher CP content compared to the other GM corn. But the carbohydrate fractions were not statistically different among the GM corn and commercial corn used in this study. This indicates that the slight difference in CP had no great influence on the gross energy (GE) content of the dlfferent corn grains. Nonetheless, the digestibility as well as the ME content were not significantly different among GM corn and the commercial corn. According to Querubin *et al.* (2003)**,** Bt corn varieties have no significant difference in

Table 2. Nutrient composition of corn used in the study.

Parameters	Treatment				% CV
	1	2	3	4	
	Commercial Corn	MON89034 x NK603	MON890 34	NK603	
Proximate Analysis					
Moisture, %	10.44*	11.12	11.76	11.40	4.48
Ash, %	1.42	1.49	1.62	1.52	6.32
Crude Protein, %	8.28	7.36	6.94	8.06	3.94
Crude Fat, %	4.30	4.81	3.80	3.53	6.70
Crude Fiber, %	3.16	3.36	3.31	3.48	6.80
Nitrogen Free Extract, %	72.40	71.86	72.57	72.01	1.22
Mineral Analysis					
Calcium, %	0.09	0.17	0.22	0.17	1.75
Total Phosphorus, %	0.22	0.26	0.25	0.24	7.67
Gross Energy, kcal/kg	3967	3965	3983	4110	19.84
Coefficient of Metabolizability, %	74.54	69.85	68.42	69.67	3.12
Metabolizable energy, kcal/kg	2957	2770	2726	2863	10.06

*means: not statistically different (P>0.05) digestibility and provided similar energy levels as the non-Bt corn. Similar result was reported by Adriano (2005) on glyphosate-tolerant corn.

The broiler starter and finisher diets containing the commercial corn, insect-protected herbicide-tolerant corn, insect-protected corn and herbicide-tolerant corn are shown in Table 3. The differences on the nutritional content of the diets could be attributed to the differences in nutrient composition of the feed ingredients. Corn

Table 3. Nutrient composition of broiler starter and finisher diets used in the study.

Parameters	Treatment				% CV
	1	2	3	4	
	Commercial corn	MON89034 x NK603	MON890 34	NK603	
Starter Diet					
Proximate Analysis					
Moisture, %	10.19*	10.41	10.53	10.03	1.63
Ash, %	7.41	6.85	6.82	6.94	5.96
Crude protein, %	21.26	20.45	21.41	22.25	1.72
Crude Fat, %	7.87	7.54	8.10	7.60	4.95
Crude Fiber, %	3.82	3.79	3.52	4.17	12.10
Nitrogen Free Extract, %	49.45	50.96	49.62	49.01	1.75
Mineral Analysis					
Calcium, %	0.93	0.92	0.88	0.88	9.32
Total Phosphorus, %	0.84	0.83	0.82	0.83	6.31
Gross Energy, kcal/kg	4217	4318	4362	4362	7.55
Coefficient of Metabolizability, %	69.40	69.78	68.87	69.44	2.71
Metabolizable energy, kcal/kg	2927	3013	3004	3029	2.71
Finisher Diet					
Proximate Analysis					
Moisture, %	11.12	11.70	11.28	10.79	1.46
Ash, %	6.27	6.18	6.36	6.42	1.36
Crude protein, %	19.48	19.40	19.64	19.44	3.69
Crude Fat, %	5.12	5.36	4.38	5.40	4.51
Crude Fiber, %	3.61	3.62	3.45	3.56	10.04
Nitrogen Free Extract, %	54.40	53.74	54.89	54.39	1.21
Mineral Analysis					
Calcium	0.80	0.80	0.86	0.90	5.04
Total Phosphorus	0.88	0.79	0.87	0.90	11.04
Gross Energy, kcal/kg	3943	4040	4035	4205	17.99

*means: not statistically different (P>0.05).

was incorporated in the diet at 50% for all diets and there were slight variations on the nutritional composition of GM corn including that of commercial corn. The nutrient composition content of other feed ingredients as listed in PHILSAN (2003) was used in the feed formulation. These variations are still within the acceptable levels for birds to have normal growth. In particular, the coefficient of metabolizability and ME content of broiler starter diets were not statitically different among treatments. Aeschbacher *et al.* (2005) reported that diets with Bt corn had the same nutrient content as those with non-modified corn; the diets formulated were also isonitrogenous and isoenergetic (Rossi *et al.,* 2005). Similar findings of no substantial compositional effects have been reported for insect-resistant (Bt) and conventional corn (Sidhu *et al.,* 2000) and for herbicide-tolerant corn, NK603 (Ridley *et al*., 2002).

Performance of broilers

Body weight and body weight gain

The initial body weight ranged from 127-128 g at 7 days of age and there was no significant difference among treatments (Table 4). At 28 days of age, the birds fed diet with commercial corn were significantly heavier than those fed diet

Table 4. Summary performance of broilers fed diets with different corn hybrids.

Parameters	Treatment				% CV
	1	2	3	4	
	Commercial corn	MON89034 x NK603	MON890 34	NK603	
Body weight, g					
initial^{ns}	128	127	127	128	2.6
28	1346^{a}	1022^{b}	996^{b}	1014^{b}	3.53
42	2316^{a}	2011^{b}	1998^{b}	2001^{b}	3.25
Body weight gain, g					
8-28	1218^{a}	895^{b}	869^{b}	886^{b}	3.91
28-42^{ns}	970	989	1002	987	5.23
8-42	2188^{a}	1884^{b}	1871^{b}	1873^{b}	3.41
Avg. feed consumed, g					
8-28	1686^{a}	1526^{b}	1486^{b}	1509^{b}	3.11
28-42	1941^{a}	1807^{b}	1841^{b}	1808^{b}	4.03
8-42	3627^{a}	3333^{b}	3327^{b}	3317^{b}	2.11
Feed efficiency					
8-28	1.38^{a}	1.71^{b}	1.71^{b}	1.70^{b}	3.87
28-42	2.00^{b}	1.83^{a}	1.84^{a}	1.83^{a}	5.96
8-42	1.66^{a}	1.77^{b}	1.78^{b}	1.77^{b}	3.62

ns: not statistically different (P>0.05)

^{ab}means with different superscripts within row are significantly different (P<0.05).

with GM corn (P<0.05). The variation on the CP content of the commercial corn could have contributed to the improved body weight of birds fed the control diets. There were no significant differences observed on body weight and body weight gain among birds fed diet with GM corn (P>0.05). The average body weight of birds fed diets with insect-protected herbicide-tolerant corn (MON89034 x NK603), insect-protected corn (MON89034), and herbicide-tolerant corn (NK603) at 28 days of age were 1022, 996 and 1014 g, respectively. Similar pattern of growth of birds was observed at 42 days of age. Other studies showed no significant difference on the body weight of broilers fed diets with isogenic and transgenic corn (Rossi *et al.*, 2005) or with different genetically modified corn hybrids (Taylor *et al.*, 2003a). Results suggest that GM corn are nutritionally equivalent and had no negative effect on the body weight and body weight gain of broilers.

<u>Feed consumption</u>

Birds fed diets with commercial corn consumed more feeds than those fed diets with GM corn. The increased feed consumption of birds fed diets with commercial corn could be attributed to the slightly but non-significantly lower ME content of diets, but had caused significant increase on the body weight and body weight gain. On the other hand, birds fed diets with GM corn consumed statistically the same amount of feeds. Similar result was reported by Taylor *et al.* (2003a and 2003b) and Querubin *et al.* (2003).

<u>Feed conversion ratio</u>

Birds fed diets with commercial corn showed better feed efficiency compared to those fed diets with the different GM corn (P<0.05). The increased amount of feed consumed was efficiently utilized causing a corresponding increase in body weight gain. On the other hand, birds fed diets with GM corn required 1.77-1.78 kg of feed to gain a kg of body weight. Similar result was reported by Gaines *et al*. (2001) that commercial corn was more effciently utilized than corn hybrids. On the contrary, Brake and Vlachos (1998) showed that broilers fed transgenic Bt176 corn exhibited a significantly better feed conversion efficiency compared to those fed with conventional corn.

<u>Livability</u>

There was no mortality among birds used in the study (100% livability). All birds were in good health throughout the feeding period. Similarly, Brake and Vlachos (1998) identified no difference on livability of broilers fed Bt and non-Bt corn. Also, Brake *et al*. (2003) reported no significant difference in percentage livability of broilers fed diets with transgenic, isoline and commercial corn.

<u>Carcass yield</u>

There were no significant differences on the dressing percentage, liver weight and abdominal fat observed in broilers fed diets containing the different GM corn and commercial corn (Table 5). Dressing percentage with giblets ranged from 72.20-75.53%. Brake and Vlachos (1998) reported a dressing percentage of 74.36 and 73.94% for transgenic and non-transgenic corn, respectively. Abdominal fat ranged from 1.30-1.83%. Results indicate that neither the commercial corn nor the

Table 5. Carcass yield of finished broilers fed diets with different corn hybrids.

	Treatment				% CV
	1	2	3	4	
	Commercial corn	MON89034 x NK603	MON890 34	NK603	
Dressing percentage^{ns}					
With giblets	74.66	75.53	73.27	72.20	4.48
Without giblets	70.46	70.92	68.88	67.84	5.05
Abdominal fat, %^{ns}	1.30	1.59	1.67	1.83	25.63
Liver, %^{ns}	2.52	2.55	2.43	2.44	18.94
Organoleptic characteristics					
Flavor^{ns}	4.98	5.35	5.63	5.23	12.29
Off-flavor^{ns}	1.54	1.29	1.25	1.33	23.29
Tenderness	5.29^{b}	5.85^{ab}	6.02^{a}	5.85^{ab}	17.33
Juiciness^{ns}	5.15	5.29	5.44	5.31	7.14
General acceptability^{ns}	5.13	5.33	5.19	5.15	7.00

ns: not significantly different (P>0.05)
^{ab}means different superscripts within row are significantly different (P<0.05).

GM corn used in this study had an effect on the carcass quality of broilers, which confirm the report of Taylor *et al.* (2007).

Organoleptic characteristic

There were no significant differences on the organoleptic characteristics of cooked broiler meat among treatments except for the tenderness (Table 5). Cooked meat from broilers fed diets with MON89034 was more tender than those fed diet with commercial corn but not significantly different from those fed diets with other corn hybrids. On the average, cooked meat from broilers fed diets with GM corn were generally acceptable; the flavor, tenderness and juiciness were within the acceptable scores. Results manifest that the GM corn had no detrimental effect on the organoleptic characteristics of broiler meat. Querubin *et al.* (2003) also found no significant difference on the organoleptic characteristics of cooked meat from broilers fed diets with Yieldgard corn.

CONCLUSION

GM corn such as the insect-protected herbicide-tolerant corn (MON89034x NK603), insect-protected corn (MON89034) and herbicide-tolerant corn (NK603) developed by MONSANTO Philippines, Inc. are statistically equivalent in proximate composition but lower in crude protein compared to commercial corn. Crude fat, crude fiber, nitrogen-free extract, calcium, phosphorus and metabolizable energy contents were likewise statistically the same as that of commercial corn. Feeding broilers with diets containing any of the GM corn resulted to non-significant differences on the performance parameters measured such as body weight, body weight gain, feed consumption and feed efficiency (P>0.05). Furthermore, the carcass quality, dressing percentage and the organoleptic characteristics of cooked meat from broilers fed diets with GM corn and commercial corn were not significantly different among treatments, except for tenderness. Results suggest that insect-protected herbicide-tolerant corn and other GM corn used in this study were nutritionally comparable to commercial corn and elicited no detrimental effect on the growth performance of broilers.

REFERENCES

Adriano RA. 2005. Metabolizable energy content of glyphosate-tolerant corn in broiler chicken. *Undergraduate Thesis*. University of the Philippines Los Baños.

Aeschbacher K, Messikommer R, Meile L and Wenk C. 2005. Bt176 corn in poultry nutrition: Physiological characteristics and fate of recombinant plant DNA in chickens. *Poult Sci* 84:385-394.

Association of official analytical chemists (AOAC). 1995. Official method of analysis. Cunnif. P. (ed) Virginia: AOAC International.

Brake J, Faust MA and Stein J. 2003. Evaluation of transgenic event Bt11 hybrid corn in broiler chickens. *Poult Sci* 82: 551-559.

Brake J and Vlachos D. 1998. Evaluation of event 176 *"Bt"* corn in broiler chickens. *Poult Sci* 77: 648-653.

Cheeke PR. 1999. *Applied Animal Nutrition: Feeds and Feeding* (2^{nd} ed). New Jersey: Prentice-Hall Inc.

Gaines AM, Allee GL, and Ratliff BW. 2001. Nutritional evaluation of Bt (Mon810) and roundup ready corn compared with commercial hybrids in broilers. *Poult Sci* 80 (Suppl. 1):51. (Abstr.)

PHILSAN. 2003. *Feed Reference Standards. (*3^{rd} ed). Philippine Society of Animal Nutritionists.

Querubin LJ, Bantoc CDQ, Centeno JR, Dahilig DR and Carandang NF. 2003. Feeding value for broiler of two YieldGard (YG) corn hybrids versus their isogenic counterparts treated with and without insecticide. *Philipp J Vet Anim Sci* 29 (2): 84-96.

Ridley WP, Sidhu RS, Nemeth MA, Breeze ML and Astwood JD. 2002. Comparison of the nutritional profile of glyphosate-tolerant corn event NK603 with that of conventional corn (*Zea mays* L.). *J Agric Food Chem* 50 (25): 7235-7243.

Rossi F, Morlacchini M, Fusconi G, Pietri A, Mazza R and Piva G. 2005. Effect of Bt corn on broiler growth performance and fate of feed-derived DNA in the digestive tract. *Poult Sci* 84: 1022-1030.

Sidhu RS, Hammond BG, Fuchs RL, Mutz JN, Holden LR, George B and Olson T. 2000. Glyphosate-tolerant corn: The composition and feeding value of grain from glyphosate-tolerant corn is equivalent to that of conventional corn (*Zea mays* L.). *J Agric Food Chem* 48: 2305-2312.

Stevenson AE. 1962. Measurement of feed intake by grazing cattle and sheep. VIII. Some observation in the accuracy of the chromic oxide technique for the estimation of faeces output in dairy cattle. *New Zeal J Agr*.

Taylor ML, Hartnell GF, Riordan SG, Nemeth MA, Karunanandaa K, George B, and Astwood JD. 2003a. Comparison of broiler performance when fed diets containing grain from Roundup Ready (NK603), Yieldgard X Roundup Ready (MON 810 × NK603), non-transgenic control, or commercial corn. *Poult Sci* 82: 443-453.

Taylor ML, Hyun Y, Hartnell GF, Riordan SG, Nemeth MA, Karunanandaa K, George B, and Astwood JD. 2003b. Comparison of broiler performance when fed diets containing grain from Yieldgard rootworm (MON863), Yieldgard plus (MON 810 × MON 863), nontransgenic control, or commercial reference corn hybrids. *Poult Sci* 82:1948-1956.

Taylor ML, Lucas D, Nemeth MA, Davis S and Hartnell G. 2007. Comparison of broiler performance and carcass parameters when fed diets containing combined trait insect-protected and glyphosate – tolerant corn (MON 89034 X NK60), control corn or conventional reference corn. *Poult Sci* 86:1988-1994.