Effect of different corn hybrids on the growth performance, survival and carcass yield of broilers - a review

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Journal of Livestock Science (ISSN online 2277-6214) 14: 224-232
Received on 11/5/23; Accepted on 5/7/23; Published on 25/7/23
doi. 10.33259/JLivestSci.2023.224-232

Abstract

The most popular energy source in commercial animal diets worldwide is corn which has a consistent and high nutritional value when it comes to livestock feeding. However, there are concerns about how nutrient variability can be affected by major factors such as genetics, agronomic conditions, proximate composition, and pre- and post-harvest processing. Agricultural biotechnology has led to the creation of several new crop plant varieties with better qualities like pest resistance, herbicide tolerance, and higher quality traits. The purpose of this article was to assess the safety, carcass yield, and growth performance of broilers fed with corn hybrids. According to the review, there were no significant differences between all parameters in broilers fed transgenic or non-transgenic corn across different studies. Lysine corn, on the other hand, was considered a major factor because of its higher-than-average Lys content which resulted in improved or similar results for all parameters thus it is thought to be as healthful as and more nutrient-dense than regular maize.

Keywords: Broiler; Corn hybrid; Lysine; Agricultural biotechnology

Introduction

Corn is the most widely used energy source in commercial animal diets especially in the United States, Asia, and Southern Europe, wherethe primary cereal for poultry feed is corn grain (Larbier*et al*., 1994). Corn can provide up to 65% metabolizable energy and 20% protein in poultry diets due to its high dietary inclusion rate (Melo-Durán, 2021). It has a consistent and high nutritional value for livestock, but its feeding value varies greatly (Summers, 2001; Cowieson, 2005). Major factors affecting nutrient variability include genetics, agronomic conditions, proximate composition, and pre- and post-harvest processing. Genetics has been shown to be an important source of biochemical and nutrient variability among these (Uribelarrea*et al*., 2004; Reynolds *et al*., 2005). Each genotype has its own phenotypic characteristics, such as grain-filling duration, which is linked to physiological maturity, kernel composition, growth rate, and moisture, all of which can affect the nutrient value. Protein solubility, zein content, amylose to amylopectin ratio, and vitreousness are the main differences in corn composition (Gehring *et al*., 2013).

With the help of agricultural biotechnology, this has resulted in the development of a number of new crop plant varieties with improved characteristics such as pest resistance, herbicide tolerance, and improved quality traits (Brake *et al*., 2003). In 1996, the first commercial plantings of insect-protected field corn hybrids using the "Bt" genetic modification, known as "Event 176," took place. Cry1Ab, an insecticidal protein produced in nature by certain subspecies of the common soil bacterium Bacillus thuringiensis, is expressed in these corn hybrids (Bt) (Koziel*et al*., 1993). Aside from Cry1Ab, a second novel protein, phosphinothricin acetyltransferase is expressed in Event Bt11 field corn. Anactive component foundin Liberty herbicide, phosphinothricin, is inactivated by this protein. Liberty is a corn-specific postemergence herbicide that has been approved for use. Corn plants expressing the phosphinothricin acetyltransferase protein, unlike most weeds in corn fields, are unaffected by Liberty herbicide when applied according to the manufacturer's instructions.

Another new transgenic corn event has also been developed that exhibits broad-spectrum lepidopteran insect resistance (Brake *et al*., 2005). This "Pacha" event expresses VIP3A, a novel pesticidal protein with activity against several lepidopteran species, including but not limited to Helicoverpazea, Spodoptera frugiperda, and Agrotisipsilon, which can all cause significant economic damage to corn production. Efforts are in progress for increasing the ecological and food value of meat of broiler and meat products (Tedtova et al, 2019).

This study aims to determine the differences on growth performance, survival, and carcass yields in broilers between different corn hybrids.

Effects of Different Hybrids on Growth Performance

GM crops have generated questions from the general public and scientists regarding the safety of the environment and food, despite the possible advantages afforded by biotechnology to increase food quality (Conner *et al*., 2003). The unknown effects that newly inserted sequences may have on the organism are among the main concerns with the use of GM organisms in human and animal feeding (Beever and Kemp, 2000).Many elements, including genetics and environmental variables, can affect the nutritional makeup of corn. The high heritable parameters, such as kernel weight, volume, endosperm type, degree of damage, density, and kernel breakage, can be influenced by genetic selection in different ways (Melo-Durán et al., 2021). Variations in a corn's nutritional and anti-nutritional components can also result from genetic diversity (Reynolds et al., 2005). The anti-nutritional factors of corn, such as non-starch polysaccharides (NSP), may interact with important nutrients, lowering their availability and lowering the digestibility and performance of birds as a result. The effect of different hybrids on growth performance was shown in table 1.

The Cry1Ab protein used in Event 176 “bt” hybrid corn is toxic only to the larvae of the European Corn Borer (ECB) and a few other lepidopteran species, but not to other insect orders, animals, or humans. Since 1938, commercial Bt formulations have been used as topical insecticides, and Bt-based products have been approved for use on food crops in the United States since 1961. The hybrid number 5506BTX, generated from Event 176, was produced in 1994 in Bloomington, Illinois wherein it was utilized to produce the transgenic corn grain.

At any point (14, 28, or 38 days), there were Males developed faster than females, as was predicted, and broilers fed pelleted diets grew faster than those provided mash diets. (Brake *et al*., 1993). The birds that consumed diets containing transgenic corn showed better-adjusted feed conversion ratios. It cannot be said that the meals generated from transgenic and nontransgenic corn were similar despite attempts being made in this work to correct the diets for observed slight discrepancies in maize source with regard to total protein. It was not possible to formulate the corresponding transgenic and nontransgenic corn diets in such a way that they would be identical with respect to all other measured components due to the small differences in percentage moisture and total protein of the corn sources and the efforts to account for the difference in total protein when formulating the diets. As a result, the higher feed conversion ratios cannot be directly linked to the corn source. However, these findings do not demonstrate any negative consequences of transgenic corn diets when compared to nontransgenic corn diets. Although it is commonly accepted that a pellet diet promotes chicken development, several studies have found no difference in performance between chickens fed a pellet or mash diet.

Table 1. The effect of different hybrids on growth performance

Type of corn hybrids	Growth performance	Source
Event 176 "bt" hybrid corn, transgenic 5560BTX corn and nontransgenic G4665	no statistically significant differences in BW between the transgenic (5506BTX) corn-fed birds and nontransgenic (G4665) corn-fed birds. The diet's maize content did not have any statistically significant interaction between corn content with any major impacts (feed form or sex).	Brake and Valchos (1999)
transgenic Event Bt11 hybrid corn	broilers fed diets containing Bt maize were somewhat heavier at the finish than broilers fed the non-Bt isoline control hybrid.	Piva *et al*. (2001)
transgenic Event Bt11 hybrid corn	Bt hybrids had no effect on broiler final BW or BW gain.	Brake *et al*., 2003), and Miralese*t al*., (2000)
isoline N7070, transgenic N7070Bt, and N7070Bt + Liberty corns, NC2000	no differences in the BW of any of the chicks placed in the research at hatch or placement. Due to the underwhelming performance of broilers fed the NC2000 diets, corn source had a significant impact on FCR during the starter period, finisher period, and for the overall results (0 to 42 d). The NC2000 diets did not appear to be as well-tolerated as the N7070 series diets. The NC2000 diet may have had lower-quality pellets, which would have reduced feed intake, or it could have been more hygroscopic at the time of the trial which was during the humid summer climate, or both.	Brake *et al*. (2003)
Transgenic hybrid VIP3A and isogenic (isoline) conventional hybrid	There was no difference in body weight (BW) among groups of chicks in the study conducted. Males weighed significantly more than females at the age of 21 days, as was to be expected, indicating the impacts of sex. Between 21 and 49 days of age, there were statistically significant BW variations related to corn source. At 35 days of age, the BW of the birds given the VIP3A and isoline corn-based diets was numerically higher.	Brake *et al*., (2005)
DP-Ø9814Ø-6, maize (*Zea mays* L.) plants (98140, Optimum GAT).	The body weights and weight gain of broiler chickens fed diets made with grain from the 98140 (unsprayed or sprayed), non-transgenic near-isogenic control, or reference maize sources did not differ biologically from those of the chickens fed the diets from the other sources.	McNaughton *et al*. (2008)
DP202216 diet	did not substantially vary in terms of BW, weight growth, or mortality adjusted FCR	McNaughton *et al*. (2020)
The grain from the 98140 (unsprayed or sprayed), nontransgenic near-isogenic control	did not differ biologically from those of the chickens fed the diets from the other sources. No differences in carcass yields or performance measures between broiler-fed diets containing maize grain from non-transgenic near-isogenic control, unsprayed transgenic event Bt11, or transgenic event Bt11 in either case.	Brake and Vlachos, 1998; Sidhu *et al*., 2000; Taylor *et al*., 2003; Brake *et al*., 2005; McNaughton *et al*., 2007
hybrid Roundup Ready Corn (NK603) and the combined features of glyphosate-tolerant corn event NK603 and insect-protected YieldGard corn (MON 810).	there were no differences in the performance metrics that were assessed. The treatments had similar live weight at day 0-42, total feed intake, and feed conversion.	Taylor *et al.* (2003)
Roundup Ready corn, the combined-trait corn, and YieldGard Roundup Ready	no changes in the nutritional value of diets. BW and fat pad weights for broilers were within the predicted ranges	(Sidhu *et al*., 2000)
MON 810 combined with MON 88017	Performance measures assessed in broilers showed no differences compared to those fed a standard control diet and commercial maize	Taylor *et al*. (2005)
LY038 or LY038 MON 810	The rate of weight gain and feed efficiency of broilers fed diets containing control and conventional reference maize supplemented with Lys compared with their non-supplemented Lys-deficient counterparts for days 0 to 21, days 21 to 42, and days 0 to 42, respectively, demonstrated differences in the growth responsiveness of broilers to Lys.	Lucas *et al*. (2007)
Corn hybrid Event DP-2-2216-6 maize (DP202216) has a ZMM28 gene	have the same composition as regular maize. Broiler chickens' rapid development rate makes them particularly susceptible to nutritional deficiencies and antinutrients in their diet	Herman and Ekmay, 2014

The results of the current study showed that pellet diets increased laying rate, feed intake, egg albumen quality, and apparent digestibility of laying hens, which in turn enhanced production performance and nutrition metabolism (Wan *et al*., 2021). The decreased mycotoxin levels in this corn may have contributed to the broilers' improved performance when fed Bt-containing diets but other studies (Halle *et al*., 1998; Miralese*t al*., 2000; Piva *et al*., 2001; Taylor *et al*., 2001) suggest no differences when it comes to FCR.

During the starting phase (0 to 21 days), corn supply significantly impacted FCR, but this impact was not noticeable as the animals aged. At 21, 35, and 49 days of age, males` had considerably higher adjusted FCR than females. As was discovered in this study, it is widely known that males have a higher FCR than females (Brake and Vlachos, 1999). For the cumulative FCR through 49 days, there was a sex and corn source interaction. This interaction resulted from males receiving VIP3A and isoline having superior FCR than males receiving NC 1999 and NC 2000, although there were no changes in the FCR of the females. It cannot be said that the dietsgenerated from transgenic and nontransgenic corn were similar despite attempts being made in this work to correct the diets for observed slight discrepancies in maize source with regard to total protein. There are no overtly harmful consequences connected to meals derived from transgenic maize when compared to diets prepared from nontransgenic corn.

DP-Ø9814Ø-6 rearranging the genes in the isolated gat4621 gene from *Bacillus licheniformis*, the glyphosate acetyltransferase enzyme's kinetics for acetylating glyphosate were enhanced (Castle *et al*., 2004; Siehl*et al*., 2005). Tolerance to the herbicide glyphosate is conferred in plants by the GAT4621 protein, which is encoded by the gat4621 gene. By preventing the inhibition of acetolactate synthase, an enzyme necessary for the production of branched-chain amino acids, the ZM-HRA protein, which is encoded by the zm-hra gene, imparts tolerance to herbicide. The stable insertion of two gene cassettes encoding *Agrobacterium* sp. 5-enolpyruvylshikimate-3-phosphate synthases led to the development of the Roundup Ready corn event NK603. The CP4 strain (CP4 EPSPS) confers resistance to glyphosate, the main component of Roundup herbicide. The Roundup Ready corn event GA21 expresses a modified corn EPSPS (mEPSPS), in contrast to event NK603 (Sidhu *et al*., 2000). *Agrobacterium* species' cp4 epsps genes. A single polypeptide of 455 amino acids makes up the 47.6 kDa proteins that strain CP4 encodes (Padgette*et al*., 1996). While functionally identical to plant EPSPS enzymes, the CP4 EPSPS proteins have a significantly lower affinity for glyphosate. In the literature, a thorough analysis of the CP4 EPSPS protein's safety has been detailed (Harrison *et al*., 1996). In addition to producing the Cry1A(b) protein, the combination trait YieldGard (event MON810) and Roundup Ready (event NK603) maize also gives insect protection from the European corn borer (Ostrinianumbilalis). The Cry1A(b) protein from *Bacillus thuringienisis* subsp. was added to YieldGard corn. HD-1 strain of the kurstaki (Sanders *et al*., 1998). The two single-trait products with transgene origins were traditionally bred to create YieldGard and Roundup Ready corn.

Several studies evaluating the effects of diets including transgenic corn or soybean on broiler development and performance were recently compiled by Clark and Ipharraguerre (2001). Corn hybrids can also improve lysine deficiency. This is typical in corn gluten meal, animal protein products, and other protein supplements used in maize-soybean meal-based broiler diets. This necessitates lysine supplementation for optimum bird performance and carcass features (NRC, 1994; Kidd *et al*., 1998; Corzo*et al*., 2002, 2006). By boosting the quantity of Lys in maize grain, the creation of Lys maize (LY038) through the use of biotechnology offers an alternative to directly adding extra Lys to chicken diets. By permanently integrating the cordapA coding sequence under the control of the maize Glb1 promoter into the maize genome, the Corynebacterium glutamicum-derived Lys feedback insensitive dihydrodipicolinate synthase (cDHDPS) protein was directed to be expressed primarily in the germ region of maize kernels, giving rise to lysine maize (also known as LY038 or LY038 MON 810). (Belanger and Kriz, 1991; Falco*et al*., 1995; Galili, 2002).According to earlier research, increased amounts of lysine supplementation in broiler diets were responsible for higher body weight gain and better feed conversion ratio (Viola *et al*., 2009). These findings concur with Corzo*et al*.'s (2002) results that broiler chicken FCR was improved by increasing dietary lysine concentrations.

Plants with greater grain yield potential arise from the prolonged and increased expression of the ZMM28 protein (Wu *et al.*, 2019). Phosphinothricin acetyltransferase (PAT) protein, which is extensively expressed in marketed genetically modified (GM) crops, confers glufosinate tolerance (Hérouet*et al*., 2005). The DP202216 maize has already been discovered to have the same composition as regular maize (Anderson *et al*., 2019). GM maize plants (McNaughton *et al*., 2007, 2008, 2011; Herman *et al*., 2011), which showed that groups of broilers fed diets containing either GM grain or non-GM near-isogenic control grain experienced comparable growth performance. High amounts of maize grain in their diet will be helpful due to the fact that weight growth and death are sensitive markers of dietary quality changes (ILSI, 2003).

Effects of Different Hybrids on Survival

All corn hybrids used had no effect on the health of the broilers. According to Taylor *et al* 2003's analysis, male broilers with a random distribution among diet corn source groups had a higher death rate. No significant differences were observed for event 176 “Bt” corn, Bt11, and VIP3A corn when compared to nontransgenic corn diets. The males in Bt11 and VIP3A had higher mortality rates than the females due to their more rapid growth and they can also be more prone to heat stress which can be another factor. The effect of different hybrids on survival was shown in Table 2.

Effects of Different Hybrids on Carcass Yield

Transgenic corn event 176, Bt11, and VIP3A all had a higher pectoralis minor yield when compared to nontransgenic corn which can be caused by the decrease in mycotoxin levels for the Bt maize used in their respective experiments. MON 810 x NK603 and MON 88017 x MON 810 had no significant differences seen when compared to commercial corn together with DP202216 corn. 98140 corn showed no significant differences for kidney and liver yields for male broilers. However, females had higher overall liver yields when compared to the control diet group. LY308 or lysine maize showed significant differences when it came to carcass yields. LY308 had increased yields in total carcass parts with the inclusion of breast, wings, and drums in comparison with Lys-deficient reference corn.

When several factors are evaluated, a proportion of them should change between treatment groups by chance; this percentage shouldn't be used as evidence of repeated effects with biological, and most definitely not with practical, importance. Prior research suggested that birds fed Bt-containing diets would produce more pectoralis minor than isoline control hybrids (Brake and Valchos, 1999); however, a number of other studies (Brake *et al*., 2003; Taylor *et al*., 2003) found no appreciable differences in carcass yield and composition when it comes to broilers fed with Bt and nonBt corn.

Table 2. The effect of different hybrids on survival

Type of corn hybrids	Survival/mortality	Source
transgenic maize (event 176) and those fed non transgenic corn diets	At any age, there were no statistically significant differences in the proportion of surviving and o statistically significant interactions, changes owing to feed type (pellet vs. mash), or sex.	Brake and Valchos (1999)
Bt11 hybrid corn (N7070 isoline, and the conventional NC2000 corn diets)	at any age, there were no appreciable differences in the proportion of surviving	Brake *et al*. (2003)
VIP3A corn	At any age, there were no statistically significant differences in the total percentage mortality between the birds fed the transgenic corn diet and those on one of the three nontransgenic corn diets.	Brake *et al*. (2005)
control hybrids and Bt-fed	no differences broilers in terms of mortality	(Brake and Vlachos, 1999; Brake *et al*., 2003)
DP-Ø9814Ø-6 (sprayed or unsprayed)	no significant differences in mortaility when compared to nontransgenic near-isogenic control, or reference maize sources.	McNaughton *et al*. (2008)
Roundup Ready Corn (NK603) and the combined features of glyphosate-tolerant corn event NK603 and insect-protected YieldGard corn (MON 810)	Mortality varied from 1 to 4% among treatments and averaged 2.6% from day 7 until trial conclusion. The most of the apparent causes of mortality in both experiments between days 7 and 42 were assigned to abrupt death and ascites, which occur often in broilers. The surviving broilers were all in good health.	Taylor *et al*. (2003)
MON 88017	Mortality was an average rate of 3.5%. Bacterial infection, dehydration, rejection of feed, or ascites were the main reasons of mortality during the first 7 days, while abrupt death and ascites, which are prevalent in broilers, were the main causes of death between days 8 and 42 which is also similar to the previous hybrid (NK 603 x MON 810).	Taylor *et al*. (2005)
LY038 or LY038 MON 810	had no negatice effects on mortality. The death rate from days 7 to 42 was also low and unrelated to treatment, averaging 1.1% and ranged from 0% to 2% across all regimens	Lucas *et al*. (2007)
DP202216 diet and broilers on the control diet	no discernible difference in mortality. Mortality percentage for DP202216 and control maize were identical with both having 4.17%	McNaughton *et al*. (2020)

Table 3. The effect of different hybrids on carcass yield

Type of corn hybrids	Carcass yield	Source
transgenic maize (event 176)	the breast skin and Pectoralis minor yield in the birds fed the transgenic corn diets significantly increased	Brake and Valchos (1999)
mash feed, the pelleted	the males produced a larger proportion of legs, whereas the females produced a higher percentage of fat pad, breast skin, and P. minor	Brake *et al*., (1993)
Corn hybrid Bt11	Higher pectoralis minor yield for birds fed diets containing Bt vs. isoline control hybrids may have been due to decreased mycotoxin levels for Bt maize in their experiment.	Brake *et al.* (2003), Taylor *et al*. (2001)
corn hybrid VIP3A	no effect on carcass yield of males and females except for percentage wings	Brake *et al.* (2005)
Bt related corn hybrid 98140	For carcass or individual component yields, there were no statistically significant variations	McNaughton *et al.* (2008)
Corn hybrid Roundup Ready Corn (NK603) and the combined features of glyphosate-tolerant corn event NK603 and insect-protected Yield Gard corn (MON 810)	The carcass measures of the final live weight, the chill weight, the breast meat, the thighs, the drums, and the wings did not differ between treatments.	Taylor *et al.* (2003)
MON 88017 or MON 88017 MON 810	the carcass yield measures of the chill weight, fat pad, breast, thigh, drum, and wing weights across treatments, no changes were found. Only one variable—thigh weight (kg)—showed evidence of a diet by gender interaction. The proportions of moisture, protein, and fat in the meat from the breast and the thighs were the same.	Taylor *et al.* (2005)
GM maize grain (DP202216)	no statistically significant changes for carcass, individual component, or liver yields	McNaughton *et al.* (2020)
LY038 or LY038 MON 810 grain	Both meat composition (moisture and protein, but not fat) and carcass yield measurements (chilled carcass, fat pad, breast, drum, and wing weight, but not thigh weight) responded to a calculated 0.079% Lys addition to starter and grower-finisher diets containing less total Lys than necessary for the best bird performance and carcass quality.	Lucas *et al.* (2007)

According to Carew *et al*. (2005), liver and kidney yields are indications of broiler health caused by dietary deficiencies or the presence of antinutritional agents (Bailey *et al*., 2000; Farran*et al*., 2005). Measures of organ weights are frequently used as health indicators in nutritional performance tests of transgenic grains in other species, such as rats (Hammond *et al*., 2004; MacKenzie*et al*., 2007; Malley *et al*., 2007). Kidney yields were not substantially different between the control, 98140, or 98140 + Spray test diet groups. In the control and 98140 test diet groups, there were no appreciable differences in overall liver yields or liver yields for male broilers. However, liver yield was higher among females. The organ yield findings in this study are consistent with those of earlier studies, wherein biologically significant differences in organ yields were not found when it comes to broilers fed diets prepared with feed fractions (McNaughton *et al.*, 2007) or transgenic grain (McNaughton *et al*., 2007) and those that were fed diets with grain or feed fractions from nontransgenic controls.

The values in the few instances where discrepancies were noted matched those published in the literature (Taylor *et al*., 2003). The grain from the genetically modified corn products assessed in this study is nutritionally equal to grain from the control and commercially available corn references in broiler diets, it was determined. This result is in line with the compositional analysis of genetically modified maize expressing the Cry1Ab, CP4 EPSPS, or Cry3Bb1 proteins, which revealed no appreciable alterations in the nutritional and compositional features compared to control and commercial corn (Sanders *et al*., 1998, Ridley, *et al*., 2002, and George, *et al*., 2004). These findings support the idea that MON 88017 grain, whether consumed on its own or with MON 810 maize, is just as nutrient-dense as conventional corn.

Studies on the nutritional efficacy of GM maize in other species, such as rats, frequently include measurements of organ weight (Hong *et al*., 2017). Because of food deficiencies or the presence of antinutritional substances, liver and kidney yields may suggest consequences on broiler health (Farran*et al*., 2005; Olajide, 2012; Farshid and Alibeyghi, 2017).Khwatenge*et al*. (2020) suggests that early body developmental issues caused by slowed growth and lessened muscular development, as well as high mortality, are signs of low lysine content. There is evidence supporting Benevenga and Blemings' 2007 finding that lysine contributes to the early development of avian and mammalian animals.

Conclusion

This investigation was conducted to see if broiler chicken performance will differ significantly between diets produced with different types of transgenic and nontransgenic maize. In broiler diets, grain from the genetically modified corn products tested in different studies that contained insect-protected characteristics was nutritionally equivalent to grain from the corresponding nontransgenic control corn and commercially available corn hybrids. All hybrid corns in this study exhibited no negative effects on growth performance, survival, and carcass yields. The addition of lysine in corn hybrids had positive effects which improved almost all parameters that were tested. The higher performance of broilers compared to that of broilers fed control or traditional reference grain diets without supplementary Lys but otherwise comparable in composition revealed enhanced growth, feed efficiency, and carcass output due to the increased level of accessible Lys. There were no unforeseen consequences on the health or performance of the birds. As a result, when fed to broilers, transgenic corn hybrids can be regarded as equally healthy as normal corn.

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