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Performance Response of Broiler Chickens to Dietary Maize Stover with Mycotoxin Binder (Toxidex®) Inclusion

By

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Abstract

A 49-day feeding trial was conducted to evaluate the performance, carcass characteristics, and haematological responses of broiler chickens fed maize stover-based diets supplemented with a mycotoxin binder (Toxidex®) as a partial replacement for yellow maize. A total of 144 day-old Abor Acre broiler chicks were randomly assigned to six dietary treatments in a Completely Randomised Design (CRD). Each treatment had three replicates of eight birds per replicate. The diets were formulated to contain 0% (control), 5%, 10%, 15%, 20%, and 25% maize stover, each supplemented with Toxidex®. Birds were fed and watered ad libitum throughout the experimental period. Data were collected on feed intake, weight gain, and feed conversion ratio (FCR). Blood samples were analysed for haematological parameters following standard laboratory procedures. The results showed a significant ($P < 0.05$) difference in body weight and carcass characteristics among treatment groups. Birds fed the 15% maize stover diet supplemented with Toxidex® recorded the best FCR (2.42), highest live weight (1703.33 g), and dressed weight (1166.67 g). Haematological parameters were generally not significantly affected ($P > 0.05$), except for packed cell volume (PCV). The highest mean corpuscular haemoglobin (MCH) value (34.66 pg) was observed in birds fed the 25% maize stover diet. In conclusion, maize stover supplemented with Toxidex® can effectively replace up to 15–20% of dietary yellow maize in broiler diets without negative effects on growth performance, carcass yield, or haematological indices, likely due to the mycotoxin-binding capacity of phyllosilicates in Toxidex®.

Keywords: *Broiler Chicken, Maize Stover, Mycotoxin Binder (Toxidex®)*

INTRODUCTION

Mycotoxins are toxic secondary metabolites produced primarily by fungal species such as *Aspergillus*, *Fusarium*, and *Penicillium*, which commonly contaminate poultry feed ingredients, especially under poor storage and environmental conditions (Smith et al., 2016). Among these, aflatoxins produced by *Aspergillus flavus* and *A. parasiticus* are of major concern due to their high toxicity and prevalence in tropical regions. Mycotoxin contamination poses a significant threat to animal health and food safety, as residues may accumulate in edible animal products and enter the human food chain (Tolosa et al., 2020).

Although poultry and swine are generally considered less sensitive to aflatoxins than ruminants due to their ability to excrete mycotoxins to a certain extent, several studies have documented deleterious effects of mycotoxins in broiler chickens. These include reduced feed intake, poor body weight gain, impaired feed conversion ratio, and compromised production efficiency (Elarousi et al., 2006; Rahendran et al., 2020). Furthermore, mycotoxins adversely affect poultry health by altering haematological and biochemical indices and suppressing immune function, thereby increasing susceptibility to diseases.

To mitigate the negative effects of mycotoxins in poultry diets, various strategies have been employed, among which the use of toxin binders remains the most widely adopted and effective. Toxin binders are inert adsorbents capable of binding mycotoxins in the gastrointestinal tract, thereby reducing their bioavailability and subsequent absorption into the bloodstream (Rahendran et al., 2020). Products such as Toxidex® are commercial mycotoxin binders designed to minimize the toxicological impact of contaminated feed in monogastric animals.

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On the other hand, maize stover—the residue remaining after harvesting maize (*Zea mays* L.) for grain—has gained attention as a potential alternative feed resource in poultry production. It comprises various plant parts including stalks (40–60%), leaves (20–30%), cobs (15–20%), and husks (10–15%) (Lizotte et al., 2015). Although maize stover is fibrous and relatively low in crude protein (ranging from 2.5% to 6.3%), it has notable energy content (approximately 9 MJ ME/kg dry matter) and moderate palatability (Tona et al., 2013). Its widespread availability in maize-producing regions makes it a promising candidate for inclusion in poultry diets, especially under resource-limited conditions.

However, one of the limitations of using maize stover in poultry feeding is its susceptibility to fungal contamination and aflatoxicosis, particularly when stored under inadequate conditions. Additionally, its low crude protein content may limit its inclusion level without nutritional supplementation. Despite these challenges, only a fraction (less than 50%) of maize stover is actually consumed by livestock, while the rest is wasted through trampling, termite infestation, and soiling (Munthali et al., 2000).

Processing techniques and dietary supplementation strategies—such as the inclusion of toxin binders—may enhance the utilization of maize stover and reduce its inherent risks. Therefore, this study was designed to evaluate the growth performance, carcass characteristics, and haematological indices of broiler chickens fed diets containing maize stover supplemented with a mycotoxin binder (Toxidex®).

MATERIALS AND METHODS

Experimental site

The experiment was carried out at the Poultry Unit of the Teaching and Research Farm, Michael Okpara University of Agriculture, Umudike, Abia State, Nigeria. The area falls within the tropical rain forest zone with an annual rainfall of 2177mm, a temperature range between 20-30^{o}C °C, and with relative humidity of 50-59%, depending on season (NRCRI, 2020).

Source and processing of maize stover

Maize stover was collected from a maize farm in Isiala Ngwa North L.G.A. of Abia State after harvesting was concluded. The stover was chopped into smaller sizes (2-4cm) and sundried. It was taken to the local mill, where it was ground for incorporation in the diets for the experiment. Ingredient such as maize, soyabean meal, groundnut cake, fish meal(Danish), palm kernel meal, bone meal, oyster shell, vitamin/mineral premix, salt, methionine, lysine and Toxidex® were procured from a commercial dealer. The Toxidex® is a broad-based mycotoxin binder. It is a product of DEX IBERICA from Spain. Its composition includes: phyllosilicate 800g, surfactant 100g and mycotoxin destroyer complex 100g and the inclusion level was 0.1%.

Experimental birds and management

A total of 144-day-old Abor Acre broiler chickens (DOC) were procured from Agrited® farms for the experiment. The initial weight of the birds was taken and randomly divided into 6 treatment groups with 8 birds per replicate, comprising 24 birds in each group. The birds were brooded together with a 60W bulb. Each group was raised in floor pens with wood shavings as litter materials, feeders and drinkers were respectively provided for the supply of *ad libitum* feed and water for seven weeks. Birds were vaccinated against Gumboro disease at 10th and 18th days of life, while the Newcastle vaccine was administered at the 28th day. Coccidiostat was administered in drinking water during the second and third weeks of the birds.

Experimental diets

Six (6) experimental broiler diets were formulated such that the control diet (T_1) did not contain Toxidex® and maize stover while diets T_2-T_6 contained maize stover at 5%, 10%, 15%, 20% and 25% and Toxidex® at 0.1% respectively. The compositions of the broiler chickens diets and calculated analysis are shown in table 1.

Table 1: Dietary Composition of Broiler Diets showing percent substitution of maize stover for yellow maize in mycotoxin binder supplemented diets (0-7 weeks)

Ingredients (%)	T_1(0%)	T_2(5%)	T_3(10%)	T_4(15%)	T_5(20%)	T_6(25%)
Yellow Maize	52.20	49.59	46.98	44.37	41.76	39.15
Maize Stover	0.00	2.61	5.22	7.83	10.44	13.05
Soyabean Meal	15.00	15.00	15.00	15.00	15.00	15.00
Groundnut Cake	15.00	15.00	15.00	15.00	15.00	15.00
Fish Meal (Danish)	4.00	4.00	4.00	4.00	4.00	4.00
Palm Kernel Meal	10.00	9.90	9.90	9.90	9.90	9.90
Bone Meal	2.00	2.00	2.00	2.00	2.00	2.00
Oyster Shell	1.00	1.00	1.00	1.00	1.00	1.00
Premix	0.25	0.25	0.25	0.25	0.25	0.25

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Salt	0.25	0.25	0.25	0.25	0.25	0.25
Methionine DL	0.15	0.15	0.15	0.15	0.15	0.15
Lysine	0.15	0.15	0.15	0.15	0.15	0.15
Toxidex®	-	0.10	0.10	0.10	0.10	0.10
Total	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**	**100.00**
Calculated Analysis						
Crude protein %	21.00	20.80	20.60	20.40	20.20	20.00
MEKcal/Kg	3000.08	2910.32	2820.55	2730.79	2641.02	2551.25
Analyzed composition						
Dry matter %	91.50	91.46	91.35	91.51	91.51	91.44
Crude protein %	20.55	20.15	19.65	19.00	18.85	18.50
Crude fibre %	5.93	7.25	9.78	9.87	10.18	10.25
Ether extract %	3.65	3.42	3.40	3.35	3.34	3.30
Moisture %	8.50	8.54	8.65	8.49	8.49	8.56
NFE %	52.17	49.14	44.68	44.98	43.85	42.63
Ash	9.20	11.50	13.84	14.31	15.29	16.76
ME Kcal/kg	2761.86	2683.72	2612.63	2596.41	2566.55	2516.69

Vitamin-mineral premix supplied the following: Vitamin A 8,000,000 iu, Vitamin D_3 2,000,000, Vitamin E 5,000mg, Vitamin K_3 2,000mg, Folic acid 500mg, Niacin 15,000mg, Vitamin B_2 8,000mg, Vitamin B_{12} 10,000mg, Vitamin B_1 1,500mg, B6 1,500mg, Biotin 20mg, Calpan 5,000mg.

Table 2: Analyzed Proximate Composition of Maize Stover

Parameters	% Composition
Dry matter	92.9
Crude protein	6.48
Crude fat	0.50
Crude fibre	31.73
Ash	23.33
Moisture	8.02
Metabolizable energy (Kcal/kg)	972.72

Data Collection

Growth performance

Data on performance characteristics such as average initial weight, average weight, and average feed intake were collected, while average weight gain, feed conversion ratio, protein intake and protein efficiency ratio were calculated.

Carcass evaluation

At the end of the experiment, two (2) birds of similar body weight were selected from each of the treatment groups, fasted, weighed and slaughtered by severing the in jugular vein. They were thoroughly bled and scalded by dipping in hot water of 60°C and defeathered. The carcass values from head, shank, neck and visceral were removed in order to determine the dressed weight as described by Ojewola and Longe (1999).

$$\text{Dressing \%} = \frac{\text{Dressed weight}}{\text{Live weight}} \times \frac{100}{1}$$

$$\text{Organs} = \frac{\text{Heart/liver/kidney/intestine/proventriculus}}{\text{Live weight}} \times \frac{100}{1}$$

Haematological indices

Blood samples (10mls) were taken from the jugular vein of the birds at the end of the experiment using a sterile needle and syringe to withdraw the blood, where 5mls from each of the birds were kept in a sample containing Ethylene Diamine Tetra Acetic Acid (EDTA), an anti-coagulant to prevent blood clotting. The blood samples were put into properly labelled and sterilised tubes and taken to the laboratory for haematological assessment. The following were determined: Packed Cell Volume (PCV), Red Blood Cells (RBC), White Blood Cells (WBC), Haemoglobin (Hb), Mean Corpuscular Volume (MCV), Mean Corpuscular Haemoglobin (MCH), Mean Corpuscular Haemoglobin Concentration (MCHC).

Mean Corpuscular Haemoglobin (MCH)

$$\frac{\text{Hb} \times 10}{\text{RBC}}$$

Mean Corpuscular Volume (MCV)

$$\frac{\text{PCV} \times 10}{\text{RBC}}$$

Mean Corpuscular Haemoglobin Concentration (MCHC)

$$\frac{\text{Hbx100}}{\text{PCV}}$$

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Statistical Analysis

The data generated were statistically analysed using the Analysis of Variance (ANOVA) procedure as described by Steel and Torrie (1980) in a Completely Randomised Design (CRD). Significant means were separated using Duncan Multiple Range Test (Duncan, 1995), taking $P<0.05$ as the significance level.

Results and Discussion

The proximate composition of maize stover used in this study is presented in Table 2. It includes the dry matter 92.9%, crude protein 6.48%, crude fat 0.50%, crude fibre 31.73%, ash 23.33%, moisture 8.02% and metabolizable energy 972.72Kcal/kg.

Growth Performance

The result showed that there were significant differences ($P<0.05$) across the treatment groups on final weight, total weight and average daily weight, feed conversion ratio and protein efficiency ratio of broiler chickens fed maize stover-mycotoxin-binder–supplemented diets as presented in Table 3. Final weight and total weight values were higher, 1801.19g and 1757.85g, in birds fed maize stover and mycotoxin binder-supplemented diet at 15% followed by birds fed 25% level of maize stover-mycotoxin-supplemented diets, which had 1659.40 and 1616.90g, respectively. Birds fed the diet at 5% had the lowest value of 1451.77g. The highest values, 1801.19g and 1757.85g, recorded in 15% showed the positive effects of toxin binder in binding fibre and toxins in the diet and counteracting their adverse effects and improved utilisation of nutrients to the birds. Oguza (2000) reported a significant decrease in the body weight of broiler birds for 42 days. Aflatoxin could have interfered with the metabolic pathways of treatment of the birds on diet 2, whose values 1488.02g and 1451.77g were low by inhibiting protein synthesis and the enzyme system involved in carbohydrate metabolism and energy release, thereby affecting normal growth for broilers as reported by Ali (2000). Total feed intake was highest, 4471.03g, at 0% which is the control diet, followed by the birds fed 5% mycotoxin binder-supplemented diet, 4446.90g. Feed conversion ratio value was highest, 3.07, in birds fed 5% mycotoxin binder-supplemented diet, but was optimal, 2.42, for birds fed 15% maize stover diets supplemented with toxin binder, which has a total weight of 1757.85g among the treatment groups. The toxin binder in the diet was observed to improve the feed conversion ratio. Also, the broad-spectrum toxin binder acts as an antioxidant and inhibits the formation of free radicals. Its action against oxidative stress resulted in the efficient conversion of feed to energy thereby improving the feed conversion ratio of the broiler chickens and these was in agreement with the reports on studies conducted by Bobade *et al*. (2009) and Mubarak *et al.* (2009) when selenium was supplemented in broiler diets which improved performance by increasing body weight and feed consumption. Plumb (2004) reported that activated charcoal at 10% in the diet would reduce ochratoxin uptake. Adsorbent increased body weight by coating mycotoxins and other toxic metabolites and excreted through the faecal material. Poor FCR values in other treatment groups might be due to inefficiency of digesting high fibre feed by broilers, as well as the high and fibrous texture when toxin binder was fed to broiler chickens (Zulkfli *et al.*,2009). Daily protein intake was highest, 19.16g for birds fed 0% maize stover, and mycotoxin-supplemented diets, followed by 18.70 g for birds fed 5% and was lowest, 17.46g, in birds fed 25% maize stover-mycotoxin-supplemented diets. As the inclusion level of maize stover was increasing, the daily protein intake of the birds reduced and this agrees with the report of Isikwenu *et al.* (2005), that crude fibre depresses nutrient digestibility, absorption, availability and utilization of other nutrients. Protein efficiency ratio was highest, 2.03, at birds fed mycotoxin binder and maize stover at 15% and this implies that the toxin binder was able to counteract the adverse effect of mycotoxins in the diet.

Table 3: Performance of broiler chickens fed diets containing maize stover diets supplemented with Mycotoxin Binder (Toxidex®) (0-7 weeks)

Parameters (%)	T_1(0%)	T_2(5%)	T_3(10%)	T_4(15%)	T_5(20%)	T_6(25%)	SEM
Live Weight (g/b)	1433.33^b	1360.00^b	1450.00^b	1703.33^a	1450.00^b	1683.33^b	29.27
Defeathered Weight (g/b)	1283.33^b	1233.33^b	1300.00^b	1556.67^a	1316.67^b	1300.00^b	28.53
Dressed Weight (g/b)	850.00^b	820.00^b	866.67^b	1166.67^a	850.00^b	873.33^b	30.67
Dressing %	59.28^b	60.27^b	59.78^b	68.49^a	58.58^b	58.92^b	0.93
Back cut	26.28^a	29.15^a	27.47^a	21.69^b	28.28^a	26.49^a	0.70
Thigh	21.33^a	20.15^a	20.39^a	14.52^b	20.63^a	20.20^a	0.63
Drumstick	15.59	16.34	16.26	14.53	16.23	15.95	0.26
Wings	16.02^a	15.69^a	15.66^a	11.98^b	15.20^a	16.09^a	0.39
Breast	35.00^a	33.03^a	35.16^a	25.67^b	34.15^a	35.69^a	0.92

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[a,b,c,] Means within the rows with different superscripts are significantly different (P<0.05); SEM=Standard error of mean. FW:Final Weight; TW: Total Weight ; ADW: Average Daily Weight; ADFI: Average Daily
Feed Intake;TFI: Total Feed Intake; FCR: Feed Conversion Ratio; PI: Protein Intake; PER: Protein Efficiency Ratio.

Carcass Characteristics

The result of the carcass characteristics of broiler chickens fed maize stover diets supplemented with Toxidex® is presented in Table 4. The result of carcass characteristics showed significant differences across dietary treatments in live weight, dressed weight, defeathered weight, dressing percentage, back cut, thigh, wings and breast (P<0.05). Drumstick did not show any significant difference (P>0.05). Birds fed a 15% maize stover diet with mycotoxin binder had the highest value across dietary treatment groups on live weight 1703.33g/b, dressed weight 1166.67g/b, defeathered weight 1556.67g/b, while birds fed a maize stover diet with toxin binder at 5% showed the least values in live weight 1360.00g/b, dressed weight 850g/b, defeathered weight 850.00g/b. Dressing percentage was the highest, 68.49% in birds fed 15% maize stover and mycotoxin binder diets. This really showed that phyllosilicate reduced the effects of mycotoxins in the diet. Back cut values were significantly highest, 29.15% in birds fed 5% maize stover diet supplemented with mycotoxin binder Toxidex® (P<0.05). The thigh showed the highest value, 21.33% in the control group, followed by birds fed a 20% maize stover and toxin binder diet. The addition of toxin binder did not improve the carcass percentage yield in the thigh by 15%. Drumstick did not show any statistical difference (P>0.05) but had the highest value, 16.34% in birds fed 5% maize stover and toxin binder diet.

Table 4: Carcass Characteristics of Broiler Chickens fed diets containing maize stover diets supplemented with Toxidex® binder.

Parameters (%)	T_1(0%)	T_2(5%)	T_3(10%)	T_4(15%)	T_5(20%)	T_6(25%)	SEM
Live Weight (g/b)	1433.33[b]	1360.00[b]	1450.00[b]	1703.33[a]	1450.00[b]	1683.33[b]	29.27
Defeathered Weight (g/b)	1283.33[b]	1233.33[b]	1300.00[b]	1556.67[a]	1316.67[b]	1300.00[b]	28.53
Dressed Weight (g/b)	850.00[b]	820.00[b]	866.67[b]	1166.67[a]	850.00[b]	873.33[b]	30.67
Dressing %	59.28[b]	60.27[b]	59.78[b]	68.49[a]	58.58[b]	58.92[b]	0.93
Back cut	26.28[a]	29.15[a]	27.47[a]	21.69[b]	28.28[a]	26.49[a]	0.70
Thigh	21.33[a]	20.15[a]	20.39[a]	14.52[b]	20.63[a]	20.20[a]	0.63
Drumstick	15.59	16.34	16.26	14.53	16.23	15.95	0.26
Wings	16.02[a]	15.69[a]	15.66[a]	11.98[b]	15.20[a]	16.09[a]	0.39
Breast	35.00[a]	33.03[a]	35.16[a]	25.67[b]	34.15[a]	35.69[a]	0.92

[a,b,] Means within the rows with different superscripts are significantly different (P<0.05); SEM-Standard Error of mean. As the inclusion level of maize stover increased, the drumstick values decreased by 16.34%, 16.26%, and 14.53%. Wing had the highest value 16.09% in birds fed 25% maize stover and toxin binder diet among the treatment groups, while breast cut values were highest values 35.69% for birds fed 25% maize stover and toxin binder diet among the treatment groups showing the positive effect or ability of mycotoxin binder in trapping and binding toxins in the gastrointestinal tract of the animals as the toxins were excreted in the faeces (Hussien *et al.*, 2012).

Haematological Indices

The results of the carcass characteristics of broilers fed maize stover diets supplemented with Toxidex® are presented in Table 5. The results of haematological indices showed that all the haematological parameters except PCV were not (P>0.05) affected by the inclusion of toxin mycotoxin binder in the broiler diets. Packed cell volume was significantly affected (P<0.05). All the Packed cell volume values were within the normal range of 25-45% as reported by (Bounous and Stedman, 2000). RBC values were highest, 3.18µl in birds fed the control diet among the treatment groups, while WBC values were highest, 3.15µl in birds fed the 10% maize stover and mycotoxin binder (Toxidex®) diet. Obtaining a higher value in 10% implies high immunity of the birds against infection (Togun and Oseni, 2005). Hb values were the highest, 9.50g/dl, in birds fed 25% maize stover and mycotoxin binder-supplemented diets. When there is high Haemoglobin (Hb), it implies high oxygen carrying capacity, but when Hb is below normal, it means the oxygen carrying capacity is low, and the birds can easily succumb to respiratory stress as iron is present in the blood for oxygen and carbon dioxide transportation (Aderemi and Alabi, 2013).

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Table 5: Haematological indices of Broiler Chickens fed maize stover diet supplemented with mycotoxin binder Toxidex® (0-7 weeks)

Parameters	T_1(0%)	T_2(5%)	T_3(10%)	T_4(15%)	T_5(20%)	T_6(25%)	SEM
RBC ($\times 10^6$/ µl)	3.18	2.98	3.05	2.65	2.62	2.90	0.15
WBC ($\times 10^3$/µl)	2.85	3.05	3.15	3.00	2.69	3.03	0.13
Hb (g/dl)	8.29	8.93	8.19	8.03	8.57	9.50	0.34
MCV (fl)	88.58	96.26	98.24	109.31	94.66	95.83	4.81
MCH (pg)	25.88	32.36	28.58	30.26	32.48	34.66	1.75
MCHC (g/dl)	29.42	33.25	28.64	27.95	34.75	35.95	1.28
PCV (%)	28.00^{ab}	26.83^{ab}	28.50^{a}	28.83^{a}	24.67^{b}	26.33^{ab}	0.51

[a,b] Means within the rows with different superscripts are significantly different (P<0.05); SEM-Standard Error of the mean. PCV: Packed Cell Volume; Hb: Haemoglobin; RBC: Red Blood Cell; WBC: White Blood Cell; MCV: Mean Cell Volume; MCH: Mean Cell Haemoglobin; MCHC: Mean Cellular Haemoglobin Concentration.

Also, Haemoglobin concentration (Hb) values were within the accepted range of 7.0-13 g/dl for broiler chickens. MCV values were highest, 109.31fl at birds fed a 15% maize stover-supplemented diet, followed by the 10% 98.24fl, and MCV measures the average size of the RBC. MCH was the highest 34.66pg in birds fed 25% maize stover- mycotoxin-binder-supplemented diets, showing that the birds cannot easily succumb to anaemia since low levels indicate anaemia (Aster, 2004). MCHC was the highest, 35.95g/dl, in birds fed 25% maize stover and mycotoxin binder diets among the treatment groups. PCV values were the highest, 28.83% in birds fed a 15% maize stover and mycotoxin binder-supplemented diet.

CONCLUSION

In conclusion, maize stover supplemented with mycotoxin binder (Toxidex®) can replace yellow maize in broiler chicken diets from 10% to 15%. This was shown in increased growth rate and better feed efficiency, higher haematological values, reduced cost of feed and bigger cut parts as the binder trapped the toxins in the feed without adverse effects on growth performance, carcass characteristics and haematological parameters.

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