Ameliorative Effect of Turmeric Rhizome Extract on Performance, Blood Chemistry and Liver Histopathology of Finisher Broiler Exposed to Aflatoxin

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Abstract

Aflatoxin is known to affect poultry and other farm animals causing cancer. While it has become almost impossible to completely eliminate the scourge of aflatoxin contamination in feeds, therefore its amelioration has become inevitable. In this study, 4-week old Abor Acres broiler chicks totalling 90 were allotted to five (5) experimental groups of 3 replicates and 6 birds per experimental unit in a completely randomized design (CRD). Treatments were: treatment 1 (control, as uncontaminated standard diet, C), treatment 2 (C + 0.5mL of turmeric extract per litre of water), treatment 3 (C + 0.5mg/kg aflatoxin), treatment 4 (C + 0.5mg/kg aflatoxin + 0.5mL turmeric per litre of water), treatment 5 (C + 0.5mg/kg aflatoxin + 1.0ml turmeric per litre of water). The feeding trial lasted for four weeks. The effects of treatments on feed intake (FI), body weight change (BWC), feed conversion ratio (FCR) and mortality were subjected to analysis of variance and means were separated based on Duncan multiple range test (5% α-value).

The FI (g) in T5 has the highest (3326.70) and T2 been the lowest (2604.07) while BWG (g) were recorded to be highest in T2 (1428.33) with T5 been the lowest (1207.00). FCR were recorded to be highest in T5 (2.65) and lowest in T4 (1.85). Highest mortality (%) was recorded in T3 and T5 (16.63) and T2 and T4 with the lowest mortality (5.53). Serum protein, Albumin and Globulin (g/dL) were highest in T1 (5.67, 1.23 and 4.43 respectively) and lowest in T5 (4.45, 0.73 and 3.72 respectively). AST and ALT (ul) were recorded to be highest in T3 (193.50 and 36.00 respectively) and lowest in T5 (180.61 and 27.33 respectively). Haemoglobin and red blood cells (g/dL) were recorded highest in T2 (11.30 and 3.38) and lowest in T5 (9.68 and 2.94). WBC (x 10^3 ul) were recorded to be highest in T2 (17683.30) and lowest in T5 (15016.70). Histopathology results shows that there was severe periportal inflammation in T5 than other treatments.

Dietary aflatoxin ingestion was detrimental to feed intake and body weight change ($p<0.05$). These parameters however were improved following the diet supplementation with turmeric extracts. Aflatoxicosis resulted in mortality in all groups that were treated with aflatoxin as supplementation of the diets with turmeric at 1ml/L of water did not show potency against mortality, whereas 0.5ml/L of turmeric anti-oxidant reduced mortality significantly ($p<0.05$).

Keywords: Aflatoxin, turmeric extracts, ameliorate, performance, broiler

Effet Amélioratif De L'extrait De Rhizome De Curcuma Sur La Performance, La Chimie Sanguine Et L'histopathologie Hepatique Des Poulets A Griller En Finition Exposes A L'aflatoxine

Résumé

L'aflatoxine est connue pour affecter la volaille et d'autres animaux de ferme, provoquant le cancer. Bien qu'il soit devenu presque impossible d'éliminer complètement le fléau de la contamination par l'aflatoxine dans les aliments, son amélioration est devenue inévitable. Dans cette étude, des poussins de chair Abor Acres âgés de 4 semaines, totalisant 90, ont été répartis en cinq (5) groupes expérimentaux de 3 répliques et 6 oiseaux par unité expérimentale dans un design complètement randomisé (DCR). Les traitements étaient : traitement 1 (témoin, en tant que régime standard non contaminé, C), traitement 2 (C + 0,5 mL d'extrait de curcuma par litre d'eau), traitement 3 (C + 0,5 mg/kg d'aflatoxine), traitement 4 (C + 0,5 mg/kg d'aflatoxine + 0,5 mL de curcuma par litre d'eau), traitement 5 (C + 0,5 mg/kg d'aflatoxine + 1,0 mL de curcuma par litre d'eau). L'essai d'alimentation a duré quatre semaines. Les effets des traitements sur la consommation de nourriture (CN), le changement de poids corporel (CPC), le rapport de conversion alimentaire (RCA) et la mortalité ont été soumis à une analyse de variance et les moyennes ont été séparées sur la base du test de plage multiple de Duncan (valeur α de 5 %). La CN (g) dans T5 était la plus élevée (3326,70) et T2 la plus basse (2604,07), tandis que la prise de poids (g) était la plus élevée dans T2 (1428,33) avec T5 étant la plus basse (1207,00). Les RCA étaient les plus élevés dans T5 (2,65) et les plus bas dans T4 (1,85). La mortalité la plus élevée (%) a été enregistrée dans T3 et T5 (16,63) et T2 et T4 avec la mortalité la plus

basse (5,53). Les protéines sériques, l'albumine et les globulines (g/dL) étaient les plus élevées dans T1 (5,67, 1,23 et 4,43 respectivement) et les plus basses dans T5 (4,45, 0,73 et 3,72 respectivement). AST et ALT (ul) étaient les plus élevés dans T3 (193,50 et 36,00 respectivement) et les plus bas dans T5 (180,61 et 27,33 respectivement). L'hémoglobine et les globules rouges (g/dL) étaient les plus élevés dans T2 (11,30 et 3,38) et les plus bas dans T5 (9,68 et 2,94). Les globules blancs (x 10³ ul) étaient les plus élevés dans T2 (17683,30) et les plus bas dans T5 (15016,70). Les résultats histopathologiques montrent qu'il y avait une inflammation périportraite sévère dans T5 par rapport aux autres traitements. L'ingestion d'aflatoxine par voie alimentaire était néfaste pour la consommation de nourriture et le changement de poids corporel (p < 0,05). Cependant, ces paramètres ont été améliorés suite à la supplémentation alimentaire avec des extraits de curcuma. L'aflatoxicosis a entraîné une mortalité dans tous les groupes traités avec de l'aflatoxine, car la supplémentation des régimes avec du curcuma à 1 ml/L d'eau n'a pas montré d'efficacité contre la mortalité, tandis que 0,5 ml/L de curcuma antioxydant a réduit la mortalité de manière significative (p < 0,05).

Mots-clés : aflatoxine, extraits de curcuma, améliorer, performance, poulets à griller

Introduction

Aflatoxins are produced by the toxigenic fungi, mainly *Aspergillus flavus* and *Aspergillus parasiticus* and constitute one of the major health hazard groups of naturally-occurring toxicants, both for humans and animals (Prescott *et al*., 2008). Aflatoxin is the most prevalent mycotoxin synthesized by *Aspergillus flavus*, *Aspergillus parasiticus*, and *Aspergillus nomius* in the ideal temperature and humidity (Morrison *et al.,* 2017). Prolonged storage of the chicken's feed creates a high synthesis of the aflatoxin (Sarma *et al.,* 2017). Aflatoxin induces severe cellular defects and carcinogenesis (Kim *et al.,* 2016). The disease condition caused by aflatoxin is known as aflatoxicosis (Wogan *et al.,* 2012). The clinical manifestations of aflatoxicosis are lethargy, anorexia, lower growth rate, microbial stress, economic losses and toxicity (Sarma *et al.,* 2017).

The target organ for metabolism of Aflatoxin B_1 is the liver, where its mechanism of action is initiated (Oyegunwa *et al*., 2023). Following ingestion with food, AFB_1 may be metabolized by cytochrome-P450 enzymes to reactive genotoxic intermediates (aflatoxin B1-8,9-oxide, AFBO) or hydroxylated and demethylated to become less harmful than AFB_1. In order to exert its hepatocarcinogenic effect, AFB_1 has to be bio-transformed by the cytochrome-P450 enzyme, which results in the production of a reactive intermediate chemical compound, AFBO. This highly reactive genotoxic compound binds to liver cell DNA as a result and DNA adducts are formed, namely 8, 9-dihydro-8 (N7 guanyl)-9-hydroxy-AFB_1 (AFB1 N7-Gua) (Obuseh *et al.,* 2011). Detoxification of highly genotoxic AFBO intermediate is an essential pathway in order to prevent the formation of DNA adducts. Conjugation of AFB_1 to glutathione and its subsequent excretion is regarded as an important detoxification pathway in animals.

The effect of aflatoxin on feed intake and body weight has been extensively researched. The reduced body weight gain observed during aflatoxicosis is suggestive of reduced appetite (anorexia), unthriftiness, inhibition of protein synthesis and lipogenesis during aflatoxicosis (Oguz and Kurtoglu, 2000, Oguz *et al*., 2000). Impaired liver functions and protein/lipid utilization mechanisms may also affect the growth performance and general health of the animal (Ortatatli and Oguz, 2001). The adverse effects of AFB_1 on growth performance have been related with a decrease in the protein and energy utilization (Dalvi and Ademoyero, 1984), probably as a consequence of a deterioration of the digestive and metabolic efficiency of the birds. Facing the digestive deterioration, Osborne and Hamilton (1981) reported increased lipid excretion in faeces of young broilers receiving a diet supplemented with the Aflatoxin B_1 (AFB_1) at 2.5 mg/kg of feed. Aflatoxin

contaminated feeds decreased the activities of several enzymes important to digestion of carbohydrates, proteins, lipid and nucleic acid in broiler chickens (Campbell *et al.*, 1983).

Although, series of research have shown that some certain anti-oxidant agents are capable of reducing the negative effects of aflatoxins on livestock. Such sources of anti-oxidants includes spinach (locally called *Efo Amunututu*), Turmeric (locally called *Ata Ile Pupa*), Carrot, Cabbage, Sweet Potatoes etc. Although, these anti-oxidants sources are not as potent as turmeric. Turmeric (*Curcuma longa*), a domestic spice has the various applications in the medicinal biology (Aggarwal and Harikumar, 2009). Turmeric produces a specific bioactive compound called curcumin, a polyphenolic phytochemical with anti-microbial, anti-inflammatory, anti-cancerous and antioxidant properties (Al-Sultan, 2003; Aggarwal and Harikumar, 2009,). It has been found that the feeding of turmeric rhizome powder in the poultry diet helped to improve the morbidity and mortality of broiler chickens (Al-Kassie *et al*, 2011). It is also proven that the use of turmeric in poultry feed is helpful for the public health with no side effects (Dono, 2014). It is against the backdrop that the study intend to assess the efficacy of turmeric antioxidant extract (*Curcuma longa*) as biosystemic sequestering agent at high aflatoxin load in broiler chicks.

Materials and Methods

Experimental Site

This experiment was conducted at the Poultry Unit, Teaching and Research Farm, Tai Solarin University of Education, Ososa Campus. Laboratory analysis and quantification of aflatoxin in maize and feed samples were carried out at the Plant Pathology Laboratory, International Institute of Tropical Agriculture IITA Moniya in Ibadan.

Experimental Plan and Design

A total of 90 4-week old Abor Acres broiler chicks were allotted to five experimental diets (T1 – T5) in a completely randomized design (CRD) as follows: Diet 1 (Basal diet with no aflatoxin and no turmeric extract); Diet 2 (Basal diet + 0.5mL/L of turmeric extract with no aflatoxin); Diet 3 (Basal diet + 0.5mg/kg aflatoxin with no turmeric extract); Diet 4 (Basal diet + 0.5mg/kg aflatoxin + 0.5ml/L of turmeric extract) and Diet 5 (Basal diet + 0.5mg/kg of Aflatoxin + 1mL/L of turmeric extract).

Each dietary treatment was replicated three times with six broiler chicks in each replicate. Aflatoxin B_1 was mixed in the feeds and offered to birds of these groups for four weeks. Data on performance, haematology and serum biochemistry were collected during and after the 4 weeks of feeding trail.

Table 1: Gross Composition of Experimental Diet

INGREDIENTS	*Treatment 1 (Control)*	*Treatment 2 (0.5mL/L turmeric)*	*Treatment 3 (0.5mg/kg AfB1)*	*Treatment 4 (0.5mg/kg AfB1 + 0.5mL/L turmeric)*	*Treatment 5 (0.5mg/kg AfB1 + 1.0mL/L turmeric)*
Maize	66.0	66.0	63.0	63.0	63.0
contaminated Maize	-	-	3.0	3.0	3.0
Soya bean meal	22.55	22.55	22.55	22.55	22.55
Groundnut cake	8.0	8.0	8.0	8.0	8.0
Bone meal	2.0	2.0	2.0	2.0	2.0
Limestone	0.5	0.5	0.5	0.5	0.5
Broiler premix	0.25	0.25	0.25	0.25	0.25

Common Salt	0.5	0.5	0.5	0.5	0.5
Methionine	0.1	0.1	0.1	0.1	0.1
Lysine	0.1	0.1	0.1	0.1	0.1
Total	100	100	100	100	100
Calculated Nutrients					
Crude Protein (%)	*18.84*	*18.84*	*18.84*	*18.84*	*18.84*
M. Energy (Kcal/kg)	3200	3200	3200	3200	3200
Crude fibre (%)	3.3	3.3	3.3	3.3	3.3
Calcium (%)	0.71	0.71	0.71	0.71	0.71
Phosphorus (available)	0.93	0.93	0.93	0.93	0.93

Preparation of Aflatoxin Contaminated Maize and Quantification

A pure culture of *Aspergillus flavus* (N3228) was obtained from International Institute of Tropical Agriculture (IITA), Ibadan. The pure culture was further sub-cultured so as to produce more *Aspergillus flavus* for high aflatoxin production. In a method described by Shotwell *et al*. (1966), maize grains were inoculated with *Aspergillus flavus* to produce the maize inoculum with aflatoxin concentration of 16.67mg/kg. Aflatoxin in the maize inoculum was quantified at the Pathology Laboratory of International Institute of Tropical Agriculture (IITA), Ibadan, Oyo State. The maize inoculum was mixed with the finished feed based on the concentration of aflatoxin in the inoculum to obtain 0.5mg/kg aflatoxin concentration.

Determination of Mixing Proportion of Aflatoxin

As formulated by Oyegunwa and Ewuola, (2015), a simple method for determining the quantity of Aflatoxin-contaminated maize to be added to the finished feed to give the required concentration in the feed, is as follows:

Required amount of contaminated maize (kg)

$$= \frac{\text{Qty of finished feed (kg) X conc. Required in finished feed (mg/kg)}}{\text{Conc. of Aflatoxin in maize carrier (mg/kg)}}$$

Method of extraction of Turmeric

Solvent extraction was used in the extraction of the active ingredient of turmeric rhizome as described by Funk *et al*., (2010) with slight modification. This process starts with the washing, drying and blending of the rhizomes into powder form. About 500g/L of dried turmeric rhizome powder was prepared and kept at room temperature for 7days. During this period, shaking of the flasks was performed daily. The solvent soluble compounds were filtered using double filter paper (Whatman™). Fresh solvents were added into the used plant material and the process was repeated three times to ensure that all the active ingredients were extracted from the rhizomes. The extract was then mixed directly with water in the concentration of 0.5mL/L and 1.0mL/L as mentioned in the diet table.

Data Collection

Clinical signs and Behavioural alterations

Clinical signs and behavioural alterations in birds of each group was subjectively recorded by observing twice daily for dullness, attraction to feed, attraction to water, condition of feaces and appearance of feathers. The presence or absence of nervous signs was also observed. Each clinical signs was subjectively evaluated and designate as normal, mild, moderate and severe change.

Feed Intake

The feed consumption in each replicates was determined daily by the differences between the daily feed supply and the leftover. The feed intake was recorded in gram (g).

Body Weight Gain

The live weight changes of the broiler chicks was taken weekly throughout the experimental periods. The average cumulative weight gain per chick was obtained by taking the difference between the initial weight at the start of the experiment and the weight at the end of the experiment.

Feed Conversion Ratio

This was calculated as the ratio of feed intake and weight gain.

FCR = Feed Intake/Weight Gain

Haematology of Broilers

At the end of the feeding trial, the chicks were starved overnight prior to blood collection. Two birds per replicates were bled through the jugular vein and blood samples (5mL) were obtained into vacutainer tubes containing Ethylene Diamine Acetic Acid (EDTA). The tubes was capped immediately while the content was mixed gently for few seconds by repeated inversion before analysis. The blood analysis was carried out at the Department of Veterinary medicine, University of Ibadan.

Serum Biochemistry of Broilers

Blood samples (5mL) were collected in plain bottles without EDTA for biochemical studies. The blood samples were kept in slanting wooden rack after collection and allowed to clot. The samples were kept in sterile vacutainer tubes and kept deep frozen prior to analysis. All serum parameters were determined using the Randox^{R} reagents and manufacturer's procedures.

Histopathology of Broilers

At the end of the feeding trial a total of 2 birds per replicate were purposively selected for histopathology. The birds were euthanized and then immediately exsanguinated by manually severing the jugular vein at the neck region with a sharp knife, after which they were allowed to bleed thoroughly. Sections of the livers of broiler chicks were collected in each treatment and prepared for analysis in the Department of Veterinary Medicine, University of Ibadan. Pathological changes were evaluated in the liver of the birds fed. The tissues were fixed in 10% formalin buffer, paraffinized in blocks and were cut into 5um thickness sections. These sections were stained with hematoxylin and eosin (H and E) according to Drury and Wallington (1980) and examined under microscope.

Statistical Analyses

The data obtained in all the groups were subjected to Analysis of Variance (ANOVA) procedure appropriate for Completely Randomized Design (CRD) using Statistical Analysis System (SAS). The means of different groups were compare by Duncan's Multiple Range Test using SPSS statistical software. The level of significance was $p \leq 0.05$.

Results and Discussion

Performance of Broilers

Table 2: Performance of broilers fed aflatoxin-contaminated diets

Parameters	***Treatments***					
	Control (no AfB1, no turmeric)	**0.5ml/L turmeric**	**0.5mg/kg Af.B1**	**0.5mg/kg AfB1 + 0.5ml/L turmeric**	**0.5mg/kg AfB1 + 1.0ml/L turmeric**	**SEM**
Initial body weight (g)	975.00	975.00	975.00	975.00	975.00	0.00
Final body weight (g)	2333.00^{b}	2403.30^{a}	2282.70^{c}	2399.30^{a}	2182.00^{d}	68.19
Body weight change (g)	1358.00^{b}	1428.33^{a}	1307.67^{c}	1424.33^{a}	1207.00^{d}	2.52
Feed intake/bird (g)	2713.23^{cb}	2604.07^{c}	2824.43^{b}	2619.67^{c}	3326.70^{a}	27.61
Feed conversion ratio	2.02	1.87	2.15	1.85	2.65	0.19
Mortality (%)	0.00^{c}	5.53^{b}	16.63^{a}	5.53^{b}	16.63^{a}	4.07

^{a,b,c,d} *Means on the same row with different superscripts are significantly different (P<0.05).*

For the initial body weight, the result showed that the starting weight of broilers were consistent across all treatments at 975.00g. For the final body weight, the result showed that broilers treated with 0.5ml/L turmeric and 0.5mg/kg AfB1 + 0.5ml/L turmeric gave the highest final body weights, while those treated with 0.5mg/kg AfB1 + 1.0ml/L turmeric had the lowest. The significant reduction in body weight of broilers that consumed higher dose of turmeric may be as a result of toxicity coming from likely overdose of the turmeric. In a similar study, Han *et al*. (2016) demonstrated a reduction in weight as well as feed intake in turmeric fed group. Seham *et al*. (2018) also demonstrated a reduction in feed intake for rats that were fed with turmeric compared with those fed with turmeric control and aflatoxin-turmeric combination

Emadi et al 2006 reported that chickens fed with turmeric did not significantly increase in body weight compared to the control. Also, negative effects on feed intake and feed conversion ratio were observed by Abbas (2010) when turmeric was fed to birds at levels of 2.0g/kg and 5.0g/kg. High level of turmeric is known to induce hyperemia and infiltration of of the parenchyma and portal space with monocellular cells (Al-Sultan and Gameel, 2004). Observing the body weight change values across the treatment groups, the group that received turmeric supplementation at a concentration of 0.5mL/L demonstrated the highest body weight change, followed closely by the group treated with 0.5mg/kg of Af.B1 and 0.5mL/L of turmeric. These results indicate that turmeric potentially fostered more significant growth and weight gain in the broilers. The result of our finding here is in agreement with the work of Platel and Srinivasan (2000) who reported an improved feed intake and growth rate as a result of stimulation of the digestive system by promoting intestinal digestive enzymes such as lipase, maltase and sucrase. The result of feed conversion ratio showed that the group supplemented with 0.5mg/kg of Af.B1 and 0.5ml/L of turmeric exhibited the lowest FCR value of 1.85, indicating that this treatment resulted in efficient feed utilization and effective weight gain. This suggests that the combination of Af.B1 and turmeric at these specific levels may have positively influenced the birds' metabolism and growth efficiency. Comparatively, the control group, which did not receive any aflatoxin or turmeric supplementation, had an FCR of 2.02.

Furthermore, the percentage of mortality indicates the proportion of birds that did not survive to the end of the experimental period. The result showed that the treatment groups displayed varying mortality percentages, reflecting the potential influence of the dietary factors being studied. Notably, the control group, which did not receive any aflatoxin or turmeric supplementation, had no mortality. Among the other treatment groups, the highest mortality percentage of 16.63% was observed in two instances: for the groups exposed to 0.5mg/kg of Af.B1 without turmeric supplementation and for the group exposed to the same level of Af.B1 along with 1.0ml/L of turmeric. This suggests that these particular treatments may have contributed to a less favorable survival rate among the broiler chickens. In contrast, the groups supplemented with 0.5mg/kg of Af.B1 and 0.5ml/L of turmeric, as well as the group supplemented with only 0.5ml/L of turmeric, had lower mortality percentages of 5.53%.

Serum Biochemistry of Broilers

Table 3: Serum biochemistry of broilers fed aflatoxin-contaminated diets

Parameters	***Treatments***					
	Control (no AfB1, no turmeric)	**0.5ml/L turmeric**	**0.5mg/kg Af.B1**	**0.5mg/kg AfB1 + 0.5ml/L tumeric**	**0.5mg/kg AfB1 + 1.0ml/L tumeric**	**SEM**
Serum protein (g/dL)	5.67[a]	5.30[a]	3.10[b]	5.12[a]	4.45[b]	0.24
Albumin (g/dL)	1.23	1.10	0.97	1.07	0.73	0.10
Globulin (g/dL)	4.43	4.20	4.13	4.05	3.72	0.14
Alb./Glo. Ratio	0.28	0.26	0.22	0.26	0.19	0.02
AST (ul)	191.50	187.67	193.50	188.17	180.67	2.99
ALT (ul)	31.50	33.50	36.00	34.67	27.33	2.16
Creatinine (mg/dL)	0.60	0.65	0.55	0.62	0.53	0.03

[a,b,c] *Means on the same row with different superscripts are significantly different (P<0.05).*

The "Serum biochemistry" parameters presented in Table 2 offer valuable insights into the impact of different treatments, involving aflatoxin-contaminated diets and turmeric supplementation, on the serum biochemical profile of broiler chickens. These parameters reflect the potential effects of dietary interventions on the birds' physiological health and metabolic processes.

The result of Serum Protein (g/dL) indicate that the concentration of serum proteins varied across the different treatment groups. The control group, which received a diet without aflatoxin and turmeric, exhibited the highest serum protein level (5.67 g/dL), while the groups exposed to aflatoxin-contaminated diets showed a decrease in serum protein levels, suggesting potential disruptions in protein metabolism. Turmeric supplementation, especially at 0.5ml/L, appeared to have a mitigating effect on serum protein levels, possibly indicating its role in counteracting the negative effects of aflatoxin exposure.

The effect of aflatoxin on other serum parameters did not show any significant difference

Haematology of Broilers

Table 4: Haematology of broilers fed aflatoxin-contaminated diets

Parameters	***Treatments***					
	Control (no AfB1, no turmeric)	**0.5ml/L turmeric**	**0.5mg/kg Af.B1**	**0.5mg/kg AfB1 + 0.5ml/L tumeric**	**0.5mg/kg AfB1 + 1.0ml/L tumeric**	**SEM**
Packed cell volume (%)	33.50[ba]	35.00[a]	33.33[ba]	31.17[bc]	29.83[c]	0.44
Haemoglobin (g/dL)	10.75[ba]	11.30[a]	10.83[ba]	10.18[bc]	9.68[c]	0.15
RBC (g/dL)	3.26[ba]	3.38[a]	3.35[a]	3.08[bc]	2.94[c]	0.05
WBC (x 10^6 ul)	16.93[ba]	17.68[a]	16.90[ba]	15.99[bc]	15.01[c]	0.64

Platelet (x 10^4 ul)	24.70[a]	24.68[a]	23.05[a]	19.85[b]	18.85[b]	0.47
Lymphocytes (%)	65.50[a]	65.67[a]	64.50[a]	62.67[a]	32.50[b]	0.74
Heterophils (%)	27.50[ba]	27.00[b]	28.00[ba]	31.83[ba]	32.50[a]	0.89
Monocytes (%)	2.67	3.50	3.00	2.00	2.50	0.26
Eosinophils (%)	3.83	3.50	4.17	3.33	3.17	0.26
Basophil (%)	0.17	0.33	0.33	0.17	0.50	0.09

[a,b,c] *Means on the same row with different superscripts are significantly different (P<0.05).*

Table 4 revealed how dietary treatments, including aflatoxin exposure and turmeric supplementation, influenced various blood components in broiler chickens. The result of packed cell volume (%) revealed that chickens in the treatment 2 had the highest packed cell volume which indicate that the presence of turmeric may have contributed to high packed cell volume as seen in treatment 2. The increased PVC in treatment 2 is in line with the findings of Vivian *et al*. (2015) and Ajit *et al*. (2015) who opined that the increased PVC in birds fed with turmeric is an indication of improved oxygen carrying capacity of the cells which translated to a better availability of nutrients for utilization by the birds and consequently affecting their well being with an active immune system. A similar result was obtained for haemoglobin, red blood cells and white blood cells. The results here for these blood parameters show a positive effect of turmeric on the birds. The presence of aflatoxin on the other hand in treatment 3 may be responsible for the significantly lower packed cell volume, haemoglobin red blood cell and white blood cell with slightly higher values in treatments 4 and 5 due to its mitigation with turmeric. Aflatoxin has been implicated in anaemic conditions and low blood cell production in birds during aflatoxicosis and there results here clearly supports this. No significant difference ($p>0.05$) was found the values of monocytes, eosinophil and basophil for birds under the current study.

Liver histopathology

The histological structure of the liver in control (treatment 1) is the only one that showed normal structure as seen in figure 1. It is however unclear if the presence of turmeric could have resulted in periportal inflammation of the liver as seen in figure 2. As expected, the liver of birds from treatment 3 showed periportal hepatocellular degeneration as a result of the toxicity of the aflatoxin. Supplementation of aflatoxin diets in treatments 4 and 5 only showed mild potency as there were random hepatocellular necrosis and inflammation in liver of broilers from treatment 4 and severe periportal inflammation in liver from treatment 5.

Liver is considered the target organ for aflatoxin B_1 because it is the organ where most aflatoxins are bioactivated to reactive 8, 9 epoxide form which is known to bind DNA and proteins, damaging the liver structures and increasing liver weight (Miazzo *et al*., 2005) Aflatoxin has been known to cause liver congestion during aflatoxicosis due to increased lipid deposits (Hsieh, 1988).

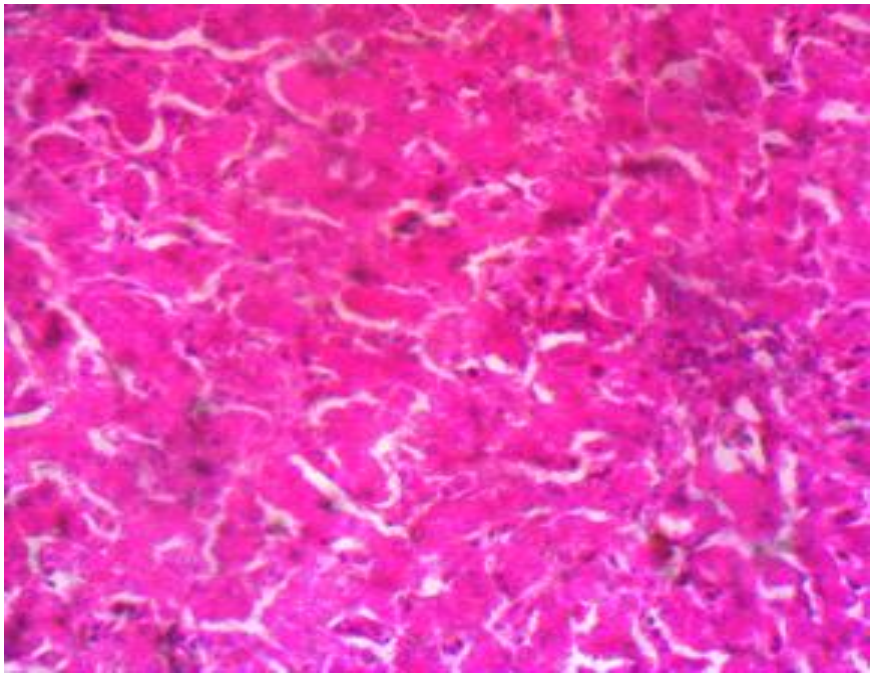

Figure 1: Liver of bird from treatment 1 showing no observable lesion.HEx400

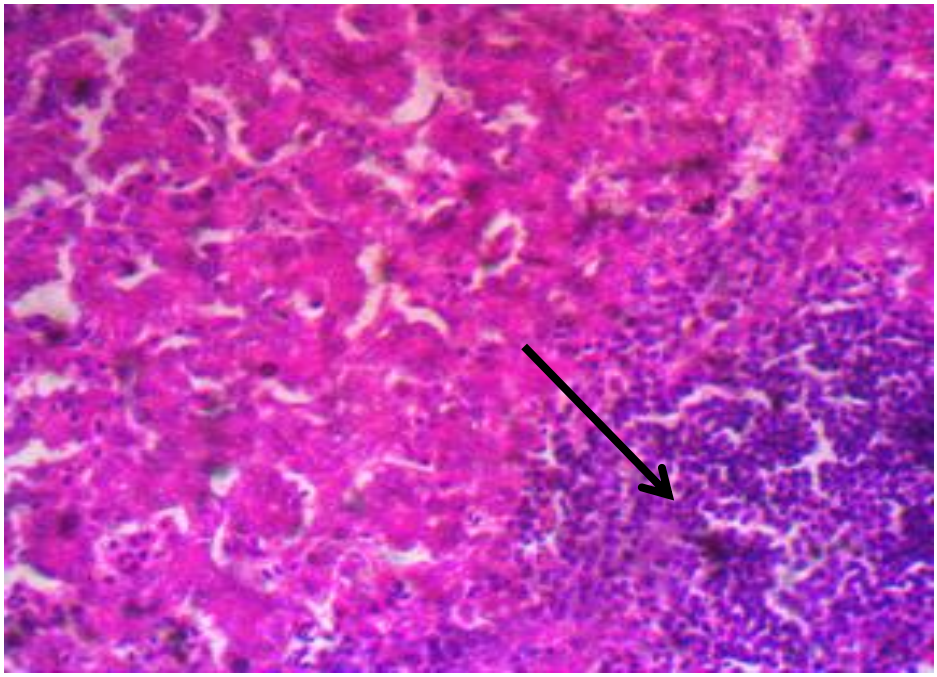

Figure 2: Liver of bird from treatment 1 showing periportal inflammation .HEx400

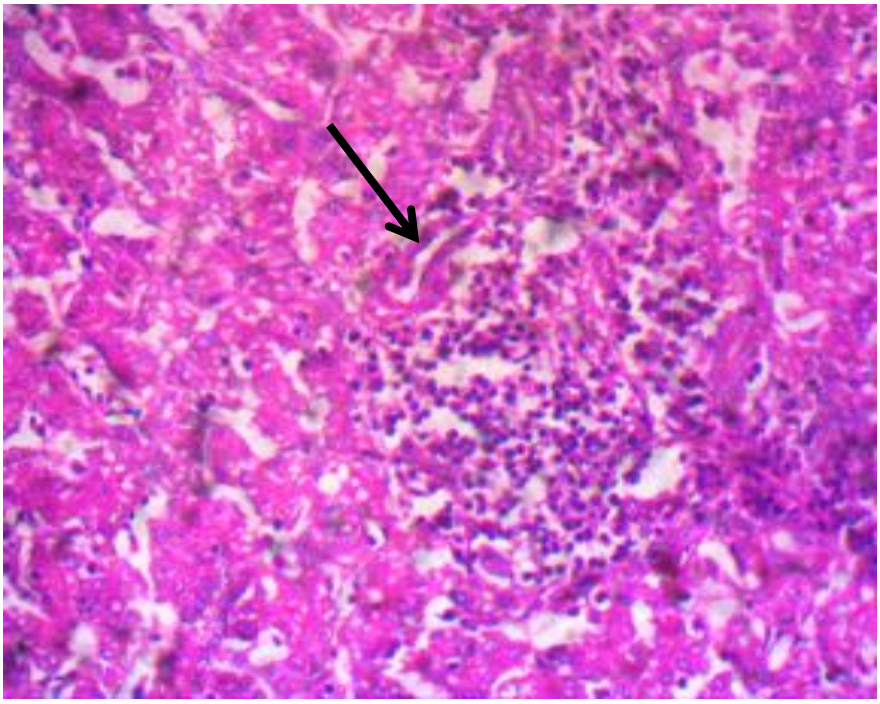

Figure 3: Liver of bird from treatment 1 showing periportal hepatocellular degeneration and inflammation (arrow). HEx400

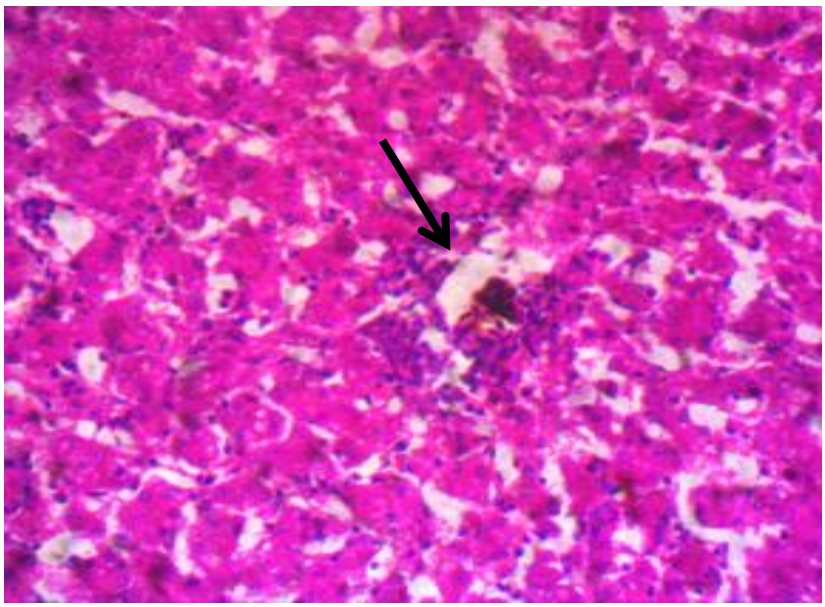

Figure 4: Liver of bird from treatment 1 showing random hepatocellular necrosis and inflammation HEx400

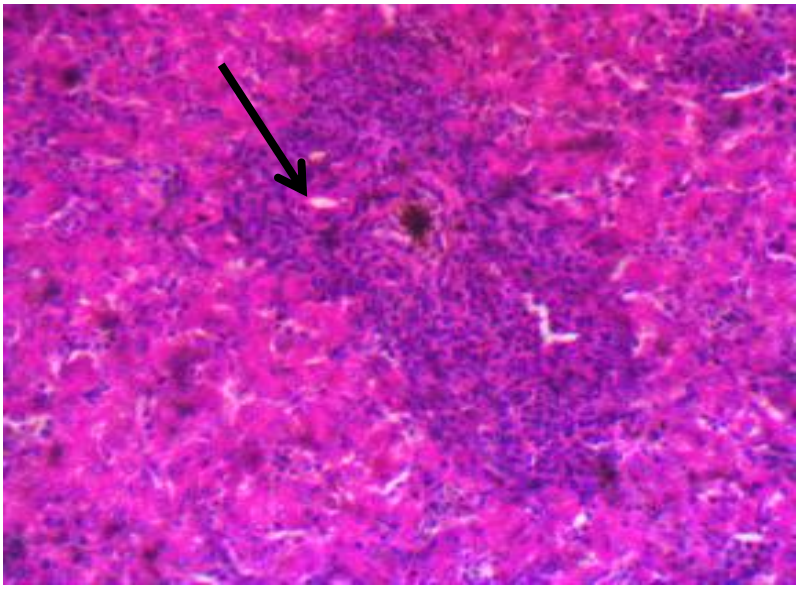

Figure 5: Liver of bird from treatment 5 showing severe periportal inflammation .HEx400

Conclusion and Recommendation

From the study, turmeric supplementation at 0.5mL/L mitigate the effect of aflatoxin exposure in broiler chicks all parameters assessed (performance, serum biochemistry and heamotology). Also, the introduction of turmeric extract at 0.5mL\L alleviate some of the liver damage, reducing the severity of lesions and potentially mitigating oxidative stress induced by aflatoxin. This suggests that turmeric may have a protective role in preserving liver health in broiler chickens, as supported by the results of this study. A level up to 1mL/L of turmeric supplementation is however not recommended.

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