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KIDNEY FUNCTIONS AND SOME BLOOD CONSTITUENTS IN BROILER CHICKS AS INFLUENCED BY DIETARY AFLATOXINS.

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ABSTRACT

An experiment was conducted to study the effects of aflatoxin B_1 (AFB_1) supplementation on kidney function, performance, some blood constituents, some digestive organs (Liver, proventriculus and gizzard) and immune glands (spleen, thymus & bursa of Fabricius) of broiler chicks.

A total of 135 one-day old broiler chicks were utilized during the whole experimental period (7 weeks of age). Birds were randomly assigned to three experimental groups. The first groups were fed the basal diet supplemented with AFB1 at a rate of µg/kg diet, respectively.

Supplementation of AFB_1 resulted in a significant ($P<0.05$) reduction in body weight, weight gain, feed consumption and feed conversion ratio while resulted in a significant ($P<0.01$) increase in mortality rate. Regardless of age, the reduction in body weight and weight gain, and the elevation in mortality rate were increased as supplemental AFB1 dose increased. Birds fed AFB1-supplemented diets exhibited a significant ($P<0.05$) increase in the relative weights of liver, kidney, proventriculus and gizzard while they showed a significant ($P<0.05$) decrease in the relative weight of spleen, thymus and bursa of Fabricius glands, this indicating immune suppression effect of AFB_1. Uric acid in blood, creatinine, alkaline phosphatase, GOT and GPT were significantly ($P<0.05$) increased while plasma total protein, calcium, phosphorus and creatine Kinase were significantly ($P<0.05$) decreased by AFB_1 feeding, which reflects nutrient and mineral metabolism disorders and kidney dysfunction. AFB_1 had also acute and direct negative effect on glomerular filtration rate, urine flow and Ca and P excretion in urine. This is coincident with the increased water consumption and excreta moisture.

It is concluded that AFB_1, the most potent nephrotoxic for birds, act directly on the kidneys to alter several hematological parameters and nutrient and mineral metabolism in chickens.

INTRODUCTION

Kidneys are one of the most important and sensitive organs of the bird because of the ultra-infiltration function and excretion of all body wastes. chemicals and even poisons and toxins. Aflatoxin contamination surveys clearly indicate that aflatoxins are a threat to animal health wherever and whenever conditions favour aflatoxin production (Dollear, 1969 and Munch and Stein, 1986). Of the numerous aflatoxins which have 1been identified. reference is usually made to the one which is by for the most predominant in occurrence and the most potent, namely aflatoxin B_1 (Glahn, 1993 and Abdel-Hamid and Mabrouk, 1999).

For the poultry industry, the nephrogenic and hepatotoxic activity of aflatoxin B_1 are of minor consequence as the life span of commercial fowl is seldom long enough to allow significant outbreaks to develop, however, the economic impact of kidney dysfunction in broilers is less obvious, probably because kidney damage rarely progress to complete renal failure and death, unless the birds have consumed a nephrotoxin or have been exposed to a virulent nephropathogenic virus (Smith and Itamilton, 1970, Rao, 1982, Dalvi, 1986, Cook, 1990 and Abd El-Hamid, *et al.,* 1992).

Dietary aflatoxin B_1 has been reported to be highly toxic to broiler chicks when fed a higher dose of AFB_1 (more than 200 ug /kg feed) from 2 to 5 weeks of age (Giambrone, *et al.,* 1985a, 1985b, 1986c and Cook, 1990).

There are general agreement in literature that AFB_1 has nephrogenic, hepatotoxic, metabolic disorders and immune suppression effects to broilers. Among these effects, impaired, growth performance (Smith and Hamilton, 1971, Tung, *et al.*, 1973; Prior, *et al.*, Dalvi and Ademoyemoyero, 1984, Mashaly, *et al.,* 1988 and Abd El-Hamid, *et al.,* 1992), kidney dysfunction (Kubena, *et al.,* 1988, Wideman, 1988, Glahn, *et al.,* 1989, 1990, 1991 and 1993), accumulation of uric acid in the blood (uricemia) and precipitates of urates in ureters and internal organs (Siller, 1959, Hamilton, *et al.,* 1982, Hnatow and Wideman, 1985 and Glahn, *et al.,* 1991), and increased water consumption and excretion due to increased urine flow and decreased glomerular filtration rate (Wideman and Cowen, 1987, Wideman, 1988b, Wideman, *et al.,* 1992 Glahn, *et al.,* 1993). Besides, changes in the blood chemistry and calcium and phosphorus levels in plasma and urine ever also reported (Wolbach, 1955, Lanza, *et al.,* 1980, Wideman and Braun, 1981, Gustavson, *et al.*, 1981, Wideman, *et al.,* 1985, 1987 and Philips, *et al.,* 1991). It is important that the post-mortem diagnosis of visceral gout provides direct evidence that death was caused by kidney failure, however, it does not identify the cause of this damage. Because many factors (toxins, diseases, nutritional imbalance) can damage the kidney, the present study was designed to determine the effect of two doses of AFB_1 in broiler chick diets on kidney function and the related haematological parameters, along with their impact on growth performance.

MATERIALS AND METHODS

Birds and Management

One hundred thirty five day old, meat type broiler (Hubbard) chicks were individualy weighed and randomized into three groups of 45 chicks each (in 3 replications) and placed in electrically heated brooder battaries. The experimental, unmedicated, starter and finisher diets used are shown in Table (1). The diets contained or exceeded levels of critical nutrients recommended by the National Research Councel (NRC, 1994). The three treatment groups of chicks received diets containing 0, 100, or 200 µg aflatoxin B_1 (AFB_1)/kg diet. Aflatoxin B_1 was produced, extracted and purified by the method of Huff, *et al.* (1974), with temperature modification reported by Abd El-Hmid *et al.* (1992). The respective diets and fluorescent lighting schedule (23L:ID) for the whole experimental period (7 weeks).

Table 1. Composition of the basal diet

Ingredients (%)	Starter	Finisher
Ground yellow corn	64.40	69.75
Soybean meal (44%)	20.00	20.00
Corn glulen meal (62%)	4.00	-
Concentrate (52%)	10	10
Vegetable oil	1.50	-
DL-Methionine	0.08	0.19
L-Lysine HCL	0.02	0.06
Calculated analysis (%):		
Crude protein	22.13	20.07
ME (Kcal/kg)	3100	2975
Calcium	0.95	0.95
Av. Posphorus	0.45	0.44
Lysine	1.10	1.10
Methionine	0.55	0.60
Methionine+cystine	0.90	0.92

The chicks were biweekly weighed and feed consumption was recorded. At six week of age, 15 chicks per treatment (5 birds/replicate) were taken for blood samples collection (wing-vein), then slaughtered and the kidney, liver, spleen, gizzard, proventriculus thymus and the bursa of fabricius were removed and individually weighed. At autopsy, all clinical signs and/or lesions in the interal organs were also recorded.

Water consumption and Manure Moisture determination:

At beginning of the 7th week of age, 20 chicks/group had free access to individual water pan containing a predetermined valume of water. Water consumption was determined by daily measurement of the volume of water remaining in each container of water. In addition water containers placed in empty cages were used to correct for evaporation. Fresh excreta samples were collected from each cage group into preweighed aluminum containers for a 2-h period and then immediately weighed to determine the wet weight. The excreta samples were then oven-dried at 100C for 3 h to obtain the dry weight. The excreta moisture was calculated as an indicator for diuresis.

Surgical preparations and inulin infusion:

At the end of the 7th week of age, 5 birds/group were randomly chosen and overmight starved before the operation. Water was however provided. Birds were anesthetized with i.v. injections of thiopentone sodium (1 ml/kg body weight). Supplemental drug (0.25 ml) was injected, as needed, to maintain general surgical anesthesia. A heat lamp was used to keep the birds warm. The brachial and the anterior tibial veins were cannulated with heparinized polyethylene tube (PE-50). The brachial cannula was used for systemic interavenous infusion of inulin (100 ml/dl inulin) while the tibial cannula was used to infuse mannitol (2.5%) into the renal portal system.

Mannitol and inulin solutions were infused at a rate of 0.2% ml/kg BW in the tibial cannula. Mannitol is necessary to hydrate the birds and increase their urine flow rates to obtain adequate urine sample volumes during short duration as reparted by Wideman and Braun (1982). Blood samples were

collected from the carotid artery. Urine was collected from ureters using a small graduated syringe as described by Hnatow and Wideman (1985).

Urine flow rates were expressed as ml/kg BW-min. Glomerular filtration rates (GFR) were colculated as clearance of inulin (INC) (Urine inulin concentration/plasma inulin concentration X Urine flow rate) as reparted by Glahn, *et al.*, (1989).

Blood analysis:

Plasma levels of uric acid, creatinine, glucose, inorganic phosphorus, Ca, total protein, creatine kinase, glutamic oxaloacetic (GOT) and glutamic-pyruvic (GPT) transaminases were spectrophotemetrically measured using available commercial kits (Biomerieux, France).

Statistical analysis:

Data were statistically analyzed as two way design by analysis of variance using the General Linear Models (GLM) procedure of SAS (SAS Institute, 1989) to determine the effects of copper-supplemented level and age. When significant treatment effects were detected. Means were separated using Duncan's new multiple range test (Steel and Torrie, 1960). A probability level of less than or equal to 0.05 was considered significant.

RESULTS AND DISCUSSION

A- Growth performance :

Average values for live body weigh, weight gain and mortality rate are presented in Table 2. The decrease in body weight due to dietary aflatoxin B_1 administration was proportional to the dose of AFB_1. All treated chicks gained significantly less than the controls during the whole experimental period. The present results are consistent with the reports of Huff *et al.* (1986a,b) and Abd El-Hamid, *et al.* (1992) who observed that chicks fed diet containing AFB_1 had reduced performance. Moreover, the mortality rate increased significantly as the dose increased.

Table 2. Effect of AFB_1 contaminated diets on live body weight (g) and weight gain (g) of broiler chicks at 2, 4 and 6 weeks of ages[1].

Variable	AFB_1 levels		
	0 µg/kg	100 µg/kg	200 µg/kg
Live body weight (g)			
One-dav old	41.29±2.2	41.66±1.9	42.18±2.1
2 wks	456.82^{a}±15.1	385.63^{b}±12.2	324.74^{c}±13.4
4 wks	998.36^{a}±20.8	864.52^{b}±35.1	736.80^{c}±42.3
6 wks	1684.44^{a}±66.3	1450.38^{b}±72.8	1339.63^{c}±74.6
Body weight gain (g)			
0-2 wks	415.53^{a}±8.6	343.97^{b}±16.4	282.56^{c}±13.4
2-4 wks	541.54^{a}±28.9	478.89^{b}±36.6	412.06^{b}±44.3
4-6 wks	686.08^{a}±35.5	585.86^{b}±29.5	602.83^{a}±32.6
0-6 wks	1643.15^{a}±81.3	1408.72^{b}±64.2	1297.45^{c}±73.4
Mortality rate (%)			
0-6 wks	4.26^{c}	6.81^{b}	11.54^{a}

[1] **Data were expressed as mean ±SEM**

[a,b,c] **Means within rows having different superscripts are significantly different (P<0.05).**

On the otherhand, feed consumption of treated chicks decreased (Table 3). When compared to the controls, the quantity of feed required per unit of gain was increased far greater by the high AFB_1 dose than by the lower dose, although the difference between treated groups was not significant. It appears from the results that growth retardation and low feed intake coincident by impaired feed conversion and high mortality rate are early signs seen in the AFB_1 treated groups. This reduction in chicks performance may be due to decreased DNA, RNA synthesis in the liver and bone marrow cells which in turn decreased muscle protein synthesis. Our results are consistent with and support the previous work of Prior, *et al.* (1980), Mashaly, *et al.* (1986) and Abd El-Hamid and Mabrouk, (1990).

Table 3. Effect of AFB_1 levels on feed consumption and feed conversion ratio of broiler chicks at 2, 4 and 6 weeks of age[1].

Variable	AFB_1 levels		
	0 µg/kg	100 µg/kg	200 µg/kg
Feed consumption (g)			
0-2 wks	482.3^{a}±30.6	430.8^{a}±22.8	393.6^{b}±32.5
2-4 wks	891.8±43.4	850.6±38.6	860.7±25.8
4-6 wks	1900.8^{a}±150.2	1749.0^{b}±130.4	1602.5^{b}±102.4
0-6 wks	3274.9^{a}±180.3	3030.4^{b}±140.2	2856.8^{c}±122.6
Feed conversion ratio			
0-2 wks	1.16^{b}±0.08	1.25^{a}±0.10	1.39^{a}±0.09
2-4 wks	1.64^{c}±0.13	1.78^{b}±0.12	2.08^{a}±0.19
4-6 wks	2.7±0.22	2.9±0.31	2.6±0.24
0-6 wks	1.99^{b}±0.09	2.15^{a}±0.12	2.2^{a}±0.08

[1] Data were expressed as mean ±SEM

[a,b,c] Means within rows having different superscripts are significantly different (P<0.05).

B- Organs relative weights and blood parameters :

Concerning the relative weights of the liver and other internal organs (Table 4), it is clear from the results that when compared with controls relative weights of the liver, kidneys, proventriculus and gizzard were increased by AFB_1 administration, whereas, the relative weights of spleen, thymus and bursa of Fabricius were significantly decreased.

Table 4. Effect of AFB_1 on relative organ weight of broiler chicks at 6 weeks of age[1].

Reletive organ Weight (%)	AFB_1 levels		
	0µg/kg	100 µg/kg	200 µg/kg
Liver	3.21±0.13	3.40^{b}±0.18	3.96^{a}±0.43
Kidney	1.12^{c}±0.09	1.52^{b}±0.14	1.73^{a}±0.22
Proventriculus	0.65^{b}±0.04	0.82^{a}±0.07	0.96^{a}±0.12
Gizzard	3.5^{b}±0.32	3.61^{b}±0.38	4.26^{a}±0.40
Spleen	0.22^{a}±0.03	0.18^{ab}±0.05	0.16^{b}±0.03
Thymus	0.69^{a}±0.02	0.62^{a}±0.06	0.48^{b}±0.09
Bursa	0.24^{a}±0.04	0.18^{a}±0.05	0.15^{b}±0.04

[1] Data were expressed as mean ±SEM

[a,b,c] Means within rows having different superscripts are significantly different (P<0.05).

The treated chicks showed also a significant increase in hematocrit (Ht) value, blood uric acid, creatinine, calcium, alkaline phosphatase activity (AIK. Ph.), GOT and GPT, whereas, plasma total protein, inorganic phosphorus and creatine kinase were significantly decreased (Table 5). The increased relative liver weight might be associated with alterations in lipid metabolism, primarily as a result of impaired lipid transport.

Table 5. Effect of AFB_1 on some blood constituents and enzymes of broiler chicks at 6 weeks of age[1].

Vairable	AFB_1 levels		
	0	100 µg/kg	200 µg/kg
Blood constituents:			
Ht (%)	$29.2^{c}\pm3.1$	$33.4^{b}\pm3.8$	$36.6^{a}\pm4.2$
Uric acid (mg/dl)	$4.2^{c}\pm0.15$	$6.5^{b}\pm0.30$	$7.8^{a}\pm0.54$
Creatinine (mg/dl)	$0.52^{b}\pm0.04$	$0.60^{ab}\pm0.03$	$0.69^{a}\pm0.06$
Total plasma proteins (g/dl)	$4.8^{a}\pm0.54$	$4.6^{a}\pm0.58$	$4.2^{b}\pm0.36$
Plasma Ca++ (mg/dl)	$12.1^{a}\pm1.2$	$11.3^{b}\pm1.1$	$9.8^{c}\pm1.2$
Plasma phosphorus (mg/dl)	$5.6^{a}\pm0.81$	$5.3^{a}\pm0.66$	$3.9^{b}\pm0.56$
Blood enzymes:			
Alk.Ph. (IU/L)	$372.6^{c}\pm40.8$	$465.5^{b}\pm61.3$	$593.8^{a}\pm58.4$
GOT (IU/L)	$54.60^{c}\pm8.64$	$75.73^{b}\pm10.30$	$95.44^{a}\pm15.38$
GPT (IU/L)	$19.66^{a}\pm2.82$	$22.86^{a}\pm2.61$	$20.18^{a}\pm2.48$
Creatine kinase (IU/L)	$180.40^{a}\pm11.53$	$152.54^{b}\pm18.43$	$120.46^{c}\pm16.36$

[1] Data were expressed as mean ±SEM

[a,b,c] Means within rows having different superscripts are significantly different (P<0.05).

The results of Dalvi and Mcgowan (1984), Giambrone, *et al.* (1985a,b), Kubena, *et al.* (1988) and Cooke, (1990). Confirm and support the present results. The increased relative kidney weights, increased blood uric acid and creatinine levels indicates impaired renal function due to the ingestion of AFB_1. Relative gizzard and proventriculus weights were significantly greater in AFB_1-treated groups than in the control one, possibly due to overall irritative properties of the aflatoxins. The response of the gizzard and proventriculus to AFB_1 appears to be related to the dose and may reflect strain variability, diet composition, feed intake, water consumption or other unidentified factors (Kubena, *et al.*, 1985, Glahn, *et al.*, 1988, 1989 and 1993). Changes in the relative spleen weights were significant at the high dose of AFB_1, compared with the control chicks. Furthermore, when compared to the controls, the relative thymus and bursa weights were significantly lower only in the high AFB_1 treated chicks.

This may be due to the immune suppressive effect of aflatoxins on these organs, which confirms the previous findings of Mallinson, *et al.* (1984), Campbell *et al.* (1982), Dwivedi and Butns (1985) and Chang *et al.* (1982).

Because the kidneys are the primary organs that regulate electrolyte balance, the present results revealed that the reduction in could be plasma Ca and Pi were significantly reduced due to the effect of AFB_1, on kidney function. It appears that when renal function is impaired due to aflatoxicosis, reabsorption of Ca and excretion of P may be impaired. Kubena, *et al.* (1988), Wideman, *et al.* (1987), and Glahn, (1991) reported that the depressed plasma Ca level may stimulate parathormone release which would also

enhance the renal excretion of phosphorus and adversely affect the bone ossification. This holds true as the present results show the alkaline phosphatase activity was significantly increased in the treated chicks. It is well documented that the increased alkaline phosphatase activity is related to medullary bone resorption in birds (Hnatow and Wideman, 1985, and Cook, 1990 and Glahn, 1993).

In general, results concerning uric acid, plasma total protein, creatinine and creatine kinase may explain the reduction of broiler growth when the diet is contaminated by AFB_1 uric acid is the primary product of nitrogen catabolism in chickens and is excreted by the kidney. When blood uric acid and creatine kinase increased as indicators of kidney dysfunction as reported by Huff, *et al.* (1974) and Wideman, *et al.* (1983, 1985, 1987, and 1992).

C- Renal function values:

In the present study, it was observed that water consumption signifcantly increased in the treated groups compared with the control one (Table 6). This may explain the higher hematocrit (%) obtained in the present study which reflect hemoconcentrations of blood, that could be traced to the significant incraese in urine flow rate and excreta moisture.

Table 6. Renal function of broiler chicks fed AFB_1 – contaminated diet for 7 weeks of age[1].

Vairable	AFB_1 levels		
	0 µg/kg	100 µg/kg	200 µg/kg
Water intake (ml/day)	$322^{c}\pm29$	$640^{b}\pm68$	$995^{a}\pm86$
Excreta moisture (%)	$66^{c}\pm2$	$82^{b}\pm6$	$91^{a}\pm4$
GFR (ml/min)	$0.87^{a}\pm0.04$	$0.76^{ab}\pm0.03$	$0.72^{b}\pm0.04$
Urine flow (ml/min)	$0.04^{b}\pm0.002$	$0.06^{b}\pm0.003$	$0.09^{a}\pm0.006$
Urine excreted Ca (µm/min)	$0.09^{c}\pm0.01$	$0.14^{b}\pm0.03$	$0.29^{a}\pm0.08$
Urine excreted Pi (µm/min)	$0.52^{b}\pm0.09$	$0.58^{ab}\pm0.08$	$0.61^{a}\pm0.11$

[1] **Data were expressed as mean ±SEM**

[a,b,c] **Means within rows having different superscripts are significantly different (P<0.05).**

It is clear that AFB_1 caused an increase in urine flow rates. However, glomerular filtration rate (GFR) decreased as the dose of AFB_1 increased (Table 6). At the same time Ca and P excretion in urine increased which explains their low levels in blood plasma. It appears that AFB_1 may disrupt kidney structure and function which leads to excessive urinary loss and increased excreta moisture (Table 6). This is usually coincident with the observed increase in water intake. Similar results were obtained by Siller and Cumming (1974), Niznik, *et al.* (1985), Siller (1981) and Wideman, *et al.* (1992).

Urine flow rates averaged 04, 06 and 09 ml/min for the control, 100 and 200 µg AFB_1-treated groups. respectively. It appears that arginine vasotocin (AVT) which regulates the water and mineral balance may play a role in kidney function especially the urine flow and glomerular filteration rate. This was consistent with the findings of Wideman *et al.* (1992) and Glahn, (1993).

In general the data indicate that under the experimental conditions employed, AFB_1 may be nephrotoxic at a higher dose (200μg/kg). These data suggest caution should be made when formulating diets with poor ingredient quality to obtain good performance of chickens.

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تأثير الافلاتوكسينات فى علائق بدارى اللحم على وظائف الكلى وبعض مكونات الدم

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اجريت هذه التجربة لمعرفة تأثير الافلاتوكسينات على وظائف الكلى وبعض صفات الدم فى بدارى اللحم عند اضافتها بجرعات ١٠٠، ٢٠٠ ميكرو جرام/كجم من العليقة. استخدم عدد ١٣٥ كتكوت تسمين عمر يوم فى هذه التجربة وقسمت الكتاكيت الى ثلاث مجموعات احداها غذيت على العليقة القاعدية (مجموعة المقارنة) بينما غذيت المجموعتان الاخريتان على علائق محتوية على ١٠٠، ٢٠٠ ميكرو جرام افلاتوكسين ب١/كجم من العليقة.

ادت المعاملات الى انخفاض وزن الجسم بصفة عامة فى جميع الاعمار (٢، ٤، ٦ اسابيع من العمر) كما انخفض استهلاك الغذاء وتدهورت كفاءة التحويل الغذائى. تأثرت الاوزان النسبية لبعض اعضاء الجسم حيث ذاد وزن الكبد والكلى والمعدة الغدية والقانصة بينما انخفض الوزن النسبى للغدد المناعية بالجسم (الغدة الثيوسية والطحال وغدة البرسا).

تأثرت قياسات الدم المختلفة حيث زاد مستوى حمض اليوريك فى الدم والكرياتينين وانزيم الفوسفاتيز القاعدى والانزيمات الناقلة لمجموعات الامين بينما انخفض مستوى البروتينات الكلية فى اللبلازما والكالسيوم والفسفور وانزيم الكرياتين كينيز وذلك يعكس الاثر السلبى للافلاتوكسين ب١ على عمليات تمثيل الاملاح المعدنية والغذاء. كما لوحظ ان لاضافة الافلاتوكسين تأثير سيئ على نسبة الحى حيث ارتفعت نسبة النفوق فى الطيور كما زاد معدل شرب الماء ومعدل خروج البول مع انخفاض معدل الترشيح من الكلى.وكل ذلك ادى فى النهاية الى زيادة نسبة الرطوبة فى الزرق وبالتالى بلل الفرشة. ومن التأثيرات السيئة ايضا الزيادة المعنوية فى اخراج الكالسيوم والفوسفور فى البول لعدم قدرة الكلى على اعادة امتصاصهما او التحكم فى اخراجهما.

ومن النتائج السابقة نستخلص ان احتواء العليقة على افلاتوكسينات يصل الى ١٠٠ ميكروجرام/كجم يكون له تأثير ضار على مناعة الطيور ووظائف الكلى بما ينعكس فى النهاية على الاداء الانتاجى للطيور كما ان هذا التأثير الضار يزيد كلما زاد مستوى سمية الافلاتوكسينات فى العليقة لدجاج التسمين.