Zagazig J. Agric. Res., Vol. 46 No. (5) 2019 1593-1603

Animal, Poultry and Fish Production Research

http:/www.journals.zu.edu.eg/journalDisplay.aspx?Journalld=1&queryType=Master

# REDUCTION OF HAZARDS OF AFLATOXINS CONTAMINATED RABBIT DIETS BY SOME PLANT ADDITIVES

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**Received: 02/06/2019 ; Accepted: 28/07/2019**

**ABSTRACT:** The present work was carried out to evaluate the effect of water spinach (WS) on alleviation the toxicity of aflatoxin $B_1$ ($AFB_1$) in rabbit contaminated diets. Forty eight male New Zealand white (NZW) growing rabbits (average body weight 538.8±34.72g) were assigned to 6 experimental groups (8 rabbit/group). The animal groups were fed the following diets: control diet, control diet + 2.5% dried WS, control diet + 5.0% WS, $AFB_1$ contaminated diet (300 ppb), $AFB_1$ + 2.5% WS and $AFB_1$ + 5.0% WS. Addition of dried WS led to increase of crude protein, ether extract and ash content of diets. On the other hand, crude fiber and nitrogen free extract decreased. The rabbits performance decreased by $AFB_1$ contaminated diet (live body weight, body weight gain, daily feed intake, feed conversion, digestibility of dry matter, organic matter, crude fiber, ether extract, nitrogen free extract, total digestible nutrients and digestible crude protein). Also, the blood hematology and biochemistry impaired by $AFB_1$. Addition of dried WS to$AFB_1$ contaminated diet led to improve rabbit performance and blood parameters which negatively affected by $AFB_1$. In conclusion, addition of 2.5% of dried water spinach to $AFB_1$ contaminated diet can be recommended to reduce the toxic effects of $AFB_1$ on rabbit's performance.

**Key words:** Water spinach, aflatoxin, rabbits, body weight, feed conversion, digestibility, blood.

## INTRODUCTION

One of the most important problems in the field of human and animal nutrition is contamination of human foods and animal feeds with molds and mycotoxins. More than 25% of the world's cereals are contaminated with known mycotoxins. These toxins are mainly produced by the fungal genera of *Aspergillus, Fusarium* and *Penicillium* **(Devegowda *et al.,* 1998)**. Aflatoxins are secondary metabolites produced by some fungi such as *Aspergillus* spp., *Penicillium* spp. and *Rhizopus* spp. Aflatoxins are considered the most dangerous mycotoxins. Aflatoxicosis caused by aflatoxin $B_1$ and related toxins represent one of the most serious diseases for rabbits and other animal species **(Marai, and Asker, 2008)**. Aflatoxicosis take form of carcinogenicity, hepatitis, nephritis, dermatitis and genacologic forms **(Gong *et al.,* 2016).** Different methods were used to reduce mycotoxins for animals and humans **(Nowar *et al.,* 1996; Shehata, 2002; Shehata and Mohamed, 2011; Helal, 2014)**. Water spinach (WS) is easy to grow on soil or in water and is highly growth responsive to fertilizers. Spinach has high nutritive value for rabbits **(Samkol, 2009)**. Addition of chlorophyll of WS to aflatoxin $B_1$ contaminated diet at level of 2 or 4 g/kg diet had significant favorable effects on rabbits live body weight, daily body weight gain, daily feed intake, digestibility of nutrients and nutritive value as digestible crude protein. Also, chlorophyll improved blood constituents of rabbits **(Helal, 2014)**. This work was carried out to study the ability of dried WS on detoxification of $AFB_1$ contaminated rabbits diet.

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# MATERIALS AND METHODS

The present work was carried out at the Rabbit Farm and Laboratories of the Animal Production Department, Faculty of Agriculture, Zagazig University, Zagazig, Egypt.

## Experimental Treatments

Forty eight growing NZW male rabbits with average body weight 538.8 ± 34.72g were assigned to 6 experimental groups (8 animals/ group). The animal groups were fed the following diets: Control diet (diet 1), Control diet + 2.5% spinach (diet 2), Control diet + 5.0% spinach (diet 3), $AFB_1$ contaminated diet (300 ppb) (diet 4), $AFB_1$ + 2.5% spinach (diet 5) and $AFB_1$ + 5.0% spinach (diet 6).

Ingredient (%) of basal diet as follows: yellow corn 28.30%, clover hay 26.00%, wheat bran 23.00%, soybean meal 19.00%, sodium chloride 0.30%, methionine 0.35%, vitamin and mineral premix 0.30%, dicalcium phosphate 2.35% and limestone 0.40%. The chemical composition of spinach (%): DM 100%, OM 74.82%, CP 26.65%, CF 13.49%, EE 4.74%, NFE 29.95% and Ash 25.18%. The chemical composition of basal diet, basal diet + 2.5 or 5% dried WS are shown in Table 1. The experimental diets were form alated to be iso caloric and iso nitrogenous and met the nutritional requirements of rabbits according to **NRC (1977)**.

## Preparation of Aflatoxin

The media was found to contain $AFB_1$ alone. *Aspergillus flavus* MD 341 was obtained from the Central Lab. of Residues of Agricultural Products, Agriculture Pesticides Residues Centre, Dokki, Egypt for production of $AFB_1$. The fungus of *Aspergillus flavus* was incubated for 8 days on liquid media containing 2% yeast extract and 20% sucrose. Aflatoxins concentration in media was determined by using the method of **AOAC (1990)**.

## Preparation of Diets

Water spinach (WS) was purchased from local market at Zagazig area, Egypt. It was dried in oven at 60ºC and then ground. The ingredients of basal diet with or without dried WS were mixed and pelleted. The fungal media containing $AFB_1$ was sprayed on pelleted diet with or without WS to obtain level 300ppb of $AFB_1$.

## Animal Rearing

All animals were individually housed in stainless steel cages. All rabbits were continually provided with fresh water, and were maintained under the same managerial, hygienic and environmental conditions all over the experimental period (7 weeks). Rabbits were fed *ad-libitum*. All rabbits were individually weighed at the beginning of the experiment and at weekly intervals. Also feed intake was determined weekly and then daily feed intake was calculated. The feed conversion (feed intake/weight gain) was calculated.

## Digestibility Trail

At the end of experimental period, digestibility trial (4 animals/group) was carried out to evaluate the effect of treatments on nutrients digestibility and feeding values as TDN% and DCP%. Digestibility trail lasted for 5 days as a collection period. Coprophagy was not prevented. Samples from both feeds offered and dried feces of each animal were taken daily during the collection period for chemical analysis which was carried out according to **AOAC (2000)**.

## Blood Parameters

At the end of the experimental feeding period, blood samples with or without heparin of 4 rabbits/ group were collected at slaughter time. Blood hematology was carried out in private laboratory. Also, total protein, albumin, aspartate amino transferase (AST) and alanine amino transferase (ALT) of rabbit serum were analyzed using commercial kits purchased from Diamond Diagnostics Company, Egypt.

## Carcass Traits

At the end of the experimental period four rabbits from each group were randomly taken for slaughter after being fasted for 12 hours. After complete bleeding, the carcass organs were weighed and then the% of organs related to the live body weight was calculated.

## Statistical Analysis

Data of the experiment were statistically analyzed using the general linear model program of **SAS (1996)**. Significant differences between treatment means were tested by Duncan's Multiple Range Test **(Duncan, 1955)**.

# RESULTS AND DISSCUSION

## Chemical Composition of the Experimental Diets

Addition of WS (2.5 or 5%) led to increase of crude protein, ether extract and ash content and decreased the crude fiber and nitrogen free extract of the basal diet (Table 1). These results may be due to the chemical composition of WS.

## Body Weight and Daily Body Gain

The live body weight was significantly (P<0.05) decreased in rabbits fed $AFB_1$ contaminated diet in all experimental weeks in comparison with control (Table 2). Also, $AFB_1$ reduced daily body weight gain at 1st, 2nd, 3rd, 7th weeks and the average of total period (Table 3) compared to the control. These results agree with those recorded by **Salem *et al.* (2001), Orsi *et al.* (2007), Shehata (2012), Prabu *et al.* (2013) and Helal (2014).** These effects of $AFB_1$ may be due to the depression of feed intake, but may also be due to the reduction in metabolism of protein, lipids, carbohydrate and dissolved vitamin in lipid **(Marai and Asker, 2008).** Addition of WS at 2.5 or 5% of diet led to significantly (P<0.05) improve of body weight and daily body weight gain (except 1st and 2nd week) which the results did not significantly differ with control. These results agree with those recorded by **Kea *et al.* (2003)** in pigs, **Simonich *et al.* (2008)** in the rainbow trout and **Shehata (2012)** in rabbits**.** The improvement in body weight gain by WS may be due to its content of natural chlorophyll (CHL), which reduce the absorption of aflatoxins from the intestine and increase the excretion of it in feces **(Simonich *et al.*, 2008)**. Also, WS enhances the activity of antioxidantaL enzymes such as glutathione peroxidase, superoxide dismutase, catalase and glutathione-s-transferase, indicating that WS bosses a potent protective effect against $AFB_1$ **(Kumar *et al.*, 2012)**.

## Feed Intake

$AFB_1$ significantly (P<0.05) decreased daily feed intake at 4th, 5th, 6th and 7th weeks and average of total period in compared to control (Table 4). These results agree with those recorded by **Shehata (2002), Shehata *et al.* (2003) and Helal (2014)**. Addition of WS at 2.5 or 5% of the diet led to significantly (P<0.05) increase in daily feed intake of rabbits at 4th, 6th, 7th weeks and average of total period comparing to rabbits fed $AFB_1$ contaminated diet without supplementation. These results agree with those recorded by **Devienne *et al.* (2005), Chat *et al.* (2005), Shehata (2012) and Helal (2014)**.

## Feed Conversion

Feed conversion ratio was significantly (P<0.05) impaired at 1st, 2nd, 5th, 7th weeks and average of the experimental period in rabbits fed $AFB_1$ contaminated diet comparing to animals fed control diet (Table 5). These results agree with those reported by **Boonyaratpalin *et al.*, (2001), Bintvihok *et al.*, (2003) (Samkol, 2009) and Burgos-Hernandez *et al.*, (2005). Also, Shehata, (2012)** reported that the worst feed conversion was obtained in rabbits fed 350ppb $AFB_1$ contaminated diet. However, the bad feed conversion with $AFB_1$ contaminated diet might be due to that the relative advers effect of $AFB_1$ on body weight gain was over than that on daily feed intake. Feed conversion ratio was significantly (P<0.05) improved at 1st, 2nd and 3rd weeks by addition 5% WS. Generally, the average of feed conversion ratio did not improve in rabbits fed 2.5 or 5% WS plus $AFB_1$ comparing to animals fed $AFB_1$ diet alone (Table 5). These results agree with those reported by **Shehata (2012) and Helal (2014)**. The improvement in feed conversion ratio by addition WS may be due to CHL in spinach which form molecular complexes with carcinogens material like $AFB_1$ and blocking their bioavailability, therefore reduce the deleterious effects on organs body functions **(Egner *et al.*, 2003)**.

## Digestibility and Nutritive Values

Digestibility of dry matter (DM), organic matter (OM), crude fiber (CF), ether extract (EE), nitrogen free extract (NFE) and total digestible nutrients (TDN) were decreased compared to the control (Table 6). These results agree with those reported by **Ibrahim (2000), Shehata (2002) and Helal (2014)**. This bad effect

**Table 1. Chemical composition of the experimental diets**

| Nutrient | Diet | | |
|---|---|---|---|
| | Control diet | Control diet + 2.5% dried water spinach | Control diet + 5% dried water spinach |
| **Dry matter** | 100 | 100 | 100 |
| **Organic matter** | 88.02 | 87.70 | 87.39 |
| **Crude protein** | 18.92 | 19.11 | 19.29 |
| **Crude fiber** | 17.41 | 17.31 | 17.22 |
| **Ether extract** | 4.08 | 4.10 | 4.11 |
| **Nitrogen free extract** | 47.61 | 47.18 | 46.77 |
| **Ash** | 11.98 | 12.30 | 12.61 |

**Table 2. Effect of aflatoxin $B_1$ and water spinach on rabbits body weight (g) (X±SE)**

| Item | Diet | | | | | |
|---|---|---|---|---|---|---|
| | Control | 2.5% water spinach | 5% water spinach | Aflatoxin contaminated | Aflatoxin + 2.5% water spinach | Aflatoxin + 5% water spinach |
| **Initial weight** | 602.14±148 | 547.14±141 | 502.86±154 | 539.29±105 | 520.71±154 | 520.71±150 |
| | a | a | ab | b | b | b |
| **1st week** | 905±203 | 838.57±136 | 758.57±219 | 750.71±180 | 764.29±207 | 753.60±178 |
| | a | a | ab | c | bc | b |
| **2nd week** | 1189.29±172 | 1174.29±213 | 1013±294 | 920±233 | 955.71±278 | 977.86±190 |
| | a | a | ab | b | ab | ab |
| **3rd week** | 1400.71±173 | 1430.71±283 | 1225.14±331 | 1082.86±299 | 1166.43±284 | 1166.43±202 |
| | a | a | ab | b | ab | ab |
| **4th week** | 1630±172 | 1660±265 | 1460.86±340 | 1266.43±368 | 1369.29±304 | 1352.14±238ab |
| | a | a | ab | b | ab | b |
| **5th week** | 1892.14±247 | 1897.14±302 | 1650.86±314 | 1430.71±413 | 1577.14±284 | 1520.71±226 |
| | a | a | ab | b | ab | ab |
| **6th week** | 2108.57±251 | 2105.71±306 | 1848.71±301 | 1605±482 | 1806.43±285 | 1740±265 |
| | a | a | ab | b | ab | ab |
| **7th week** | 2372.86±267 | 2281.43±327 | 2043±299 | 1760±540 | 2038.57±296 | 1981.42±265 |

a, b, c means in the same row with different superscript different significantly ($p<0.05$).

**Table 3. Effect of aflatoxin $B_1$ and water spinach on rabbit's daily body weight gain (g) (X±SE)**

| Item | Diet | | | | | |
|---|---|---|---|---|---|---|
| | Control | 2.5% water spinach | 5% water spinach | Aflatoxin contaminated | Aflatoxin+2.5% water spinach | Aflatoxin+5% water spinach |
| | a | a | ab | b | b | b |
| 1st week | 43.27±12.18 | 41.63±8.76 | 36.53±13.15 | 30.20±12.97 | 34.80±8.84 | 33.27±8.04 |
| | a | a | ab | c | bc | b |
| 2nd week | 40.61±10.78 | 47.96±13.34 | 36.35±13.17 | 24.18±1087 | 27.35±11.52 | 32.04±6.45 |
| | ab | a | ab | b | ab | b |
| 3rd week | 30.20±10.78 | 36.63±11.27 | 30.31±8.77 | 23.27±10.88 | 30.10±8.33 | 26.94±6.25 |
| 4th week | 32.76±10.78 | 32.76±6.99 | 33.67±3.46 | 26.22±12.75 | 28.98±8.19 | 26.53±7.82 |
| 5th week | 37.45±10.78 | 33.88±11.10 | 27.14±6.19 | 23.47±16.97 | 29.69±8.13 | 24.08±4.38 |
| 6th week | 30.92±10.78 | 29.80±5.23 | 28.26±8.28 | 24.90±20.14 | 32.76±3.53 | 31.33±8.52 |
| | a | bc | bc | c | ab | ab |
| 7th week | 37.76±10.78 | 25.10±4.37 | 27.76±3.39 | 22.14±11.44 | 33.16±6.62 | 34.49±4.59 |
| | a | a | a | b | ab | ab |
| Average | 36.14±10.78 | 35.39±4.94 | 31.43±4.02 | 24.91±10.10 | 30.98±3.01 | 29.81±3.47 |

a, b, c, means in the same row with different superscript different significantly ($p<0.05$).

**Table 4. Effect of aflatoxin $B_1$ and water spinach on daily feed intake (g) (X±SE)**

| Item | Diet | | | | | |
|---|---|---|---|---|---|---|
| | Control | 2.5% water spinach | 5% water spinach | Aflatoxin contaminated | Aflatoxin+2.5% water spinach | Aflatoxin+5% water spinach |
| | a | ab | ab | ab | b | ab |
| 1st week | 79.28±14.75 | 68.57±13.88 | 68.06±21.88 | 65.30±8.37 | 59.04±17.61 | 62.34±17.22 |
| | a | ab | bc | ab | bc | bc |
| 2nd week | 111.88±23.24 | 94.13±19.66 | 84.33±29.96ab | 99.35±26.91 | 86.66±34.17 | 63.52±23.96 |
| | a | a | a | ab | a | b |
| 3rd week | 105.06±13.57 | 94.10±24.27 | 92.73±20.51 | 89.94±34.08 | 101.22±37.38 | 72.97±27.77 |
| | a | a | b | b | a | a |
| 4th week | 108.73±9.33 | 106.10±12.58 | 85.02±24.94 | 80.51±43.19 | 115.89±30.02 | 113.71±28.45 |
| | a | a | b | c | a | b |
| 5th week | 111.07±16.62 | 110.85±23.76 | 98.77±26.37 | 87.96±63.46 | 125.90±29.47 | 95.50±34.94 |
| | a | ab | bc | c | a | ab |
| 6th week | 114.99±14.45 | 104.40±23.06 | 83.45±19.98 | 71.93±28.01 | 120.02±21.22 | 103.44±25.83 |
| | ab | bc | c | d | ab | a |
| 7th week | 130.61±18.68 | 109.08±26.89 | 91.35±28.41 | 70.08±41.80 | 130.44±18.46 | 146.98±33.22 |
| | a | ab | bc | c | a | ab |
| Average | 108.80±13.51 | 98.44±18.04 | 86.23±18.45 | 80.72±29.27 | 105.60±17.29 | 94.04±19.63 |

a, b, c, d, means in the same row with different superscript different significantly ($p<0.05$).

**Table 5. Effect of aflatoxin $B_1$ and water spinach on feed conversion ratio (g feed/g gain) (X±SE)**

| Item | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | Control | 2.5% water spinach | 5% water spinach | Aflatoxin contaminated | Aflatoxin+2.5% water spinach | Aflatoxin+5% water spinach |
| | b | b | b | a | b | b |
| 1st week | 1.83±0.45 | 1.65±0.43 | 1.86±0.27 | 2.16±2.36 | 1.70±0.22 | 1.87±0.37 |
| | b | b | b | a | ab | b |
| 2nd week | 2.75±1.76 | 1.96±0.76 | 2.32±0.40 | 4.11±3.08 | 3.17±1.34 | 1.98±1.07 |
| | ab | b | ab | a | ab | b |
| 3rd week | 3.48±1.96 | 2.57±0.93 | 3.06±1.37 | 3.87±4.03 | 3.36±1.93 | 2.70±1.06 |
| | ab | ab | c | bc | a | a |
| 4th week | 3.32±1.34 | 3.24±1.02 | 2.53±0.79 | 3.07±2.69 | `4.00±2.62 | 4.29±1.42 |
| | c | bc | b | ab | a | ab |
| 5th week | 2.97±0.80 | 3.27±0.49 | 3.64±1.29 | 3.75±3.98 | 4.24±1.26 | 3.97±2.16 |
| | | | | | | |
| 6th week | 3.72±0.54 | 3.50±0.81 | 2.95±1.59 | 2.89±5.39 | 3.66±1.06 | 3.30±1.14 |
| | a | a | b | b | a | a |
| 7th week | 3.46±0.51 | 4.35±0.84 | 3.29±1.25 | 3.17±3.96 | 3.93±0.95 | 4.26±0.67 |
| | b | b | b | a | a | ab |
| Average | 3.01±0.36 | 2.78±0.27 | 2.74±0.52 | 3.24±3.24 | 3.41±0.57 | 3.15±0.61 |

a, b, means in the same row with different superscript different significantly ($p<0.05$).

**Table 6. Effect of aflatoxin $B_1$ and water spinach on nutrients digestion coefficients and nutritive values (%)(X±SE)**

| Item | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | Control | 2.5% water spinach | 5% water spinach | Aflatoxin contaminated | Aflatoxin+2.5% water spinach | Aflatoxin+5% water spinach |
| **Nutrients digestion coefficient** | | | | | | |
| | ab | ab | ab | b | ab | a |
| Dry matter | 68.25±6.09 | 72.11±3.15 | 70.01±2.50 | 65.30±1.93 | 69.10±3.42 | 75.32±10.71 |
| | ab | ab | ab | b | ab | a |
| Organic matter | 70.52±5.38 | 74.04±3.14 | 71.26±2.50 | 67.62±2.21 | 70.92±3.68 | 76.43±10.35 |
| Crude protein | 74.23±4.90 | 80.30±3.20 | 77.91±2.41 | 74.75±2.70 | 77.60±2.92 | 80.36±8.01 |
| | c | ab | ab | c | b | a |
| Crude fiber | 34.93±6.71 | 50.41±5.90 | 48.92±4.93 | 31.95±13.98 | 46.70±7.70 | 65.81±21.63 |
| Ether extract | 80.36±8.99 | 80.17±5.95 | 74.58±7.03 | 76.76±5.86 | 77.34±7.21 | 80.57±15.16 |
| Nitrogen free extract | 81.19±5.19 | 80.59±4.04 | 76.46±2.60 | 77.04±3.12 | 76.58±3.08 | 81.68±7.16 |
| **Nutritive values** | | | | | | |
| Total digestible nutrients (TDN) | 66.15±4.83 | 69.50±2.88 | 66.11±2.42 | 63.42±6.31 | 66.17±3.56 | 72.48±9.93 |
| | b | ab | ab | b | ab | a |
| Digestible crude protein (DCP) | 14.04±0.93 | 15.35±0.61 | 15.03±0.46 | 14.14±0.51 | 14.83±0.56 | 15.50±1.54 |

a, b, c means in the same row with different superscript different significantly ($p<0.05$).

of aflatoxin may be due to its interfering with the bioavailability nutrients of ingested feed **(Shehata, 2010)**. Addition of dried WS at 2.5 or 5% of diet led to increase the digestibility of DM, OM, CP, CF, (EE), TDN and DCP% comparing to animals fed $AFB_1$ diet without supplementation (Table 6). These results agree with those reported by **Sudakin (2003), Simonich *et al.* (2008), Shehata (2012) and Helal (2014).** The improve in nutrieents digestibility by addition of WS may be due to its content of CHL which reduce aflatoxin effects on body function, enhance the activates of antioxidant enzymes and increase the excretion of aflatoxin in feces **(Simonich *et al.,* 2008; Kumar *et al.,* 2012).** Generally, the results did not significantly differ between rabbits fed $AFB_1$ contaminated diet plus 2.5 or 5% WS.

## Blood Parameters

Aflatoxin $B_1$ reduced the counts of white blood cells, lymphocyte, mono cytes (MID), granules, red blood cells and the values of hemoglobin, hematocrit and platelets comparing to animals fed control diet (Table 7). Concentrations of total protein, albumin and globulin (Table 8) were significantly ($P<0.05$) decreased by aflatoxin. These results are in accordance with **Abd El-Baki *et al.* (2002), Shehata (2010) and Dönmez *et al.* (2012)**. The ALT and AST activities and the values of globulin and A/G ratio did not significantly affected by $AFB_1$ as compared to the control (Table 8). **Orsi *et al.* (2007)** recorded a decrease in total protein and albumin concentration and an increase in ALT activity in $AFB_1$ treated rabbits. Increasing ALT may be due to the hepatocellular necrosis or increasing the permeability of cell membrane **(Zaky *et al.,* 2000).** The decrease in total protein and albumin may be attributed to the aflatoxin interaction with protein synthesis and cellular integrity in liver (**Orsi *et al.,* (2007).** Decrease of globulin concentration may be due to adverse effect of aflatoxin on immunity **(Marai and Asker, 2008).** Addition 2.5% WS to $AFB_1$ contaminated diet significantly ($P<0.05$) increased the percentage of lymphocyte, granules and hematocrit compared to animal fed $AFB_1$ contaminated diet alone. However, all blood hematology parameters did not significantly ($P<0.05$) differ between rabbit fed $AFB_1$ contaminated diets plus 2.5 or 5% WS (Table 7). Addition 2.5% WS to $AFB_1$ contaminated diets led to significant ($P<0.05$) improve the values of total protein, albumin, globulin and the activities of alkaline phosphatase and AST comparing to animals fed $AFB_1$ diet alone. On the other hand, addition of 2.5% WS to $AFB_1$ contaminated diet led to decrease in ALT (Table 8). Improve the blood parameters by WS may be due to the beneficial effect of CHL in WS on reduction the $AFB_1$ effects and improve body organs function. However, CHL has potential protection against several classes of mutagenis, including aflatoxin **(Dashwood *et al.,* 1998). Daniel and Sudakin, (2003)** suggested that chlorophyllin (synthetic chlorophyll dissolved in water) may modify the genotoxic effects of $AFB_1$ by inhibiting bioactivation pathways and stimulating detoxification pathways (Table 8).

## Carcass Traits

$AFB_1$ significantly ($P<0.05$) increased the viscera and liver weight as (%) of live body weight comparing to the control. The weight of kidneys, lungs and heart did not significantly affected by the dietary treatments (Table 9). These results agree with the results of **Shehata (2012) and Helal (2014)**. Increase liver weight by aflatoxin may be due to accumulation of fat in liver (fatty liver). This accumulation may be due to failure of transfer of synthesized lipids from liver **(Guerre *et al.,* 1996)**. Also, $AFB_1$ significantly reduced the carcass (%) compared to the control group. Addition 2.5% WS to $AFB_1$ contaminated diet reduced liver, viscera, lung and heart weights but increased the carcass (%) comparing to animals fed $AFB_1$ diet alone. Improvement the body weight organs by addition of WS may be due to its content of CHL which reduces the effect of aflatoxin on the organs.

In conclusion addition of 2.5% of dried water spinach to $AFB_1$ contaminated diet can be recommended to reduce the toxic effects of $AFB_1$ on rabbit's performance.

**Table 7. Effect of aflatoxin $B_1$ and water spinach on blood hematology parameters (X±SE)**

| Item | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | Control | 2.5% water spinach | 5% water spinach | Aflatoxin contaminated | Aflatoxin + 2.5% water spinach | Aflatoxin + 5% water spinach |
| White blood cells count ($10^9$/L) | 13.90±0.47 b | 13.97±0.79 a | 14.01±0.61 a | 11.72±3.95 c | 16.57±3.88 a | 12.66±2.49 b |
| Lymphocyte count ($10^9$/L) | 3.99±0.27 b | 5.75±1.22 a | 6.71±2.87 a | 2.90±0.65 b | 6.38±1.54 a | 3.93±0.43 b |
| Lymphocyte count% | 28.80±2.88 ab | 40.72±6.38 ab | 47.04±18.40 ab | 25.88±3.19 b | 47.66±8.28 a | 32.88±9.75 ab |
| Mono cytes ($10^9$/L) | 2.33±0.34 | 2.27±0.32 | 2.05±0.18 | 1.74±0.61 | 2.63±0.41 | 2.11±0.46 |
| Mono cytes% | 16.60±1.88 | 16.13±1.39 | 14.56±0.65 | 14.72±0.20 | 16.59±0.87 | 16.54±0.35 |
| Granules ($10^9$/L) | 7.59±2.70 a | 5.96±0.75 ab | 5.25±2.44 b | 7.08±2.70 a | 5.90±0.43 b | 6.64±2.46 a |
| Granules% | 54.59±1.00 ab | 43.15±7.77 ab | 38.40±19.05 a | 59.41±2.99 b | 35.75±7.42 ab | 50.59±9.41 b |
| Red blood cells ($10^{12}$/L) | 4.69±0.03 | 4.74±0.04 | 4.89±0.23 | 4.32±0.25 | 4.79±0.06 | 4.39±0.52 |
| continue | | | | | | |
| Hemoglobin (g/ dL) | 10.35±0.45 | 10.70±0.10 | 10.50±0.10 | 10.06±0.15 | 10.70±0.10 | 10.30±0.70 |
| Mean corpuscular hemoglobin concentration (g/ dL) | 31.02±.25 ab | 31.43±0.20 ab | 30.83±0.52 b | 31.07±0.41 a | 30.59±0.03 ab | 31.15±0.71 a |
| Mean corpuscular hemoglobin (pg.) | 22.06±0.84 | 22.70±0.06 | 21.53±0.99 | 23.31±1.01 | 22.59±0.26 | 23.63±1.19 |
| Mean corpuscular volume (FL) | 71.09±0.54 ab | 72.21±0.26 abc | 78.78±15.73 a | 75.02±2.26 cd | 73.87±0.91 bcd | 75.82±2.09 d |
| Red cell distribution width - CV (%) | 20.16±0.26 ab | 19.63±0.12 abc | 20.84±1.04 a | 18.43±0.95 c | 18.89±0.39 bc | 18.09±0.86 c |
| Red cell distribution width - SD(FL) | 50.03±0.27 ab | 49.48±0.13 ab | 50.69±1.04 ab | 48.18±1.03 b | 48.69±0.43 a | 48.17±1.13 ab |
| Hematocrit (%) | 33.35±0.43 | 34.19±0.37 | 34.06±0.57 | 32.38±0.91 | 35.32±0.03 | 33.14±3.00 |
| Platelets ($10^9$/L) | 483±78 | 394±11 | 385±38 | 312±208 | 330.33±56.50 | 372±103 |

a, b, c, d, means in the same row with different superscript different significantly ($p<0.05$).

**Table 8. Effect of aflatoxin $B_1$ and water spinach on blood biochemical constituents (X±SE)**

| Item | Treatment | | | | | |
|---|---|---|---|---|---|---|
| | Control | 2.5% water spinach | 5% water spinach | Aflatoxin contaminated | Aflatoxin+ 2.5% water spinach | Aflatoxin + 5% water spinach |
| Total protein (mg/dL) | a 6.59±0.435 | b 5.71±0.26 | a 6.70±0.26 | c 5.67±0.24 | ab 6.27±0.28 | ab 6.44±0.15 |
| Albumin (mg/dL) | a 3.85±0.34 | b 3.04±0.05 | a 3.84±0.29 | b 3.42±0.23 | a 3.77±0.12 | b 3.24±0.25 |
| Globulin (mg/dL) | ab 2.74±0.10 | ab 2.67±0.31 | ab 2.86±.04 | c 2.25±0.46 | b 2.51±0.39 | a 3.21±0.39 |
| A/G ratio | ab 1.40±0.70 | b 1.13±0.15 | ab 1.34±0.16 | a 1.52±0.46 | a 1.50±0.28 | b 1.01±0.41 |
| Alkaline phosphatase (u/L) | c 180.00±11.48 | b 245.75±37.39 | a 302.95±13.48 | c 186.80±13.10 | b 248.29±8.12 | c 184.71±16.59 |
| Alanine amino transferase (u/L) | c 58.24±6.48 | b 81.68±4.04 | a 103.93±20.19 | bc 71.14±12.91 | c 60.29±4.94 | a 103.93±5.76 |
| Aspartate amino transferase (u/L) | c 45.55±5.44 | a 63.08±2.96 | a 65.30±4.90 | c 42.14±2.03 | b 51.64±1.52 | d 37.57±7.58 |

a, b, c, d, means in the same row with different superscript different significantly ($p<0.05$).

**Table 9. Effect of aflatoxin B1 and water spinach on rabbits organs weight (as % of live body weight) (X±SE)**

| Item | Control | 2.5%water spinach | 5%water spinach | Aflatoxin contaminated | Aflatoxin+2.5% water spinach | Aflatoxin+5% water spinach |
|---|---|---|---|---|---|---|
| | C | c | bc | a | ab | a |
| **Viscera** | 13.59±1.27 | 13.72±0.30 | 14.57±1.73 | 17.04±1.61 | 16.16±1.46 | 17.12±0.88 |
| | C | b | bc | b | b | a |
| **Liver** | 2.32±0.14 | 3.04±0.46 | 2.89±0.20 | 3.13±0.42 | 3.11±0.62 | 3.99±0.29 |
| **Kidneys** | 0.64±0.10 | 0.73±0.09 | 0.70±0.07 | 0.67±0.10 | 0.68±0.06 | 0.77±0.10 |
| **Lungs** | 0.79±0.05 | 0.78±0.14 | 0.73±0.07 | 0.80±0.17 | 0.75±0.14 | 0.74±0.09 |
| | Ab | ab | b | a | ab | ab |
| **Heart** | 0.25±0.03 | 0.26±0.04 | 0.23±0.02 | 0.32±0.07 | 0.29±0.08 | 0.29±0.03 |
| | A | a | a | b | ab | b |
| **Carcass** | 60.36±1.78 | 60.80±1.28 | 59.94±1.83 | 55.17±4.18 | 57.58±2.22 | 54.43±2.39 |

a, b, c, means in the same row with different superscript different significantly ($p<0.05$).

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# تقليل مخاطر أعلاف الأرانب الملوثة بالأفلاتوكسين بواسطة بعض الإضافات النباتية

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تم إجراء هذا العمل لتقييم تأثير إضافة السبانخ المائية على تقليل سمية علائق الأرانب الملوثة بالأفلاتوكسين ب١، في هذه التجربة تم استخدام ٤٨ أرنب (متوسط وزنها عند البداية ٣٤,٧٢± ٥٣٨,٨ جم) وزعت على ٦ مجموعات تجريبية (٨ أرانب/مجموعة)، وتمت تغذيه حيوانات المجموعات التجريبية على العلائق الآتية: عليقة كنترول، عليقه كنترول + ٢,٥% سبانخ مائية مجففة، عليقه كنترول + ٥% سبانخ، عليقه كنترول + الأفلاتوكسين ب١ (٣٠٠ جزء في البليون)، عليقه كنترول + الأفلاتوكسين ب١ + ٢,٥% سبانخ، عليقه كنترول مضاف لها الأفلاتوكسين ب١ + ٥% سبانخ مائية، وأوضحت النتائج أن إضافة السبانخ المائية المجففة إلى العليقة أدت إلى زيادة النسب المئوية للبروتين الخام، مستخلص الأثير، والرماد، ومن ناحية أخرى أدت الإضافة إلى تقليل نسب الألياف الخام والمستخلص الخالي من النيتروجين، انخفض أداء الأرانب التي تغذت على عليقه ملوثة بالأفلاتوكسين (الوزن الحى، معدل الزيادة الوزنية اليومية، والمأكول اليومى، معدل التحويل الغذائى وهضم كلامن المادة الجافة، المادة العضوية، البروتين الخام، الألياف الخام، مستخلص الأثير، مجموع المركبات الغذائية المهضومة، المستخلص الخالى من النيتروجين، البروتين الخام المهضوم)، حدث تدهور في الصفات الهيماتولوجية والبيوكيميائية للدم، إضافة السبانخ المائية المجففة إلى العلائق الملوثة بالأفلاتوكسين حسن أداء الأرانب وقياسات الدم والتى تأثرت سلبيا بالأفلاتوكسين ب١، تشير نتائج الدراسة إلى إمكانية استخدام السبانخ المائية بنسبة ٢,٥% في علائق الأرانب لتقليل المخاطر الناشئة عن تلوثها بالأفلاتوكسين على أداء نمو الأرانب والاستفادة الغذائية والمؤشرات الهيماتولوجية والبيوكيميائية للدم.

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