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Evaluation of Effect of *Curcuma longa* Supplementation on Production Parameters and Organ Weights in Induced Aflatoxicosis in Broiler Birds

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A B S T R A C T

The present study was undertaken to evaluate the ameliorative effects of *Curcuma longa* rhizome powder (1%) in induced aflatoxicosis in broiler chicken. In this study, commercially available broiler chickens of Vencobb strain were reared from day one to forty two days in the deep litter system of management and the birds were divided into three groups. Normal feed tested free of aflatoxin (AF), was given to the control (Group-1). Aflatoxin (1 ppm) was supplemented with the feed to Group 2 and *Curcuma longa* (1%) + AF was supplemented with the feed to Group 3. Production parameters like body weight gain, Feed consumption, FCR, and relative organ weight were recorded. The results showed that the overall feed consumption, overall live weight of *C. longa* + AF treated birds(Group-3) at 6 weeks was significantly increased (p<0.01) as compared to birds treated with only AF (Group-2). The overall feed conversion ratio of AF alone (Group-2) and *C. longa* + AF treated birds (Group-3) at 6 weeks were significantly increased (p<0.01) as compared to control, but no significant difference was observed in this respect between birds treated with *C. longa* + AF and birds treated with only AF. There was a significant rise in relative weights of liver, kidneys and spleen in the aflatoxinalone fed birds (Group-2) and the co-administration of *C. longa* (1%) with the AF (Group-3) reduced the relative weights liver and kidney. In conclusion, the present study revealed that supplementation of *Curcuma longa* rhizome powder could partially ameliorate aflatoxicity in broilers.

Keywords

Aflatoxicosis, *Curcuma longa*, Broiler, Feed conversion ratio, Organ weight, Weight gain.

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Introduction

The poultry industry has seen tremendous growth in the recent past. Aflatoxicosis continues to be a major problem in many parts of the world, in spite of better understanding and sufficient advances. Studies on the mycotoxicosis gained momentum following the identification of aflatoxin (AF), a highly toxic and carcinogenic fungal metabolites produced by certain strains of fungus viz., *Aspergillus flavus* and *Aspergillus parasiticus*, as the causative factor of the turkey ˂x˃ disease (Blount, 1961; Abedi and Talebi, 2015). Of the aflatoxins, B_1, B_2, G_1, G_2 and M_1, the aflatoxin B_1 is the most potent toxin, affecting primarily the liver. At the sublethal, AF causes poor growth rate and immunosuppression in broilers. In India the problem of aflatoxicosis is more severe than in the developed countries due tropical and subtropical climatic conditions coupled to great economic losses to the poultry feed conversion. The frequent contamination and chronic exposure of this toxin to poultry causes a heavy economic loss to the farmers. To detoxify the AF, various methods have been tried such as removal of the toxin. However, practical and cost effective methods to detoxify/ degrade mycotoxin containing feed stuffs on a larger scale basis are not available. Now it is accepted that aflatoxin produce their deleterious effects and some of them are mediated via normal metabolite by-products called free radicals (Yarru *et al.,* 2009). These free radicals, if not bio transformed by antioxidant enzymes like GSH-Px, catalase, superoxide dismutase, cause injury to DNA, protein and lipid membrane. The convert and subtle damage brought by the free radicals could be effectively ameliorated by pepping up the antioxidant defence of the body and thus controlling aflatoxicosis.

Herbal drugs have been used traditionally in humans by physicians, herbalists and folk healers worldwide or for the prevention and treatment of liver diseases. Recent research is being focused on this aspect of utilizing plant substances as nutraceuticals in the prevention and treatment of diseases of metabolic and infectious origin both in veterinary and human medicine. Also phototherapy would serve as an alternative safe economical source of curbing loss in production especially in poultry. Bioflavonoids, a group of polyphenolic compounds, which are widely distributed in the plant kingdom, are claimed to have hepato-protective effect and hepato regenerative effects. Hence, the present experiment has been designed to study the genesis of oxidative stress in poultry due to fungal infections like aflatoxicosis and its alleviation by employing dried powdered rhizome of *Curcuma longa* (turmeric). *C. longa* has a wide spread of therapeutic effects including antitumor, anti-inflammatory, antibacterial, antiviral, antifungal and antispasmodic activities because of one of its major metabolites, tetrhydrocurcumin (Osawa, 2007). Curcumin inhibits the formation of covalent adducts between the aflatoxin and DNA by modulating cytochrome P 450 enzyme system (Firozi *et al.,* 1996). Hence, addition of turmeric powder in poultry diet is envisaged to prevent the adverse effects of aflatoxicosis in poultry. Therefore, the present investigation has been undertaken to study the ameliorating effect of turmeric powder in induced aflatoxicosis in broiler birds on production performances parameters.

Materials and Methods

Production of aflatoxin: The AF was produced from *Aspergillus flavus* NRRL - 18079 pure culture (Institute of Microbial Technology, Chandigarh, India) via fermentation of rice by the method of Shotwell *et al.,* (1966). Fermented rice was then steamed to kill the fungus, dried and ground to fine crystalline powder. Hundred grams of powder from the culture substrate sample was sent to Animal Feed Analytical and Quality Control Laboratory, Veterinary College, Namakkal, Tamil Nadu, India for quantification of AF. The AF within the rice powder consisted of 165 ppm AFB1, 28 ppm AFB2 and 20 ppm AFB2. The rice powder was added to the basal diet to provide the required amount of 1 ppm (1mg kg^{-1}).

Collection and preparation of the plant material

Curcuma longa rhizome was procured from the local market of Durg and identified from a botanist and was shade dried and reduced to fine powder using grinder and the powder was stored in airtight containers. The powder thus obtained was used in the present investigation.

Chickens and diet

The experimental investigation was planned for histopathological evaluation of protective potential of Curcuma longa on Aflatoxin induced toxicity in broilers after obtaining approval from Institutional Animal Ethics Committee. Clinically healthy ninety day-old, Cobb- 400 broiler chicks of both sexes, weighing 48- 50 g were obtained from a commercial hatchery and were reared on deep litter system of housing using rice husk with provision of artificial light at night.

The chicks were fed a standard commercial feed starter up to 14 days, thereafter a grower diet up to 28 days and finisher upto 42 days. Chickens were allowed access to the diets and fresh and clean drinking water ad libitum. The basal diets were tested for possible residual AF before feeding and there were no detectable levels present. All the experimental chicks were kept under close observation during entire period of study.

Experiment design

Chicks were weighed and randomly allotted into 3 groups of 30 chicks in each group having 3 replicates of 10 chicks in each group. Chicks of group-1 were kept as untreated control and were given only basal diet. Chicks of group – 2 were given fed diet with aflatoxin @ 1 ppm from day first of experiment and considered as experimental aflatoxicosis group. Group-3 birds were fed diet with aflatoxin @ 1 ppm along with Curcuma longa powder @ 10 gm/kg of feed as a treatment on mycotoxicosis from day first of experiment.

Growth performance

All birds were maintained fed for 42 days. Daily record of feed intake was done. Chicks were weighted weekly throughout the experiment. Weekly gain in body weight was calculated to determine the growth pattern and feed conversion ratio (FCR).

Weekly live body weight

Accurate body weight of individual experimental chick was recorded on electronic weighing balance at end of every week.

Weekly gain in body weight

Gain in body weight of chicks was calculated by subtracting the initial weight from the final weight at the end of every week.

Weekly feed consumption

A measured quantity of feed offered and quantity left over in 7 days was recorded. A weekly record of feed consumption was calculated in each treatment group by difference of feed offered and left over for every week.

Feed conversion ratio (feed/gain)

Feed conversion ratio of experimental chicks was calculated for every week from the recorded observations by using the following formula.

$$FCR = \frac{\text{Quantity of feed consumed (g)}}{\text{Body weight gain (g)}}$$

Relative weight of organs

Weights of lungs, liver, kidneys, heart, spleen, thymus and bursa of Fabricius were recorded after sacrificing the chicks by cervical dislocation on day 42 to calculate the relative organ weights as per following formula

$$\text{Organ Weight Factor} = \frac{\text{Organ weight}}{\text{Whole body weight}} \times 1000$$

Results and Discussion

The effects of supplementation of *Curcuma longa* on performance parameters in induced aflatoxicosis in broiler birds.

Effect on weekly live weight

The effects of supplementation of *C. longa* on weekly live weightin induced aflatoxicosis in broiler birds are presented in Table 1 and Figure 1.

The live body weight (Mean ± S.E) observed on 0 day, 1st, 2nd, 3rd, 4th, 5th and 6th week in the control group of birds were 46.8 ± 0.34, 137.63 ± 2.19, 315.45 ± 4.29, 620.35 ± 5.79, 1042.62 ± 10.78, 1403.49 ± 14.70 and 1712.86 ± 17.37 grams, respectively.

Live weight (Mean ± S.E) observed on 0 day, 1st, 2nd, 3rd, 4th, 5th and 6th week in the only aflatoxin (1 ppm) treated group of birds were 46.76 ± 0.41, 103.23 ± 2.39, 251 ± 5.37, 501 ± 7.01, 808.19 ± 13.45, 1124.2 ± 19.95 and 1380.4 ± 19.80 grams, respectively.

Live weight (Mean ± S.E) observed on 0 day, 1st, 2nd, 3rd, 4th, 5th and 6th week in the aflatoxin (1 ppm) + *C. longa* (1%) treated group of birds were 47.1 ± 0.36, 114.9 ± 1.93, 275 ± 4.67, 549.3 ±7.72, 899.48 ± 13.83, 1217.3 ± 18.88 and 1483.26 ± 22.52 grams, respectively.

The results reported herein indicate that the supplementation of 1 ppm aflatoxin alone in feed caused a significant decrease ($p<0.01$) in mean live weight from 1st week to 6th week as compared to control. Supplementation of *C. longa* (1%) + AF (1 ppm) in feed also caused significant decrease ($p<0.01$) in live body weight from 1st week to 6th week as compared to control but the live weight of the birds in *C. longa* + AF treated group was significantly higher ($p<0.01$) than the AF alone treated group.

Effect on weekly body weight gain

The effects of supplementation of *C. longa* on weekly body weight gainin induced aflatoxicosis in broiler birds are presented in Table 2 and Figure 2. The body weight gain (Mean ± S.E) observed on 1st, 2nd, 3rd, 4th, 5th and 6th week in the control group of birds were 90.83 ± 2.17, 177.82 ± 3.79, 304.89 ± 7.94, 422.27 ± 14.32, 360.86 ± 16.20, 309.37 ± 22.98 grams, respectively.

Body weight gain(Mean ± S.E) observed on 0 day, 1st, 2nd, 3rd, 4th, 5th and 6th week in the only aflatoxin (1 ppm) treated group of birds were 56.46 ± 2.38, 147.37 ± 4.29, 252.81 ± 8.28, 306.42 ± 14.45, 315.44 ± 20.70, 256.2 ± 27.66 grams, respectively.

Body weight gain(Mean ± S.E) observed on 0 day, 1st, 2nd, 3rd, 4th, 5th and 6th week in the aflatoxin (1 ppm) + *C. longa* (1%) treated group of birds were 67.8 ± 1.97, 0.89 ± 4.97, 274.85 ± 9.36, 350.18 ± 17.11, 317.81 ± 23.08, 265.96 ± 23.52 grams, respectively.

The results indicated that the supplementation of 1 ppm aflatoxin alone and supplementation of *C. longa* (1%) + the AF (1 ppm) in feed caused a significant decrease ($p<0.01$) in mean body weight gain from 1st week to 4th week as compared to control. However, the mean body weight gain of the birds in *C. longa* + AF treated group were significantly higher ($p<0.01$) than the AF alone treated group in 1st, 2nd and 4th week. In 5th and 6th week**,** no significant differences were found among the different treatments.

Effect on weekly feed consumption

The effect of supplementation of *C. longa* on weekly feed consumption in induced aflatoxicosis in broiler birds is presented in Table 3 and Figure 3. The feed consumption (Mean ± S.E) observed on 1st, 2nd, 3rd, 4th, 5th and 6th week in the control group of birds 132.66 ± 3.17, 303.33 ± 7.83, 591 ± 10.59, 637.33 ± 14.76, 847.33 ± 18.58 and 947.33 ± 24.56 grams, respectively.

Feed consumption (Mean ± S.E) observed on 1st, 2nd, 3rd, 4th, 5th and 6th week in the only aflatoxin (1 ppm) treated group of birds were 111.33 ± 2.60, 284.33 ± 5.92, 503.33 ± 11.86, 553 ± 7.21, 749 ± 20.80 and 859.33 ± 14.3grams, respectively.

Feed consumption (Mean ± S.E) observed on 1st, 2nd, 3rd, 4th, 5th and 6th week in the aflatoxin (1 ppm) + *C. longa* (1%) treated group of birds were 118 ± 1.73, 291.33 ± 9.73, 518.33 ± 8.45, 595 ± 4.93, 809.66 ± 7.31 and 899.33 ± 12.17grams, respectively.

From the above results, it was evident that the supplementation of 1 ppm aflatoxin alone in feed caused a significant decrease in mean feed consumption from 1st to5th week (except 2nd week) as compared to control.

Supplementation of *C. longa* (1%) + AF (1 ppm) in feed also caused a significant decrease ($p<0.01$) in mean feed consumption on 1st, 3rd and 4th week as compared to control but the feed consumption of the birds in *C. longa* + AF treated group were significantly higher than the AF alone treated group on 4th and 5th week. In 5th week, there was no significant difference in feed consumption between the control group and the birds treated with *C. longa* + AF. In 2nd and 6th week, no significant difference in feed consumption was noticed among the different treatments.

Effect on weekly feed conversion ratio (FCR)

The effects of supplementation of *C. longa* on weekly feed conversion ratio (FCR) in induced aflatoxicosis in broiler birds are presented in Table 4 and Figure 4. The feed conversion ratio (Mean ± S.E) observed on 1st, 2nd, 3rd, 4th, 5th and 6th week in the control group of birds were 1.46 ± 0.12, 1.70 ± 0.06, 1.94 ± 0.01, 1.51±0.04, 2.34±0.10, 3.07±0.12, respectively.

FCR (Mean ± S.E) observed on 1st, 2nd, 3rd, 4th, 5th and 6th week in the only aflatoxin (1 ppm) treated group of birds were 1.97 ± 0.11, 1.92 ± 0.06, 2.00 ± 0.19, 1.80 ± 0.07, 2.39 ± 0.19, 3.40 ± 0.30, respectively.

FCR(Mean ± S.E) observed on 1st, 2nd, 3rd, 4th, 5th and 6th week in the aflatoxin (1 ppm) + *C. longa* (1%) treated group of birds were 1.74 ± 0.09, 1.81 ± 0.07, 1.88 ± 0.05, 1.70 ± 0.08, 2.55 ± 0.09, 3.38 ± 0.14, respectively.

From the above results, it is observed that the supplementation of 1 ppm aflatoxin alone and supplementation of *C. longa* (1%) + the AF (1 ppm) in feed caused a significant increase in mean feed conversion ratio on 1st and 4th week as compared to control. In the remaining weeks (2nd, 3rd, 5th and 6th) there was no significant difference among the different treatments.

Effect on overall live weight

The overall live weight of the birds of different groups was presented in Table 5 and Figure 5. The overall live weight at 6 weeks in the control, aflatoxin alone and *C. longa* (1 %) + AF treated groups of birds were 1712.81 ± 5.22, 1381 ± 11.53, 1483.67 ± 16.01 grams, respectively. The overall live weight of both AF alone and *C. longa* + AF treated groups at 6 weeks were significantly lower ($p<0.01$) as compared to control. However, the same was significantly higher (p<0.01) in *C. longa* + AF treated groups as compared to birds treated with only AF.

Table.1 Effects of supplementation of *C. longa* on weekly live weight (g) in induced aflatoxicosis in broiler birds

Groups	0 Day	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
Control	46.8 ± 0.34	137.63 ± 2.19^{a}	315.45 ± 4.29^{a}	620.35 ± 5.79^{a}	1042.62 ±10.78^{a}	1403.49 ±14.70^{a}	1712.86 ±17.37^{a}
Aflatoxin	46.76 ± 0.41	103.23 ± 2.39^{c}	251 ± 5.37^{c}	501 ± 7.01^{c}	808.19 ±13.45^{c}	1124.2 ±19.95^{c}	1380.4 ±19.80^{c}
Turmeric + Aflatoxin	47.1 ± 0.36	114.9 ± 1.93^{b}	275 ± 4.67^{b}	549.3 ± 7.72^{b}	899.48 ±13.83^{b}	1217.3 ±18.88^{b}	1483.26 ±22.52^{b}

Values are mean ± SE of 30 observations (n=30)
Mean with different superscript in column wise are differing significantly (P<0.01)

Table.2 Effects of supplementation of *C. longa* on weekly body weight gain (g) in induced aflatoxicosis in broiler birds

Groups	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
Control	90.83 ±2.17^{a}	177.82 ±3.79^{a}	304.89 ±7.94^{a}	422.27 ±14.32^{a}	360.86 ±16.20	309.37 ±22.98
Aflatoxin	56.46 ±2.38^{c}	147.37 ±4.29^{c}	252.81 ±8.28^{b}	306.42 ±14.45^{c}	315.44 ±20.70	256.2 ±27.66
Turmeric + Aflatoxin	67.8 ±1.97^{b}	160.89 ±4.97^{b}	274.85 ±9.36^{b}	350.18 ±17.11^{b}	317.81 ±23.08	265.96 ±23.52
Level of Significance	**	**	**	**	**NS**	**NS**

Values are mean ± SE of 30 observations (n=30)
Mean with different superscript in column wise are differing significantly
**P<0.01, *P<0.05, NS- Non Significant

Table.3 Effects of supplementation of *C. longa*on weekly feed consumption (g) in induced aflatoxicosis in broiler birds

Groups	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
Control	132.66 ±3.17^{a}	303.33 ±7.83	591 ±10.59^{a}	637.33 ±14.76^{a}	847.33 ±18.58^{a}	947.33 ±24.56^{a}
Aflatoxin	111.33 ±2.60^{b}	284.33 ±5.92	503.33 ±11.86^{b}	553 ±7.21^{c}	749 ±20.80^{b}	859.33 ±14.3^{ab}
Turmeric + Aflatoxin	118 ±1.73^{b}	291.33 ±9.73	518.33 ±8.45^{b}	595 ±4.93^{b}	809.66 ±7.31^{a}	899.33 ±12.17^{a}
Level of Significance	**	**NS**	**	**	*	*

Values are mean ± SE of 30 observations (n=30)
Mean with different superscript in column wise are differing significantly
**P<0.01, *P<0.05, NS- Non Significant

Table.4 Effects of supplementation of *C. longa* on weekly feed conversion ratio in induced aflatoxicosis in broiler birds

Groups	1st Week	2nd Week	3rd Week	4th Week	5th Week	6th Week
Control	1.46 ±0.12 [b]	1.70 ±0.06	1.94 ±0.01	1.51 ±0.04 [b]	2.34 ±0.10	3.07 ±0.12
Aflatoxin	1.97 ±0.11 [a]	1.92 ±0.06	2.00 ±0.19	1.80 ±0.07 [a]	2.39 ±0.19	3.40 ±0.35
Turmeric + Aflatoxin	1.74 ±0.09 [a]	1.81 ±0.07	1.88 ±0.05	1.70 ±0.08 [ab]	2.55 ±0.09	3.38 ±0.14
Level of Significance	**	NS	NS	*	NS	NS

Values are mean ± SE of 30 observations (n=30)
Mean with different superscript in column wise are differing significantly
**P<0.01, *P<0.05, NS- Non Significant

Table.5 Effects of supplementation of *C. longa* on overall live weight (g) at 6 weeks in induced aflatoxicosis in broiler birds

Groups	Control	Aflatoxin	Aflatoxin + Turmeric
Replicate 1	1722.5	1368	1453
Replicate 2	1711.333	1404	1507
Replicate 3	1704.6	1371	1491
Mean + S.E	1712.81± 5.22 [a]	1381± 11.53 [c]	1483.67± 16.01 [b]

Values are mean ± SE of 30 observations (n=30)
Mean with different superscript in row wise are differing significantly (P<0.01)

Table.6 Effects of supplementation of *C. longa* on overall body weight gain (g) at 6 weeks in induced aflatoxicosis in broiler birds

Groups	Control	Aflatoxin	Aflatoxin + Turmeric
Replicate 1	1675.9	1328.23	1408.79
Replicate 2	1664.58	1354.76	1462.08
Replicate 3	1656.6	1326.87	1441.93
Mean + S.E	1665.69 ±5.59 [a]	1336.62±9.07 [c]	1437.60±15.53 [b]

Values are mean ± SE of 30 observations (n=30)
Mean with different superscript in row wise are differing significantly (P<0.01)

Table.7 Effects of supplementation of *C. longa* on overall feed consumption (g) at 6 weeks in induced aflatoxicosis in broiler birds

Groups	Control	Aflatoxin	Aflatoxin + Turmeric
Replicate 1	3523	3101	3270
Replicate 2	3426	3056	3218
Replicate 3	3428	3024	3207
Mean + S.E	3459 ±32.00 [a]	3060.33± 22.33 [c]	3231.67 ±19.43 [b]

Values are mean ± SE of 30 observations (n=30)
Mean with different superscript in row wise are differing significantly (P<0.01)

Table.8 Effects of supplementation of *C. longa*on overall feed conversion ratio (g) at 6 weeks in induced aflatoxicosis in broiler birds

Groups	Control	Aflatoxin	Aflatoxin + Turmeric
Replicate 1	2.10	2.33	2.32
Replicate 2	2.06	2.26	2.20
Replicate 3	2.07	2.28	2.22
Mean + S.E	2.07 ±0.01 [b]	2.29 ±0.02 [a]	2.25 ±0.04 [a]

Values are mean ± SE of 30 observations (n=30)
Mean with different superscript in row wise are differing significantly (P<0.01)

Table.9 Effects of supplementation of *C. longa* on relative organ weights at 6[th] week in induced aflatoxicosis in broiler birds

Groups	Liver	Kidneys	Spleen	Thymus	Bursa of Fabricius	Heart	Lungs
Control	12.72 ±0.54 [c]	4.41 ±0.26[c]	0.63 ±0.05[b]	1.88 ±0.29	1.11 ±0.16	3.60 ±0.42	3.08 ±0.23
Aflatoxin	21.64 ±1.62 [a]	6.29 ±0.46[a]	1.37 ±0.19[a]	1.84 ±0.22	0.95 ±0.14	3.61 ±0.47	3.45 ±0.18
Turmeric +aflatoxin	16.64 ±0.84[b]	5.41 ±0.33[b]	1.02 ±0.07[a]	1.82 ±0.16	1.01 ±0.23	3.58 ±0.16	3.38 ±0.26

Values are mean ± SE of 6 observations (n=6)
Mean with different superscript in column wise are differing significantly (P<0.01)

Fig.1 Effects of supplementation of *C. longa* on weekly live weight (g) in induced aflatoxicosis in broiler birds

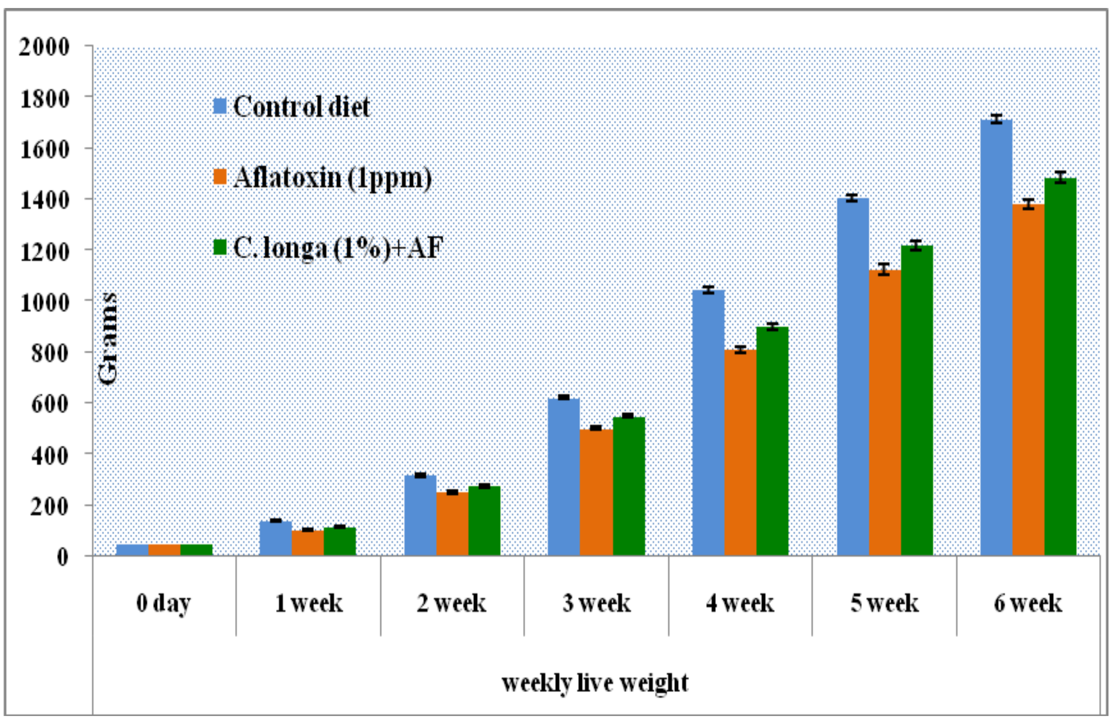


Fig.2 Effects of supplementation of *C. longa* on weekly body weight gain (g) in induced aflatoxicosis in broiler birds

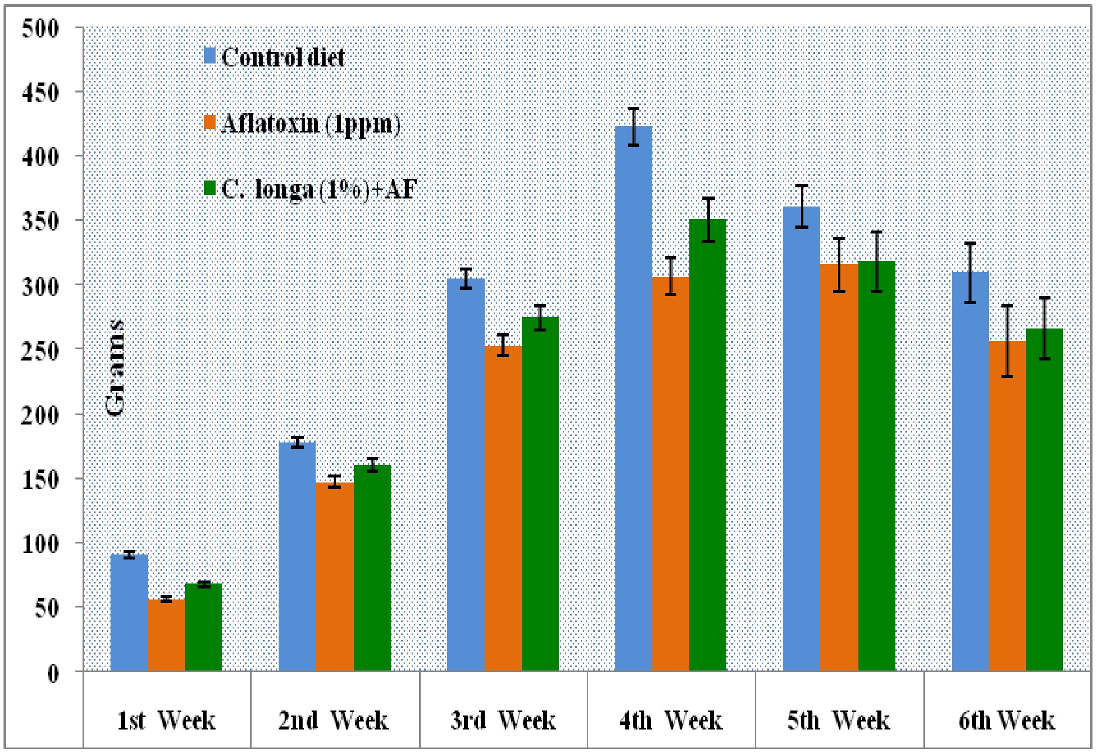


Fig.3 Effects of supplementation of *C. longa* on weekly feed consumption (g) in induced aflatoxicosisin broiler birds

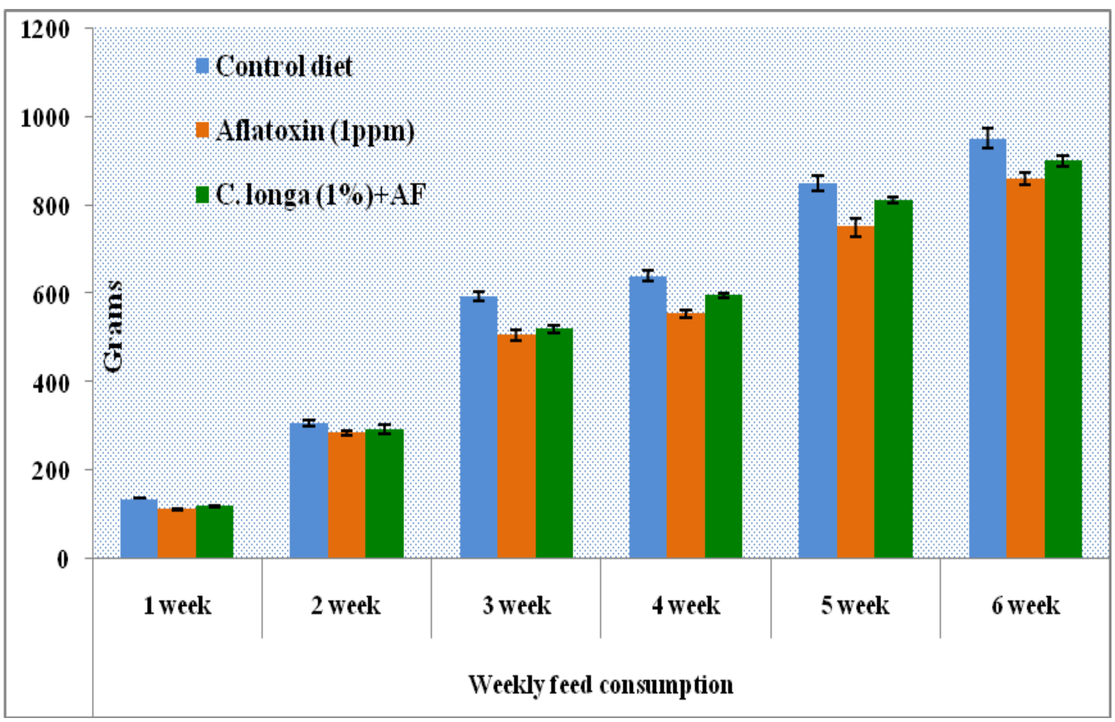


Fig.4 Effects of supplementation of *C. longa* on weekly feed conversion ratio in induced aflatoxicosis in broiler birds

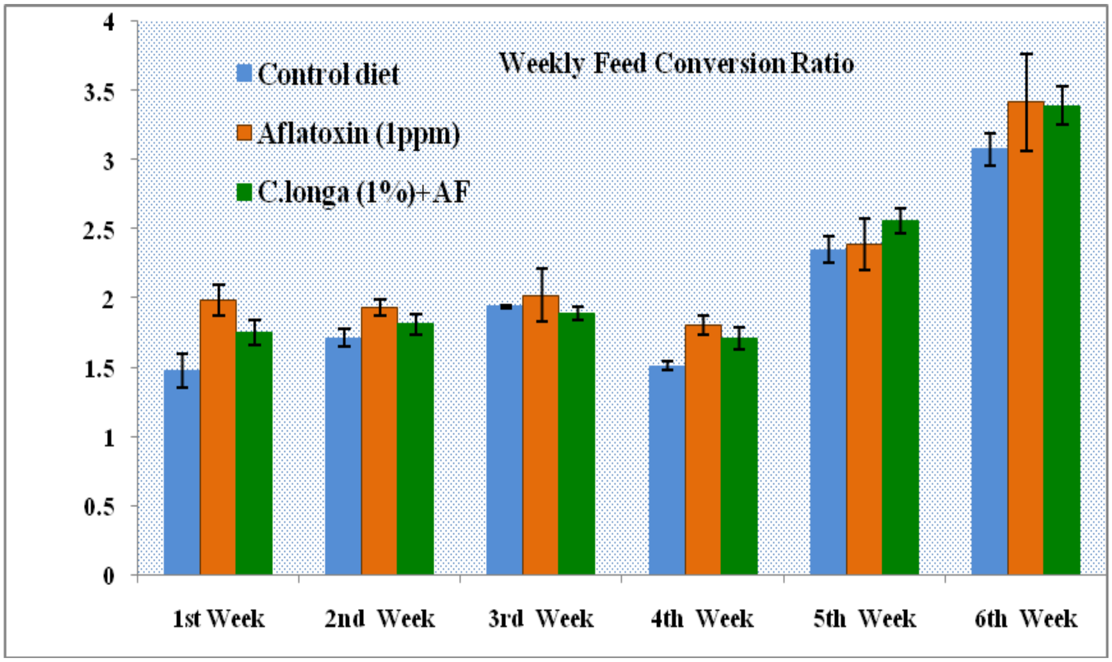


Fig.5 Effects of supplementation of *C. longa* on overall live weight, body weight gain & feed consumption (g) at 6 weeks in induced aflatoxicosis in broiler birds

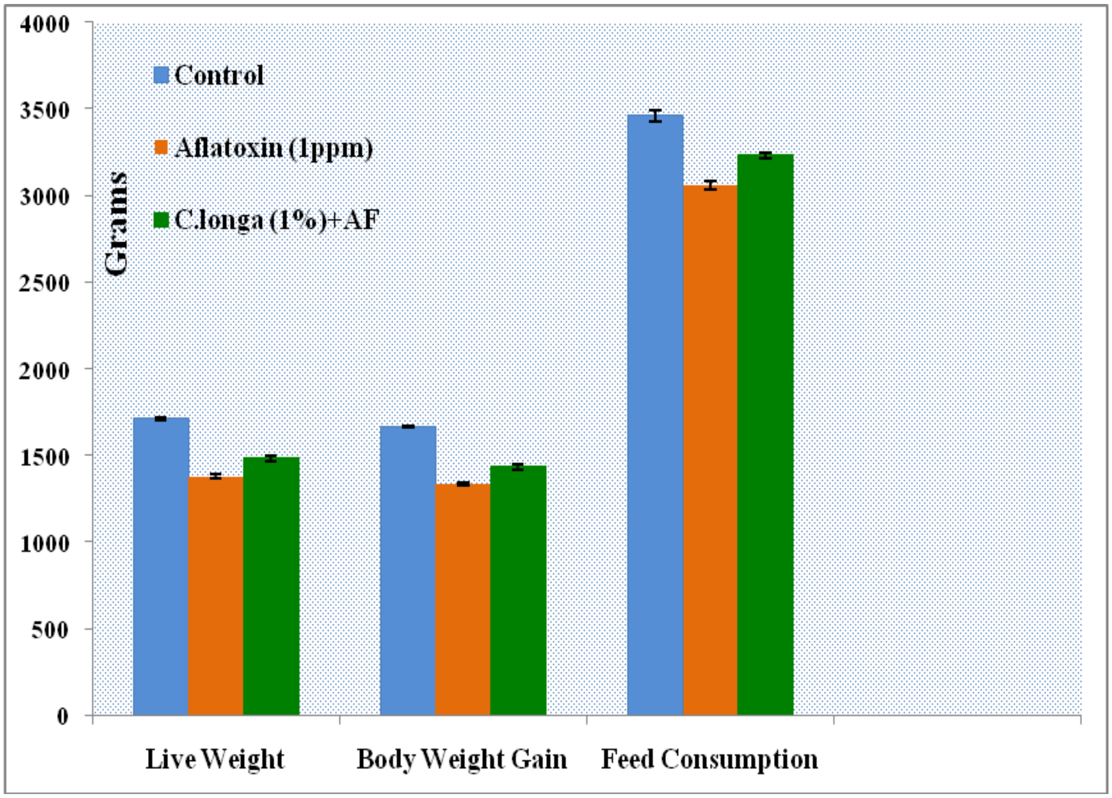


Fig.6 Effects of supplementation of *C. longa* on overall food conversion ratio at 6 weeks in induced aflatoxicosis in broiler birds

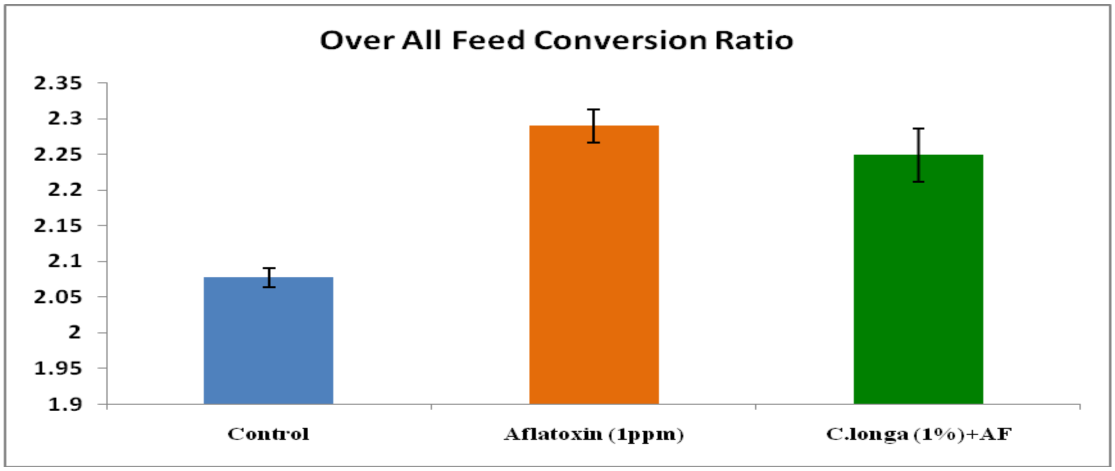
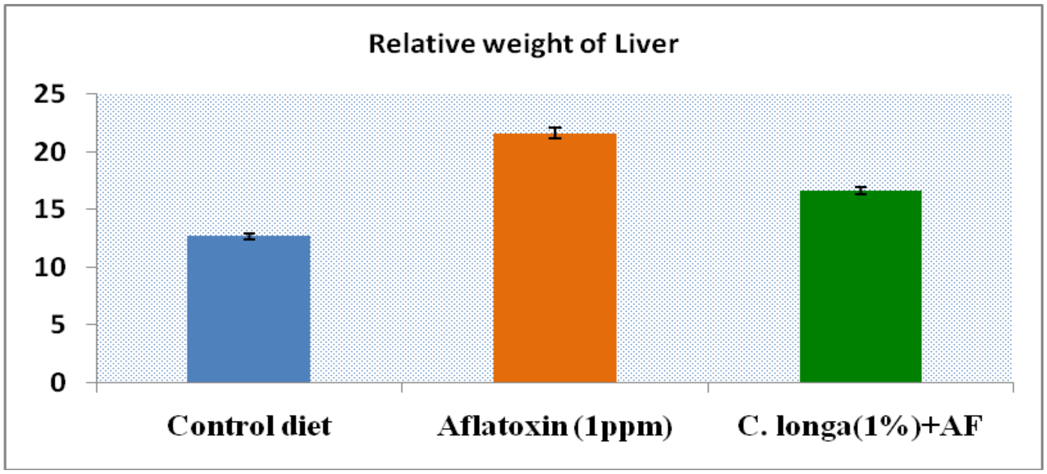
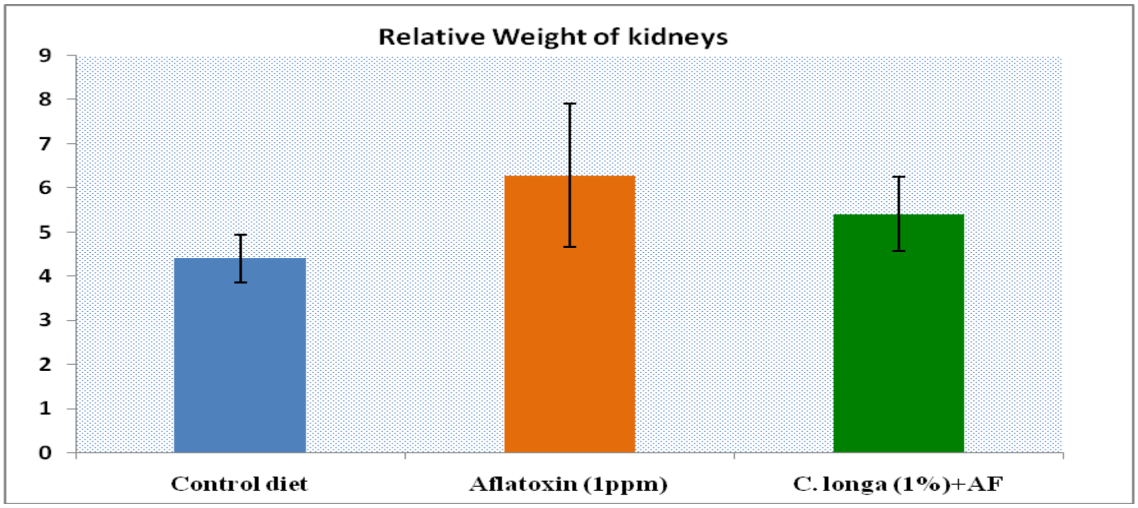


Fig.7 Effects of supplementation of *C. longa* on relative weights of liver and kidneys at 6th week in induced aflatoxicosis in broiler birds





Effect on overall body weight gain

The overall live weight and body weight gain of the birds of different groups was presented in Tables 5, 6 and Figure 5. The overall body weight gain at 6 week in the control, aflatoxin alone and *C. longa* + AF treated groups of birds were 1665.69 ± 5.59, 1336.62 ± 9.07 and 1437.60 ± 15.53 grams, respectively. The overall body weight gain of both AF alone and *C. longa* + AF treated groups at 6 weeks were significantly reduced ($p<0.01$) as compared to control. However, the same was significantly increased ($p<0.01$) in *C. longa* + AF treated groups as compared to birds treated with only AF.

Aflatoxin B_1 administered at the rate of 1 ppm alone in feed for 42 consecutive days produced a significant reduction in live weight and body weight gain compared to that of the control. These findings are in concurrence with the observation of Dalvi and Mcgowan (1984), Balachandran and Ramakrishnan (1987), Ghosh and Chauhan (1991), Vasan *et al.*, (1998), Gowda *et al.*, (2008), Yarru *et al.*, (2009a) and Manafi and Khosravinia, 2013).

Reduced live weight and body weight gain are expected of a toxic compound like AF, which inhibits functions, as vital as proteins and nucleic acid synthesis and lipogenesisis (Smith and Hamilton, 1970). Yarru *et al.*, (2009 a) also observed similar reduction in the body weight gain and recognized the genes associated with oxidative phosphorylation, ATP synthesis and carnitinepalmitoyl transferase, which transports long chain fatty acids into mitochondria for energy release, were down regulated in birds fed with AF (1 & 2 ppm) which leads to decreased energy production. The insulin like growth factor gene was also down regulated in birds fed with AF. This could lead to decreased growth rate of birds, which is in turn reflected by their reduced body weight gain.

In the present study, inclusion of *C. longa* (1%) to the AF proved to be moderately effective in improving live weight and body weight gain. These results endorse the findings of Kurkure *et al.*, (2001), Gowda *et al.*, (2008) and Yarru *et al.*, (2009 a). The improvement in the live weight and the weight gain could be attributed to curcumin, the major antioxidant ingredient of *C. longa*, is known to inhibit the biotransformation of AFB_1 to aflatoxicol in liver (Lee *et al.*, 2001) and thereby reducing the toxicity and stimulating the protein synthesis (Durrani *et al.*, 2006).

Effect on overall feed consumption

The Overall feed consumption of the birds of different groups was presented in Table 7 and Figure 5. The Overall feed consumption at 6 weeks in the control, aflatoxin alone and *C. longa* + AF treated groups of birds were 3459 ± 32.00, 3060.33 ± 22.33, 3231.67 ± 19.43 grams, respectively. The Overall feed consumption of AF alone and *C. longa* + AF treated groups at 6 weeks was significantly reduced ($p<0.01$) as compared to control. However, the same was significantly increased ($p<0.01$) in *C. longa* + AF treated groups as compared to birds treated with only AF.

Effect on overall feed conversion ratio

The Overall feed conversion ratio of the birds of different groups was presented in Table 8 and Figure 6. The overall feed conversion ratio at 6 weeks in the control, aflatoxin alone and *C. longa* + AF treated groups of birds were 2.07 ± 0.01, 2.29 ± 0.02, 2.25 ± 0.04, respectively. The Overall feed conversion ratio of AF alone and *C. longa* + AF treated groups at 6 weeks were significantly increased ($p<0.01$) as compared to control, but no significant difference was observed in this respect between birds treated with *C.*

longa + AF and birds treated with only AF. In the current study, there was a significant reduction in overall feed consumption, and increased FCR in AF alone treated birds. Corroborative observations were reported by Ghosh and Chauhan (1991), Mani and Sundaresan (1998) and Vasan *et al.*, (1998). The poor feed conversion efficiency in AF alone fed group is mainly due to the impaired nutrient absorption (Tung and Hamilton, 1973). Supplementation of *C. longa* improved the feed consumption when compared with the AF alone treated groups, which can be attributed to the hepato protective properties of *C. longa* which stems from its potent antioxidant effects, anti-inflammatory and cholerectic activity (Luper, 1999) which reduce the hepatotoxic effects associated with the AF. However, the FCR is not improved between the birds treated with AF alone and *C. longa* (1%) + AF.

The effect of supplementation of *Curcuma longa* on relative organ weights in induced aflatoxicosis in broiler birds

The effects of supplementation of *C. longa* on various relative organ weights like liver, kidneys, spleen, thymus, bursa of Fabricius, heart and lungs in induced aflatoxicosis in broiler birds were presented in Table 9 and Figure 7.

The relative weights of liver and kidneys (Mean ± S.E) observed at 6th week in the control, aflatoxin alone (1 ppm) and *C. longa* (1%) + AF (1 ppm) treated groups of birds were 12.72 ± 0.54, 21.64 ± 1.62, 16.64 ± 0.84 and 4.41 ± 0.26, 6.29 ± 0.46, 5.41 ± 0.33,respectively.

From the above results, it was observed supplementation of 1 ppm aflatoxin alone and supplementation of *C. longa* (1%) + the AF (1 ppm) in feed caused a significant increase ($p<0.01$) in the relative weights of both liver and kidneys at 6th week as compared to control but the relative weights of both liver and kidneys of the birds in *C. longa* + AF treated group were significantly lower ($p<0.01$) than the AF alone treated group.

The relative weights of spleen, thymus and bursa of Fabricius (Mean ± S.E) observed at 6th week in control, aflatoxin alone (1 ppm) and *C. longa* (1%) + AF (1 ppm) treated groups of birds were 0.63 ± 0.05, 1.37 ± 0.19, 1.02 ± 0.07 and 1.88 ± 0.29, 1.84 ± 0.22, 1.82 ± 0.16 and 1.11 ± 0.16, 0.95 ± 0.14, 1.01 ± 0.23, respectively.

The results indicated that the supplementation of 1 ppm aflatoxin alone and supplementation of *C. longa* (1%) + the AF (1 ppm) in feed caused a significant increase ($p<0.01$) in the relative weight of spleen at6th week as compared to control. As regards to the thymus and bursa of Fabricius, there was no significant difference in the relative weights among the different treatments.

The relative weights of heart and lungs (Mean ± S.E) observed at 6th week in the control, aflatoxin alone (1 ppm) and *C. longa* (1%) + AF (1 ppm) treated groups of birds were 3.60 ± 0.42, 3.61 ± 0.47, 3.58 ± 0.16 and 3.08 ± 0.23, 3.45 ± 0.18, 3.38 ± 0.26, respectively. The results showed that there was no significant difference in the relative weights of heart and lungs among the different treatments.

Aflatoxin increased the relative weights of liver, kidneys and spleen in the current study. This is in concurrence with the earlier findings of Smith and Hamilton (1970), Huff *et al.*, (1986), Yarru *et al.*, (2009). Earlier investigators have attributed the increase in the relative weight of the liver, induced by aflatoxin, to an accumulation of lipid in the liver, which produces characteristic, enlarged, friable, fatty liver associated with aflatoxicosis of broilers. Tung *et al.,* (1975) related the enlargement of spleen to concurrent occurrence of haemolytic anemia caused by Yarrru*et al.*, (2009) reported that the genes involved in fatty acid metabolism (lipoprotein lipase precursor, peroxisomal bifunctional enzyme) were down regulated in birds fed with AFB_1, as a result, fatty acids were not metabolized and they accumulated in the liver, which leads to the fatty livers and increased liver weights. Furthermore, down regulation of carnitinepalmitoyl transferase gene could also contribute to fatty liver condition because of impaired long chain fatty acid transport into mitochondria.

The co-administration of *C. longa* (1%) with the AF reduced the relative weights liver and kidney. The present findings endorses the reports of kurkure *et al.*, (2000) who also reported the decreased in relative liver weights and attributed to the hepatoprotective properties of the *C. longa*.

The present experiment showed that broiler chicks consuming an aflatoxin (1 ppm) supplemented diet experienced a significant decrease in body weight gain with a poorer feed efficiency. The addition of *C. longa* rhizome powder (1 %) to the aflatoxin-contaminated diet could only partially reduced the negative effect of aflatoxin on growth performance of broiler birds.

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