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Aflatoxin B_1 Toxicity Reduction by Tafla Clay, Honey and *Nigella Sativa* Addition in Fish

Shehata, S.A.[1]; El-Melegy, Kh.M.[2]*; Ebrahim M.S.[3] and Abou-Seif, R.A.[3]

[1] Department of Animal Production, Fac. of Agric., Zagazig University, Zagazig, Egypt.

[2] Regional Center for Food and Feed, Agric. Res. Center, Ministry of Agric., Giza, Egypt.

[3]Aquaculture Research Lab. Abbassa, Abo-Hamad, Egypt.
***Corresponding Author**

ABSTRACT

Reduction of aflatoxicosis in Nile tilapia (*Oreochromis niloticus*) fish by adding tafla clay, honey, and/ or *Nigella sativa* (Ns) to aflatoxin B_1 contaminated diets was attempted in a feeding trial for 8 weeks. Seven experimental groups were used, the 1st group (control) fed basal diet without aflatoxin B_1 or any other additivies, whereas the 2nd group fed basal diet with 3 mg aflatoxin B_1/ kg diet. The other groups (3-7) fed basal diet with 3 mg aflatoxin B_1/ kg plus 0.5% tafla, 3% honey, 1% Ns, 0.5% tafla + 1% Ns and 3% honey + 1% Ns, respectively. In each group, a total number of 30 fish (average body weight 10.05 ±0.10 g) was used in 3 replicates glass aquaria of 10 fish per aquarium. Aflatoxin B_1 contaminated diet significantly ($P<0.05$) decreased growth performance (live body weight, body weight gain and relative growth rate) and all tested blood parameters (total protein, albumin, globulin, aspertate aminotransferase and alanine aminotransferase). Mortality rate significantly ($P<0.05$) increased (50% versus 10% for the control) by aflatoxin B_1. All evaluated additivies significantly ($P<0.05$) improved growth performance, blood parameters measured and mortality rate which negatively affected by aflatoxin B_1 contamination. The best results were obtained by honey + Ns followed by honey alone, tafla + Ns, tafla alone or Ns alone. The economical efficiency took the same trend. It could be concluded that the tested natural materials have the ability to alleviate aflatoxicosis and improve the economical efficiency of fish.

Key words: Aflatoxin B_1, Fish, *Nigella sativa*, honey, clay.

INTRODUCTION

Aflatoxins produced by certain strains of the fungi *Aspergillus flavus* and *Aspergillus parasiticus* under favurable conditions of temperature and humidity (Abdelhamid, 2000, 2003, 2005a&b and 2009). These fungi grow on certain foods and feeds resulting in the production of aflatoxins, which can enter to animals and human directly through foods of plant origin (cereal grains) or indirectly (for humans) throuth foods of animal origin (Abdelhamid and Saleh, 1996; Abdelhamid *et al*., 1996, 1998, 1999a and Rojas-Duran, *et al*., 2006).

Aflatoxin B_1 was recorded with high levels in commerical fish-feeds used in Egypt and some of aquatic fauna (Abdelhamid *et al*., 1998). The ingestion of aflatoxin contaminated diets leads to hazard effect on fish production and health (Jantrarotai and Lovell, 1990; Abdelhamid *et al*., 1998 and 2002c,d&e; Hussein *et al*., 2000 and Shehata *et al*., 2003). Utilization of adsorbents was the most applied method for protecting animals and humans from mycotoxicosis (Abdelhamid and Mahmoud, 1996; Nowar *et al*., 1996; Huwig *et al*., 2001; Abd El-Baki *et al*., 2002; Abdelhamid *et al*., 2002a, b&e and Zaki *et al*., 2008). Tafla clay was efficient in the binding of different mycotoxins (aflatoxins, ochratoxin A and zearalenone). It is nearly similar to bentonite and better than kaolin in binding of mycotoxins (Shehata, 2002). Honey is used in prevention and treatment of many diseases and poisoning (Cleave *et al*., 1969; Siddiqui, 1969; Stegn, 1973, Rodwan *et al*., 1987a&b and Honey Wikipedia, update), also in reduction of aflatoxin effect (Abd El-Mageed, 1987). *Nigella sativa* (Ns) significantly counteracted the effect of aflatoxin B_1 on pekkin ducklings (Zaky *et al*., 2000) and rats (Youssef and Ashry, 1999 and Abdelhamid *et al*., 2002a and 2005). Rearly found literature concerning the protective effect of Ns against aflatoxicosis in fish (Hussein *et al*., 2000). Using much method together in detoxification of aflatoxin is scarce such as Zaki *et al*., (2008), who reported that daily injection of 0.2% Fix in Toxin (kind of pentonite clay) and 1% Ns oil diminished aflatoxicosis in fish.

The present study was carried out to evaluate the efficiency of tafla clay, honey and Ns to aflatoxin B_1 contaminated diet in reducing the aflatoxicosis in fish.

MATERIALS AND METHODS

The experimental work was carried out in the Aquaculture Research Lab., Abbassa, Abo-Hamad, and Animal Production Dept., Zagazig Univ., Egypt. Seven experimental groups were used, the 1st group (control) fed basal diet without aflatoxin B1 or any other additivies, whereas the 2nd group fed basal diet with 3 mg aflatoxin B1/ kg diet. The other tested groups (3-7) fed basal diet with 3 mg aflatoxin B1/ kg plus 0.5% tafla, 3% honey, 1% Ns, 0.5% tafla + 1% Ns and 3% honey + 1% Ns, respectively. Commercial pelleted diet, a product of Factory of General Authority for Fish Resources Development was used in the experiment, it composed of fish meal, soybean meal, meat meal, yellow corn, bone meal and a mixture of vitamins and minerals. The chemical composition of diet was adopted according to A.O.A.C. (1980). The OM, CP, CF, EE, NFE and ash of basal diet (as dry matter basis) were 80.00, 29.00, 6.50, 4.93, 39.57and 20.00% respectively.

Aspergillus flavus MD 341, was used for production of aflatoxin B_1 on liquid media (2% yeast extract and 20% sucrose). The aflatoxin concentration was determined according to the method of A.O.A.C. (1990). The media contain aflatoxin B_1 alone. The media were sprayed on diet to obtain required aflatoxin B_1 level. Tafla was ground (diameter of grinding was 0.1 mm), also Ns was purchased from local market, crushed then added to a ground commerical diet which was pelleted again before aflatoxin addition. Tafla contained (%) 50.05 SiO_2, 20.26 AlO_3, 9.74 Fe_2O_3, 2.02 CaO, 1.95 MgO, 2.19 Na_2O, 1.05 K_2O and 12.74 others (Nowar *et al*., 1996). Honey were purchased from local market, diluted with tap water, then sprayed on contaminated diet.

A total number of 210 fish (average body weight 10.05 ± 0.1 g) was used in 3 replicate glass aquaria (per treatment) of 10 Nile tilapia fish (*Oreochromis niloticus*) per aquarium. The dimensions of each equarium were 150 x 150 x 50 cm, these aquaria were supplied

with dechlorinated tap water up to 80% of its highest and continueous aeration was adapted by using an air pump and airstones. Fish wastes were filtered by siphon method each day and the rearing water was completely changed every 3 days. Mean water temperature was 27.0 ± 2°C. The fish were fed 2 times a day (900 and 1600 h.) at a rate of 3% of the total body weight (at two equal meals). The fish were weighed every 2 weeks for 8 weeks. At the end of the experiment, blood samples were taken from the cadual vien of 6 fish for each treatment (2 fish/ replicate). Serum was separated and stored at -20 °C to analysis, then analyzed for total protein, albumin, aspertate aminotransferase (AST) and alanine aminotransferase (ALT) by using commerical kits from Diamond Diagnostics Company, Egypt. Data of the trial were statistically analyzed using the General Linear Model Program of SAS (1996).

RESULTS AND DISCUSSION

1- Growth performance

Data presented in Table 1 show that, aflatoxin B_1 had significantly ($P<0.05$) bad effects on growth performance (live body weight, body weight gain and relative growth rate). These results agree with the findings of Jantrarotai and Lovell (1990) who reported that channel catfish fed 10 mg aflatoxin B_1/ kg feed for 10 weeks had shown a significant decrease in growth rate. Also, similar results were obtained by El-Said, (1997) and Shehata *et al*., (2003) on *Oreochromis aureaus.* Decreasing of growth rate by aflatoxin may be due to disturbance of one or more basic metabolic processes (carbohydrate, lipid and/ or protein metabolism) in the liver and loss of appetite (Cheeke and Shull, 1985). Also, it might be due to detoxification process in the body utilizing glutathione enzymes, which partly composed of methionine and cysteine, hence this detoxification processes depletes the metabolic availability of methionine leading to poor growth and feed efficiency (Devegowda *et al*., 1998).

All additivies significantly ($P<0.05$) reduced the toxic effect of aflatoxin B_1 on growth performance. The best significant ($P<0.05$) results were obtained by honey + Ns and honey alone in comparison with the other

additives. Generally, the results obtained with honey + Ns addition showed insignificant differences with the control results. Diminished effect of the tafla clay on body weight gain may be due to its ability to bind aflatoxin in the gastrointestinal tract which decreased aflatoxin uptake and bioavailability (Zaki *et al*., 2008). These results agreed with the findings of Shehata *et al*. (2003) who reported that different adsorbents diminished aflatoxin B_1 effect on body weight of *Oreochromis niloticus* fish from 14.53 to 95.57% according to the kind of adsorbent and experimental duration. Also, Arab and Wayatt (1991) and Lindemann *et al*. (1993) reported that 0.5 and 1% bentonite reduced the bad effect of aflatoxin on growth rate of broiler chickens and pigs.

Reduction of aflatoxin effect by honey agreed with the findings of Abd El-Mageed, (1987) who reported that honey (3 g/ kg body weight) improved daily body gain (9.23 g) compared with (1.8 g) of rabbits dosed aflatoxin alone. The improvement by honey may be due to its antiseptic and antimicrobial properties as a results of its high osmosis and acidity (pH 3.2-4.5) and hydrogen peroxide content (3% by volume), higher content of energy, vitamins, minerals & antioxidant and laxative properties due to its content of various enzymes and its stimulatory action on metabolic processes, which may have the potential for prevention and treatment of many diseases and poisoning (Cleave *et al*., 1969; Stegen, 1973; Rodwan *et al*. 1987a and b and Honey Wikipedia, update). Hydrogen peroxide was used in degrading of aflatoxin B_1 (Mashaly *et al*., 1983 and Adegoke *et al*. 1991).

The improvement by Ns agreed with those of Hussein *et al*. (2000) on fish and Zaki *et al*., (2000) on pekkin ducklings. The improvement by Ns may be due to its active compounds such as 1- nigellaone, thymoquinon and thymohydroquinon which inhibit bacteria and improve body function and performance, 2- fat soluble unidentified factors and essential fatty & amino acids which display an essential role in growth performance, 3- several macro and micro elements which are responsible for regulating all vital functions in the body and improve

Table (1): ***Effect of dietary aflatoxin B_1 and addition of tafla, honey and Nigella sativa on fish performance (Means ± Sd).*** **(*Continued*).**

Items	Week	Treatments		
		Control	Aflatoxin	Afla. + tafla
Live body weight (g)	Initial	10.05 ± 0.05	10.10 ± 0.20	10.15 ± 0.05
	2	11.22^{a} ± 0.02	10.51^{b} ± 0.13	11.20^{a} ± 0.05
	4	13.03^{a} ± 0.03	11.33^{c} ± 0.05	12.46^{b} ±0.01
	6	15.22^{a} ± 0.11	11.21^{d} ± 0.13	13.65^{c} ± 0.01
	8	17.77^{a} ± 0.04	11.18^{e} ± 0.08	14.88^{d} ± 0.02
Body weight gain (g/2 weeks)	2	1.17^{a} ± 0.02	0.41^{b} ± 0.07	1.05^{a} ± 0.01
	4	1.81^{a} ± 0.01	0.82^{d} ± 0.08	1.26^{c} ± 0.05
	6	2.19^{a} ± 0.08	-0.12^{e} ± 0.08	1.19^{d} ± 0.01
	8	2.55^{a} ± 0.15	-0.03^{f} ± 0.05	1.23^{e} ± 0.01
	Average	1.93^{a} ± 0.02	0.27^{d} ± 0.01	1.18^{c} ± 0.01
Relative growth rate (%)	2	11.64^{a} ± 0.09	4.06^{d} ± 0.78	10.34^{c} ± 0.12
	4	16.13^{a} ± 0.03	7.80^{d} ± 0.86	11.25^{c} ± 0.44
	6	16.81^{a} ± 0.59	-1.06^{e} ± 0.67	9.55^{d} ± 0.08
	8	14.35^{ab} ± 0.77	-0.27^{e} ± 0.45	9.01^{d} ± 0.07
	Average	14.73^{a} ± 0.10	2.63^{e} ± 0.11	10.04^{d} ± 0.08
Mortality rate (%)	8	10.00^{b} ± 0.0	50.00^{a} ± 10	13.33^{b} ± 0.0

a,b,c... Means in the same row bearing different letters differ significantly (P<0.05).

the immunity, and 4- vitamins have essential role in growth performance (thiamin, riboflavin, pyridoxine and niacin) as mentioned by various authors (Mohan *et al*., 1996; William, 1999; Seleem and Riad, 2005 and Seleem *et al*., 2007). Also, may be due to its contents which regulate digestion and absorption and fight the internal parasites (Nasr *et al*., 1996; Medenica *et al*., 1997; Abdel-Azzem *et al*., 1999 and Abd El-Hakim *et al*., 2002).

Adding tafla plus Ns was better than tafla or Ns alone, also, honey plus Ns was better than honey or Ns alone. These results may be due to synergestic effect between them. Generally, the best results were obtained by honey + Ns, honey alone, tafla + Ns, tafla alone and Ns alone. These results agreed with the findings of Zaki *et al*. (2008) who reported that Ns oil + Fix in toxin (kind of pentonite clay) has a synergistic effect in diminishing aflatoxicosis in fish.

2- Blood parameters

Data of blood parameters determination are shown in Table 2. Total protein and albumin

Table (1): (***Continued***).

Treatments			
Afla. + Honey	**Afla. + *Nigella sativa***	**Afla. + Tafla + *Nigella sativa***	**Afla. + Honey + *Nigella sat.***
10.05 ± 0.10	**10.10 ± 0.20**	**10.10 ± 0.10**	**10.05 ± 0.01**
11.15^{a} ± 0.12	**11.20^{a} ± 0.32**	**11.22^{a} ± 0.10**	**11.28^{a} ± 0.08**
12.55^{b} ± 0.15	**12.46^{b} ± 0.31**	**12.50^{b}± 0.10**	**13.05^{a}± 0.13**
14.17^{b} ± 0.11	**13.63^{c} ± 0.20**	**13.87^{c} ± 0.09**	**15.18^{a} ± 0.06**
16.21^{b} ± 0.10	**14.86^{d} ± 0.24**	**15.35^{c} ± 0.42**	**17.46^{a} ± 0.03**
1.10^{a} ± 0.03	**1.10^{a} ± 0.02**	**1.12^{a} ± 0.01**	**1.23^{a} ± 0.11**
1.40^{b} ± 0.05	**1.26^{c} ± 0.01**	**1.28^{c} ± 0.01**	**1.77^{a} ± 0.07**
1.62^{b} ± 0.06	**1.17^{d} ± 0.02**	**1.37^{c} ± 0.01**	**2.13^{a} ± 0.11**
2.04^{c} ± 0.05	**1.23^{e} ± 0.05**	**1.48^{d} ± 0.06**	**2.28^{b} ± 0.11**
1.54^{b} ± 0.01	**1.19^{c} ± 0.01**	**1.31^{c} ± 0.02**	**1.85^{a} ± 0.03**
10.95^{b} ± 0.77	**10.89^{b} ± 0.07**	**11.09^{b} ± 0.14**	**12.24^{a} ± 0.50**
12.56^{b} ± 0.41	**11.25^{c} ± 0.45**	**11.41^{c} ± 0.12**	**15.69^{a} ± 0.28**
12.91^{b} ± 0.56	**9.39^{d} ± 1.05**	**10.96^{c} ± 0.15**	**16.32^{a} ± 0.27**
14.40^{b} ± 0.05	**9.02^{d} ± 1.01**	**10.67^{c} ± 1.28**	**15.02^{a} ± 0.35**
12.71^{b} ± 0.06	**10.14^{d} ± 0.11**	**11.03^{c} ± 0.13**	**14.82^{a} ± 0.18**
10.00^{b} ± 5.77	**13.33^{b} ± 0.0**	**13.33^{b} ± 0.0**	**10.00^{b} ±5.77**

concentrations were significantly ($P<0.05$) decreased in fish fed aflatoxin B_1 contaminated diet. These results agreed with the results obtained by Mamdouh (1996), El-Said (1997) and Hussein *et al*. (2000) on *Oreochromis niloticus*. The decrease in total protein and albumin may be attributed to aflatoxin interaction with protein synthesis and cellular integrity in liver (Patterson, 1976 and Srivastava, 1984), since plasma proteins are used for energy production during pollulant toxicity or increasing of protein catabolism induced by stress in order to supplementary energy (Pfeifer and Weber, 1979). The activity of AST and ALT enzymes significantly ($P<0.05$) decreased in fish fed aflatoxin B_1 contaminated diet. These results agreed with the findings of Abd El-Wahhab (1996) and Abd El-Baki *et al*. (2002). Reduction of AST and ALT may be due to toxic hepatosis (Abdelhamid and Dorra, 1993).

3- Mortality rate

The mortality rate (Table 1) was significantly ($P<0.05$) increased when fish fed aflatoxin B_1 contaminated diet (50% in comparison with 10% for control).

Table 2: ***Effect of dietary aflatoxin B_1 and addition of tafla, honey and Nigella sativa on some serum parameters of fish (Means ± Sd)*** **(*Continued*).**

Items	Treatments		
	Control	Aflatoxin	Afla. + tafla
Total protein (g/dl)	$4.07^{a} \pm 0.30$	$2.90^{c} \pm 0.25$	$3.60^{b} \pm 0.20$
Index	100	71.25	88.45
Albumin (g/dl)	$3.10^{a} \pm 0.33$	$2.40^{c} \pm 0.14$	$2.90^{b} \pm 0.36$
Index	100	77.42	93.55
Globulin (g/dl)	$0.97^{a} \pm 0.20$	$0.50^{d} \pm 0.12$	$0.70^{c} \pm 0.05$
Index	100	52	72.16
AST (u/l)	$32.50^{a} \pm 4.35$	$18.40^{c} \pm 2.22$	$28.00^{b} \pm 4.30$
Index	100	56.62	86.15
ALT (u/l)	$33.23^{a} \pm 3.11$	$21.03^{b} \pm 3.23$	$32.00^{a} \pm 1.63$
Index	100	63.29	96.30

a,b,c... Means in the same row bearing different letters differ significantly (P<0.05).

These results agreed with those reported by El-Said (1997) who reported that 3 mg aflatoxin/ kg feed caused 16.76% mortality in *Oreochromis niloticus* after 90 days. Also, Shehata *et al*. (2003) reported that 9 mg aflatoxin B_1/ kg feed caused 47.62% mortality in *Oreochromis niloticus* after 8 weeks in comparison with 4.76% of control. However, the effect of mycotoxin on fish depends on potency of mycotoxin, dose, species and strain of fish, state of health, stage of life, temperature of the water and presence or absence of substances that can modifiy the toxicity (El-Said, 1997).

The incidence of death may be due to the disturbance of organs function, since, the aflatoxicosis caused liver neoplasm, necrosis of hepatocytes and degenerative changes in pancreatic and kidney tissues of rainbow trout (Halver, 1967). Also, Lovell (1991) reported that aflatoxin caused damage of liver and other organs, thereby caused poor growth, anemia, impaired blood clotting, sensitivity to burising, tumor, necrosis and

Table (2): (***Continued***).

Treatments			
Afla. + Honey	**Afla. + *N. sativa***	**Afla. + Tafla + *N. sativa***	**Afla. + Honey + *N. sativa***
$3.93^{ab} \pm 0.27$	**$3.50^{b} \pm 0.20$**	**$3.85^{ab} \pm 0.41$**	**$3.98^{ab} \pm 0.51$**
96.56	**86.00**	**94.59**	**97.79**
$3.11^{a} \pm 0.15$	**$2.80^{b} \pm 0.25$**	**$3.05^{a} \pm 0.23$**	**$3.11^{a} \pm 0.23$**
100.32	**90.32**	**98.39**	**100.32**
$0.83^{b} \pm 0.09$	**$0.70^{c} \pm 0.07$**	**$0.80^{b} \pm 0.05$**	**$0.87^{ab} \pm 0.03$**
85.57	**72.17**	**82.47**	**89.69**
$31.47^{ab} \pm 3.12$	**$28.00^{b} \pm 3.00$**	**$30.13^{b} \pm 1.44$**	**$28.20^{b} \pm 1.53$**
96.83	**86.15**	**92.71**	**86.77**
$33.44^{a} \pm 2.89$	**$32.13^{a} \pm 2.65$**	**$32.00^{a} \pm 2.44$**	**$33.59^{a} \pm 2.31$**
100.63	**96.69**	**96.30**	**101.08**

basophillia of hepatocytes, largement of blood sinusoids in the kidney, accumulation of iron pigments in the intestinal mucosa and epithelium and necrosis of gastric glands can be caused.

All additives significantly ($P<0.05$) reduced the mortality rate. Since, it ranged from 10 to 13.33% versus to 50% for aflatoxin B_1 alone. These results agreed with the findings of Shehata *et al*. (2003) who reported that different adsorbents significantly ($P<0.05$) decreased mortality rate of *Oreochromis niloticus* fed 9 mg aflatoxin B1 from 47.62% to 9.53-28.57% according to kind of adsorbent. Also, Kubena *et al*. (1991) reported that 0.5% HSCAS caused 68% decrease in the mortality rate of growing male turkey poults by aflatoxin. Decreasing the mortality rate by Ns agreed with the findings of Hussein *et al*. (2000) who reported that 1 or 2% Ns decreased the mortality rate of fish treated with 1 µg aflatoxin B_1/ kg body weight from 60% to 26.66%. The improvement in mortality rate by honey or Ns may be due to its composition which improved animal performance and health (Abd El-Mageed, 1987; Zaky *et al*., 2000; Abdelhamid *et al*., 2002 and Zaki *et al*., 2008).

4- Economical efficiency

The economical efficiency (Table 3) indicated that all additives improved the economical efficiency which negatively affected by aflatoxin B_1, the best improvement was occurred by honey + Ns, honey alone, tafla + Ns, tafla alone then Ns alone.

It could be concluded that the tested natural materials have the ability to alleviate the toxic effects of aflatoxin B_1 and to improve the economical efficiency of fish (the best results were obtained by honey + Ns followed by honey alone, tafla + Ns, tafla or Ns alone).

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Table 3: ***Effect of dietary aflatoxin B_1 and addition of tafla, honey and Nigella sativa on econonmical efficiency by fish.***

Items	Treatments						
	Control	Aflatoxin	Afla. + tafla	Afla. + Honey	Afla. + *N. sativa*	Afla. + Tafla + *N. sativa*	Afla. + Honey + *N. sativa*
Total gain (g)[1]	7.72	1.08	4.73	6.16	4.76	5.25	7.41
Total feed intake (g)[2]	23.37	17.88	21.03	22.06	20.97	21.38	23.11
Total feed cost (piastres)[3]	5.84	4.47	5.27	6.51	5.49	5.61	7.09
Selling price (piastres)[4]	9.26	1.30	5.58	7.39	5.71	6.30	8.89
Net revenue (piastres)[5]	3.42	-3.17	0.31	0.88	0.22	0.69	1.80
Relative revenue (%)[6]	100	-92.69	9.06	25.73	6.43	20.18	52.63

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تقليل سمية الأفلاتوكسين B_1 باستخدام طين الطفلة، عسل النحل وحبة البركة فى السمك

صبرى عبد الحافظ شحاتة1، خالد مصطفى المليجى2، محمد صلاح محمد3 و رمضان عبد الهادى أبو سيف3

1- قسم الإنتاج الحيوانى - كليه الزراعة - جامعه الزقازيق- الزقازيق- مصر.

2- المركز الاقليمى للأغذية والأعلاف – مركز البحوث الزراعية – وزراه الزراعة – الدقى – مصر.

3- **معمل بحوث الزراعات المائية- العباسة – أبو حماد- مصر.**

أجريت التجربة لتقليل التسمم الأفلاتوكسينى لأسماك البلطى النيلى بإضافة طين الطفلة, عسل النحل, حبه البركة للعليقه الملوثه بالأفلاتوكسين B_1 لمدة 8 أسابيع . تم عمل 7 مجموعات تجريبية, غذيت المجموعة الأولى (كنترول) على عليقة لا تحتوى على الأفلاتوكسين B_1 أو أية إضافات , وتغذت المجموعة الثانية على نفس العليقة مع 3 مجم أفلاتوكسين B_1 لكل كجم عليقه. وتغذت المجموعات الأخرى (3-7) على نفس العليقة مع 3 مجم أفلاتوكسين B_1 لكل كجم عليقه بالإضافة إلى 0.5 % طفله , 3% عسل نحل , 1% حبه البركة, 0.5 % طفلة + 1% حبة البركة, 3% عسل نحل + 1% حبة البركة على التوالى. فى كل مجموعة استخدم 30 سمكة (متوسط وزن الجسم 10.05 ±0.10 جم) فى 3 أحواض زجاجية (3 مكررات) بكل حوض 10 سمكات.

أدت العليقة الملوثة بالأفلاتوكسين B_1 إلى انخفاض معنوي (مستوى 5%) فى مقاييس النمو (وزن الجسم الحى, معدل الزيادة الوزنية, معدل النمو النسبى) و كل قياسات الدم التى تم تقديرها (البروتين الكلى , الألبيومين , الجلوبيولين , انزيمات نقل الأمين AST, ALT). زادت نسبه النفوق معنويا بالأفلاتوكسين B_1 حيث كانت 50% بالمقارنة ب 10% للكنترول.

حسنت الإضافات المستخدمة معنويا معايير النمو, معايير الدم و نسبه النفوق والتى تأثرت سلبيا بالأفلاتوكسين B_1 .وأفضل النتائج تم الحصول عليها من استخدام عسل النحل + حبه البركة ثم تلاها عسل النحل بمفرده , الطفلة + حبه البركة , الطفلة بمفردها أو حبه البركة بمفردها. و أخذت الكفاءة الاقتصادية نفس الاتجاه .

يمكن استنتاج أن المواد الطبيعية التى تم اختبارها لها القدرة على تقليل الأثر السام للأفلاتوكسين B_1 وتحسين الكفاءة الاقتصادية للأسماك.