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Effects of Fusaric Acid in Broiler Chicks and Turkey Poults

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Abstract: Two experiments were conducted to evaluate the effects of fusaric acid (FA) in broiler chicks (Exp. 1) and turkey poults (Exp. 2). In each experiment, 100 day-old birds were allotted randomly to dietary treatments containing 0, 100, 200, 300, or 400 mg FA/kg of feed. Each dietary treatment was fed to 4 pen replicates of 5 birds each for 21 days. Fusaric acid had no effect ($P > 0.05$) on feed intake, body weight gain, or feed conversion, which averaged 864 g, 627 g, and 1.38 g/g, and 656 g, 496 g and 1.33 g/g for chicks and poults, respectively. There were no treatment effects on organ weights of poults, however, chicks fed FA had lower ($P < 0.05$) kidney weights compared to controls. There were no treatment effects on hematology of chicks, however, poults fed the highest level of FA had ($P < 0.05$) higher hemoglobin and mean cell hemoglobin levels compared to chicks fed 100 mg FA/kg diet. Brain frontal cortex concentrations of norepinephrine, epinephrine, dopamine, and serotonin in poults were not affected by treatment ($P > 0.05$), but chicks fed 100, 200 and 300 mg FA/kg diet had higher brain concentrations of norepinephrine ($P < 0.05$) compared to controls. Chicks fed 300 and 400 mg FA/kg also had higher concentrations of epinephrine ($P < 0.05$) compared to controls. Results indicate that FA is not toxic to broiler chicks or turkey poults at these dietary concentrations.

Key words: Poults, chicks, fusaric acid, mycotoxins

Introduction

Fusaric acid (FA) is a naturally occurring metabolite of *Fusarium moniliforme* that has a low toxicity in animals when compared to other *Fusarium* mycotoxins (Smith and Sousadias, 1993). Fusaric acid has been reported to occur naturally at levels up to 250 mg/kg (Dowd, 1988). This compound is only moderately toxic to animals, but has antibiotic, pharmacological, and insecticidal properties (Burmeister *et al*., 1985), which has resulted in its being classified as a phytotoxin, rather than a mycotoxin (Matsuo, 1983).

Research has shown that FA caused vomiting in young pigs (Smith and MacDonald, 1991), suppressed cell-mediated immunity in chickens (Chu *et al.,* 1993), and was a potent inhibitor of dopamine-beta-hydroxylase, a key enzyme in the synthesis of norepinephrine, a brain neurotransmitter (Hidaka, 1971).

The effects of FA in poultry have not been extensively investigated. Whereas there are no data pertaining to FA in turkeys, there is one report on the effects of FA in chicks. Chu *et al.* (1993) fed chicks FA at levels up to 150 mg/kg diet and observed no deleterious effects on chick performance. Therefore, the objective of this research was to determine the effects of FA in the diets of young broiler chicks and turkey poults, at levels below and above the highest reported naturally occurring level of 250 mg FA/kg diet.

Materials and Methods

One hundred day-old birds (broilers in experiment 1, and poults in experiment 2) were randomly assigned to pens in stainless steel batteries. The experimental design included dietary treatments containing 0, 100, 200, 300, or 400 mg FA/kg of diet. Each dietary treatment was fed to 4 pen replicates of 5 birds per pen for 21 days. Diets were prepared in accordance with the recommendations of National Research Council (1994). Crystalline FA (purchased from Sigma Chemical Company) was dissolved in 95% ethanol, and the solution was added to 500 g of ground corn, thoroughly mixed, and allowed to air dry. Appropriate quantities for each diet were then mixed with the basal diet to produce the four FA treatments. Diets were screened by the methods of Rottinghaus *et al. (*1982, 1992), and found to be below detection limits for the following mycotoxins: the aflatoxins, T-2 toxin, fumonisin, citrinin, sterigmatocystin, zearalenone, ochratoxin A, vomitoxin, and diacetoxyscirpenol. Birds were maintained on a 24 h constant light schedule and were allowed *ad libitum* access to feed and water. Birds were also monitored daily for signs of morbidity and mortality.

At the end of week 3 of the experiments, birds were weighed individually and feed consumption was determined for each pen. On day 21, 12 birds (4 replicates of 3 birds each) from each treatment group were bled by cardiac puncture for hematological analyses. Hemoglobin was measured as cyanmethemoglobin. Red blood cell counts, mean cell volume, and hematocrits were determined with a coulter counter using instrument settings described by Steel *et*

Table 1: Effects of fusaric acid (FA) on performance of broiler chicks and turkey poults from 1 to 21 days of age[1]

FA (mg/kg)	Feed Intake (g)	Body Weight Gain (g)	Feed Conversion (g:g)
Chicks			
0	848	598	1.42
100	859	628	1.37
200	864	644	1.36
300	873	631	1.38
400	860	634	1.36
Pooled SEM	20	13	0.02
Turkeys			
0	680	521	1.30
100	675	504	1.34
200	651	497	1.31
300	612	458	1.33
400	665	497	1.34
Pooled SEM	20	15	0.01

[1]Data are means of four replicate pens of five birds each

Table 2: Effects of fusaric acid (FA) on absolute organ weights of 21 day-old broiler chicks and turkey poults[1,2]

FA	Heart	Liver	Kidney	Spleen	Bursa
(mg/kg)			g		
Chicks					
0	4.58	21.17	7.64[a]	0.65	2.00
100	4.39	20.93	6.55[b]	0.69	1.80
200	4.68	19.05	6.82[b]	0.68	2.11
300	4.36	19.41	6.67[b]	0.57	2.06
400	4.17	19.01	6.89[b]	0.59	2.22
Pooled SEM	0.16	1.08	0.23	0.14	0.05
Turkeys					
0	3.73	13.96	5.49	0.73	1.12
100	3.45	13.89	5.64	0.73	1.02
200	3.63	13.81	5.51	0.67	0.97
300	3.40	13.83	5.42	0.59	0.93
400	3.48	14.22	5.56	0.67	1.03
Pooled SEM	0.16	0.28	0.12	0.04	0.08

[1]Data are means of four replicate pens of three birds each.
[2]Absolute organ weights adjusted for final body weight by analysis of covariance. [ab]Values in column, within species, with different superscripts are significantly different (P < 0.05).

al. (1977). Twelve birds (4 replicates of 3 birds each) from each treatment group were anesthetized with CO_2, and then killed by cervical dislocation. The liver, kidney, spleen, heart, and bursa of Fabricus of these birds were removed and weighed. Samples of these organs were also quickly removed from five randomly selected birds among those that were bled, and placed in 10 % neutral buffered formalin for histopathology. Six birds from each treatment had their head severed, their brains quickly removed, frozen in dry ice with acetone, and stored at -80 degree centigrade for brain chemistry determinations. Later, brain sections (frontal cortex and cerebellum) were dissected on a cold plate and analyzed for norepinephrine (NE), epinephrine (E), dopamine (DA), and serotonin (5-HT) using high pressure liquid chromatography (HPLC) with electrochemical detection procedures as described by Waraska (1986).

Data for all response variables were analyzed by least squares method using the ANOVA procedure of SAS (1985). Absolute organ weights were adjusted for final body weight by covariance analysis (Shirley, 1977). All statements of significance are based on the 0.05 level of probability.

Results

Fusaric acid had no effect (P >0.05) on feed intake, body weight gains or feed conversion of chicks or poults, and averaged 864 g, 627 g, and 1.38 g/g, and 656 g, 496 g and 1.33 g/g for chicks and poults, respectively (Table 1). Chicks fed FA had lower (P < 0.05) absolute kidney weights compared to controls (Table 2). There were no treatment effects (P > 0.05) on absolute organ weights of turkeys (Table 2), which averaged 3.5 g, 13.9 g, 5.5 g, 0.7 g, and 1.0 g for heart, liver, kidney, spleen, and bursa of Fabricus, respectively. There were no treatment effects on hematology of chicks (Table 3). Poults fed the highest level of FA (400 mg FA/kg diet) had higher (P < 0.05) mean cell hemoglobin and hemoglobin levels than poults fed 100 mg FA/kg diet, but these values were not different from controls (Table 3). All tissues were unremarkable upon microscopic examination. No differences in histology were evident between control and FA treated chicks or poults.

Chicks fed 100, 200, and 300 mg FA/kg diet had higher (P < 0.05) concentrations of norepinephrine in the frontal cortex compared to controls and chicks fed 400 mg FA/kg diet (Table 4). Chicks fed 300 and 400 mg FA/kg diet had higher (P < 0.05) concentrations of epinephrine in the frontal cortex compared to controls and chicks fed 100 and 200 mg FA/kg diet. Concentrations of norepinephrine and epinephrine in the cerebellum were not affected by dietary treatments (P > 0.05) and averaged 942 ng/g and 1455 ng/g (data not shown). Concentrations of dopamine and serotonin were not detectable in the cerebellum.

In turkeys, concentrations of norepinephrine, epinephrine, dopamine, and serotonin (Table 4) were not affected by treatment (P > 0.05) and averaged 1505 ng/g, 901 ng/g, 452 ng/g, and 1365 ng/g in the frontal cortex. Concentrations of norepinephrine and epinephrine in the cerebellum were not affected by dietary treatments (P > 0.05) and averaged 1304 ng/g and 1610 ng/g (data not shown). Concentrations of dopamine and serotonin were not detectable in the cerebellum.

Discussion

Levels of FA used in the two experiments were based on the report that FA occurs naturally up to 250 mg/kg (Dowd, 1988), and partly on the results of Chu *et al.*

Table 3: Effects of fusaric acid (FA) on hematology of 21 day-old broiler chicks and turkey poults[1]

FA (mg/kg)	RBC ($x10^6/mm^3$)	HB (g/dL)	HCT (%)	MCV (um^3)	MCH (pg)	MCHC (g/dL)
Chicks						
0	2.08	10.97	35.5	166	55.5	32.6
100	2.01	11.85	32.9	160	60.9	37.0
200	1.99	11.11	33.7	165	57.4	33.8
300	2.11	11.19	35.8	165	55.5	32.9
400	1.91	11.43	31.6	162	61.6	37.5
Pooled SEM	0.15	0.39	2.4	2	4.9	2.8
Turkeys						
0	2.51	8.50[ab]	45.0	175	33.8[ab]	18.9
100	2.55	8.01[b]	46.0	176	31.9[b]	17.7
200	2.54	9.13[ab]	47.1	182	36.7[ab]	20.1
300	2.49	9.24[ab]	51.9	206	37.3[ab]	18.5
400	2.43	10.06[a]	44.1	179	42.4[a]	23.2
Pooled SEM	0.16	0.71	4.0	3	3.5	2.1

[1]Data are means of four replicate pens of three birds each. [ab]Values in column, within species, with different superscripts are significantly different ($P < 0.05$). RBC = red blood cells; HB = hemoglobin; HCT = hematocrit; MCV = mean cell volume; MCH = mean cell hemoglobin; MCHC = mean cell hemoglobin concentration.

Table 4: Effects of fusaric acid (FA) on frontal cortex concentrations of neurotransmitters and their metabolites of 21 day-old broiler chicks and turkey poults[1]

FA (mg/kg)	NE	E	DA	5-HT
	------------- ng/g of wet weight --------------			
Chicks				
0	705[c]	1034[b]	196	1542
100	1023[a]	977[b]	377	1588
200	862[b]	1117[b]	350	1662
300	950[ab]	1488[a]	283	1274
400	813[c]	1264[a]	321	1189
Pooled SEM	73	118	65	187
Turkeys				
0	1521	967	476	1369
100	1448	845	466	1281
200	1592	996	524	1403
300	1466	795	455	1375
400	1529	924	363	1414
Pooled SEM	130	90	80	80

[1]Data are means of six birds from each treatment.
[abc]Values in column, within species, with different superscripts are significantly different ($P < 0.05$).
NE = norepinephrine; E = epinephrine; DA = dopamine; 5-HT = serotonin.

(1993), who found no treatment effect of FA at levels up to 150 mg/kg in chicks. We looked at the effects of FA up to 400 mg/kg of diet and found no effect on performance of broilers or poults, thus supporting the claim that FA is relatively non-toxic compared with other *Fusarium* toxins. Fusaric acid caused decreased kidney weights in broilers but had no effect on kidney weight in turkeys. Other mycotoxins such as aflatoxin B_1 and fumonisin have been reported to increase kidney weights (Huff *et al.,* 1988, Weibking *et al.,* 1993). Although FA increased mean cell hemoglobin and hemoglobin levels, these values were not greatly different from the controls, and they all fell within the normal range.

The increase in brain norepinephrine and epinephrine concentrations in broilers, and the lack of effects in turkeys suggests that FA did not inhibit the enzyme dopamine beta-hydroxylase. This was surprising as FA has been shown to affect this enzyme in many species (Hidaka *et al.,* 1969; Nagatsu *et al.,* 1970). The results obtained are in contrast to reports of Smith and MacDonald (1991), who reported major neurochemical changes in swine 18 hours after exposure to FA. Hidaka (1971) and Chaouloff *et al.* (1986), also reported an increased concentration of cerebral serotonin in whole brains of rats injected with FA. Similarly, Nagatsu *et al.* (1970) found that FA lowered endogenous levels of norepinephrine and epinephrine in rabbits. However, in all studies in which FA was found to affect the biogenic amines, animals had been sampled between six and 18 hours after FA dosing. In contrast, our experimental birds were continually dosed for 21 days, a period long enough to allow these birds to accommodate the dosage, such that it had less of an effect.

In conclusion, results indicate that FA alone is not toxic to broiler chicks or turkey poults at these dietary concentrations, and the level necessary to promote toxicosis is more than 400 mg FA/kg diet. However, it remains to be seen what effects FA will have in poultry when other mycotoxins are present.

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