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Performance and Carcass Characteristics of Laying Hens Fed With Graded Levels of Fumonisin B_1 With and Without Vitamin C

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ABSTRACT

Mycotoxin contaminations are ubiquitous in livestock diets. This comes under many generic names of which Fumonisin B_1 (FB_1) was the object of evaluation on its influence on growth and laying performance of laying birds fed with graded level of FB_1 with or without vitamin C supplementation. One hundred and five (105) point-of-lay Isa brown breed at 18 weeks and twenty-one (21) cocks at 25 weeks were purchased for the experiment. The birds (layers) were assigned to Seven (7) dietary treatments of 15 birds each at three (3) birds per replicate. The treatments were classified according to inclusion level of Fumonisin B_1 and Vitamin C. Treatment A served as the control, B (10 mg/kg of FB_1), C (20 mg/kg of FB_1), D (30 mg/kg of FB_1), E (10 mg/kg of FB_1 + Vitamin C), F (20 mg/kg of FB_1 + Vitamin C), and G (30mg/kg of FB_1 + Vitamin C). Feed intake and weights of the birds were taken for performance evaluation. Eggs were daily collected and counted and analysed for Hen-house and Hen-day production. The relative weight of organs were taken to examine the influence of fumonisin on them. It was observed that there are no significant difference ($P>0.05$) in the final weight, total weight and daily weight gain of hens when compared with the control. Increased inclusion of FB1 resulted in significant ($P<0.05$) increase in total feed intake, daily feed intake and feed conversion ratio. There were no significant difference in the organ weight for treatment and levels of inclusion. The weight of the laying hens was reduced with increased feed intake. This showed that FB_1 caused poor feed conversion rate which was evident in the result of this study. Meanwhile, the Vitamin C effectively ameliorated the toxic effect of the FB_1. It is therefore important to include Vitamin C in the diet of laying hens so as to reduce the negative effects of FB_1 on the performance and Carcass characteristics.

Introduction

The effect of mycotoxin contamination are enormous and feeding of humans and livestock on this mycotoxin contaminated feed is particularly a serious problem and 25% of the global crops are contaminated with mycotoxins, whereby crops with large quantity of mycotoxins often have to be destroyed. Giving contaminated feeds to susceptible livestock species poses serious threats to the health and productivity of the livestock and causes great economic losses (Griessler and Encarnacao, 2009). Moreover, mycotoxins are virtually ubiquitous in livestock diets and are principally produced by four genera of fungi i.e *Fusarium*, *Claviceps*, *Aspergillus* and *Penicillium* which according to Petzinger and Weidenbach (2000), grow on almost every kind of nourishing medium. Fusarium verticilloides(sac), Nirenberg *(*F.*Moniliforme* Sheld) is associated with dietary staples such as corn intended for human consumption throughout the world producing mycotoxin such as *fumonisin*, *moniliform* and *trichothecenes*. Also, under the prevailed environment conditions in the tropics is the contamination of various commodities with Fusarium fungi and their mycotoxins is unavoidance (Avantaggiato *et al*., 2005). Dietary fumonisin B_1 did not have any inflammatory effect on the hens and the immunity status of the birds was not affected (Adebayo *et al.*, 2018). At present, one of the more promising and practical approaches to detoxify Fusarium contaminated grain on a large scale is the use of absorbents. Considerable research has been directed at finding methods to prevent toxicity of mycotoxins. Some of this method includes detoxification and inactivation. Detoxification and inactivation method include the use of binders or sequestering agent added to feed as an approach to reduce toxicity of mycotoxins by reducing inactivity reactivity of bond mycotoxins and reducing intestinal absorption (Chestrint *et al.*, 1992). Detoxifying agents are supposed to detoxify the contaminated feedstuff during passage through the digestive tract by absorbing and or degrading the mycotoxin under pH, temperature and moisture condition of the digestive tract.

However, increasing attention has been dedicated on the potential role of vitamin C supplementation in preventing overreaction of heat and nutritional stressful stimulation to help chicken and other animals to cope with such challenges. (Jones *et al.*, 1996). This study was therefore designed to explore the performance and carcass characteristics of laying Hens fed with graded levels of fumonisin B1 with or without Vitamin C supplementation

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Table 1. Gross Composition of the experimental diet for Layers mash.

Fumonisin B_1 (mg/kg)	Quantity (%)						
	0.02	10	20	30	10	20	30
Ingredient	**Diet 1**	**Diet 2**	**Diet 3**	**Diet 4**	**Diet 5**	**Diet 6**	**Diet 7**
Non-inoculated Maize	55.00	53.01	51.02	49.03	53.01	51.02	49.03
Inoculated maize	0.00	1.99	3.98	5.97	1.99	3.98	5.97
Soya bean meal	15.00	15.00	15.00	15.00	15.00	15.00	15.00
Groundnut cake	7.00	7.00	7.00	7.00	7.00	7.00	7.00
Wheat offal	5.49	5.49	5.49	5.49	5.49	5.49	5.49
Palm kernel cake	5.66	5.66	5.66	5.66	5.66	5.66	5.66
Dicalcium phosphate	2.00	2.00	2.00	2.00	2.00	2.00	2.00
Fish meal	0.50	0.50	0.50	0.50	0.50	0.50	0.50
Limestone	8.50	8.50	8.50	8.50	8.50	8.50	8.50
Lysine	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Methionine	0.15	0.15	0.15	0.15	0.15	0.15	0.15
Salt	0.30	0.30	0.30	0.30	0.30	0.30	0.30
Premix	0.25	0.25	0.25	0.25	0.25	0.25	0.25
Vitamin C	0.00	0.00	0.00	0.00	0.02	0.02	0.02
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00
Calculated Analysis							
Metabolisable Energy (kcal/kg)	2687.28	2687.28	2687.28	2687.28	2687.28	2687.28	2687.28
Crude protein (%)	16.74	16.74	16.74	16.74	16.74	16.74	16.74
Calcium (%)	3.49	3.49	3.49	3.49	3.49	3.49	3.49
Available phosphorus (%)	0.54	0.54	0.54	0.54	0.54	0.54	0.54
Methionine	0.35	0.35	0.35	0.35	0.35	0.35	0.35
Lysine	0.75	0.75	0.75	0.75	0.75	0.75	0.75
Crude fibre	3.51	3.51	3.51	3.51	3.51	3.51	3.51

fed with graded level of fumonisin with or without Vitamin C in their diet. This study was assess the detoxifying effect of Vitamin C inclusion in the graded level of fumonisin B^1 fed to Laying Hens on their performance and carcass characteristics.

Materials and Method

Fumonisin Production

Autoclaved maize grains were cultured with a toxigenic strain of *F. verticillioides* (MRC 286) inoculum obtained from the Plant Pathology Laboratory of the International Institute of Tropical Agriculture (IITA), Ibadan, Nigeria to produce fumonisin according to Nelson *et al*. (1994).

Experimental site and operations

The experiment was carried out in the Poultry unit of the Teaching and Research Farm, Federal University of Technology, Akure, Nigeria. The vegetation of the area is that of rainforest, characterised by two peaks of rainfall and humidity during the rains. The mean rainfall is about 1500mm and the rain last from March to November, while mean annual relative humidity is over 75 %.

Experimental birds and diets

One hundred and five (105) point-of-lays of Isa brown breed at 18 weeks and twenty-one (21) cocks at 25 weeks were purchased from a reputable farm for the experiment. The birds (layers) were assigned to 7 dietary treatments of 15 birds each at three (3) birds per replicate. The treatments were classified according to inclusion level of Fumonisin B_1 and Vitamin C. Treatment A served as the control, treatment B (10 mg/kg of Fumonisin B_1), treatment C (20 mg/kg of Fumonisin B_1), treatment D (30 mg/kg of Fumonisin B_1), treatment E (10 mg/kg of Fumonisin B_1 + Vitamin C), treatment F (20 mg/kg of Fumonisin B_1 + Vitamin C), and treatment G (30mg/kg of Fumonisin B_1 + Vitamin C).

Organ weight

The birds were slaughtered and eviscerated for gross examination of organs *in situ.* Organs were excised and weighed.

Statistical Analysis

The obtained data were subjected to analysis of variance of 2x4 factorial experiment in a completely randomized design (CRD) using SAS (2008) package and significant difference between means were tested using Duncan Multiple Range Test of the same software**.**

Results and Discussion

Performance Characteristics of Laying Hens

The performance characteristics of laying hens fed diets substituted with graded levels of fumonisin B_1 (FB_1) with or without Vitamin C supplementation are shown in Table 2. It was observed that the dietary treatments showed no significant difference ($p > 0.05$) in the final weight, total weight gain and daily weight gain of the hens when compared with the control but there was significant ($p<0.05$) influence of the final weight and hen day production by the interaction between the fumonisin B_1 levels and Vitamin C. The interaction of 20 mg/kg FB_1 with Vitamin C led to the birds having the final weight (1506.67 g) while the treatment fed 10 mg/kg FB_1 without Vitamin C had the highest hen day production (92.62 %). Also, increased fumonisin without Vitamin C at 10 mg/kg inclusion level caused a significant difference ($p \leq 0.05$) in the hen-day production.

Moreover, increased dietary FB_1 resulted in a significant ($p \leq 0.05$) increment in the total feed intake, daily feed intake and feed conversion ratio. Likewise, the interaction of increased FB_1 with or without Vitamin C and level also resulted to increased value for the mentioned parameters. The feed conversion ratio decreased from 2.19 to 2.16 and up to 2.27 when the fumonisin B_1, with Vitamin C, was 10, 20 and 30 mg/kg respectively and it was dose-dependent also in fumonisin without vitamin C 2.02, 2.18 and 2.24 respectively for 10, 20 and 30 mg/kg inclusion levels.

Organ weight of Laying Hens

The organ weight of the laying hens fed graded levels of fumonisin B_1 with or without Vitamin C supplementation is presented in Table 3. Results showed that there were no significant ($p \geq 0.05$) variations among the levels of fumonisin B_1 administered to the hens.

Table 2. Performance characteristics of Laying Hens fed dietary fumonisin B_1 with or without Vitamin C.

Treatment	Level of Fumonisin (mg)	Vitamin C treatment	Initial weight (g)	Final weight (g)	Total weight gain (g)	Daily weight gain (g)	Total feed intake (g)	Daily feed intake (g)	Feed conversion ratio	Hen Day Production (%)
Control	0		1396.67	1526.67	130.00	2.32	5624.27	100.43	1.84	91.94
10FB	10	No Vitamin C	1362.50	1512.50	150.00	2.68	6155.66	109.92	2.02	92.62
20FB	20	No Vitamin C	1403.33	1526.67	123.33	2.20	6284.32	112.22	2.18	82.14
30FB	30	No Vitamin C	1356.67	1516.67	160.00	2.86	6894.91	123.12	2.24	84.09
10FB	10	Vitamin C	1350.00	1530.00	180.00	3.21	5481.28	97.88	2.19	78.43
20FB	20	Vitamin C	1353.33	1506.67	153.33	2.74	6593.07	117.73	2.16	88.77
30FB	30	Vitamin C	1333.33	1486.67	153.33	2.74	6850.11	122.32	2.27	89.56
+ SEM			51.68	22.78	53.54	0.95	160.52	2.86	0.03	8.53
Mean separation										
Level of Fumonisin effect										
0			1396.67	1526.67	130.00	2.32	5624.27^{d}	100.43^{d}	1.84^{d}	91.94
10			1358.33	1518.33	160.00	2.86	5930.87^{c}	105.91^{c}	2.08^{c}	85.53
20			1378.33	1516.67	138.33	2.47	6438.69^{b}	114.98^{b}	2.17^{b}	85.46
30			1345.00	1501.67	156.67	2.80	6872.51^{a}	122.72^{a}	2.25^{a}	86.83
Vitamin C treatment										
Vitamin C			1341.11	1508.89	167.78	3.00	6314.62	112.76	2.20	85.59
No Vitamin C			1380.00	1515.56	135.56	2.42	6513.42	116.31	2.13	86.28
Statistical significance										
Treatment			0.33	0.50	0.38	0.38	0.0001	0.0001	<0.0001	0.35
Level			0.52	0.42	0.80	0.80	<0.0001	<0.0001	<0.0001	0.52
Treatment* Level			1.00	0.04	0.28	0.28	1.000	1.00	1.00	0.01

abcd: Means within the same column with different superscripts differ significantly ($p \leq 0.05$)

Increased levels of fumonisin B_1 caused an increase in the weight of the gizzard while it produced a reduction in the final weight of the laying hens. Meanwhile, the same trend of changes was noticed in the weight of the heart, reproductive organ and left lung where the weights increased up to 20 mg fumonisin B_1 before reducing due to increment in the level of the mycotoxin. Also, the dietary treatments with fumonisin B_1 and Vitamin C was significantly different ($p \leq 0.05$) for the weight of liver only with the higher weight (41.22 g) observed in the group without Vitamin C administration. This pattern, although not significant, was also observed in spleen and right lung. The diets with Vitamin C were found to have higher weight for pancreas, heart, reproductive organ, kidney, right lung, gizzard and intestine.

The interaction of the different levels of fumonisin B_1 with or without Vitamin C had no significant ($p \geq 0.05$) influence on the weights of the organs of the laying hens.

Table 3. Organ weight (g) of laying Hens fed dietary fumonisin B_1 with or without Vitamin C.

Diets	Level of Fumonisin(mg)	Vitamin C Treatment	Spleen	Pancreas	Heart	Repro.	Liver	Kidney	Kidney		Lungs		Gizd	Intestine
									Left	Right	Left	Right		
Control	0		1.20	3.13	6.27	35.70	36.60	10.50	5.47	5.03	3.80	2.93	58.37	150.43
10FB	10	No Vitamin C	1.43	2.60	6.00	43.05	40.63	11.15	5.70	5.45	3.40	3.30	49.55	163.38
20FB	20	No Vitamin C	1.43	2.30	6.90	44.87	41.97	9.90	5.00	4.90	4.33	2.70	58.83	150.70
30FB	30	No Vitamin C	2.00	1.93	5.80	49.53	41.23	11.13	5.73	5.40	3.33	2.63	60.80	152.20
10FB	10	Vitamin C	1.25	2.85	6.90	58.90	32.40	10.40	5.25	2.15	2.75	3.45	57.70	168.30
20FB	20	Vitamin C	1.27	2.80	7.20	59.80	32.10	11.47	5.87	5.60	3.77	3.50	57.33	157.17
30FB	30	Vitamin C	1.13	3.63	6.23	41.30	40.03	11.10	5.80	5.30	3.83	3.23	61.00	169.65
+ SEM			0.37	0.73	1.24	19.46	4.28	0.95	0.48	0.48	0.83	0.60	6.67	22.55
Mean separation														
Level of Fumonisin effect														
0			1.20	3.13	6.27	35.70	36.60	10.55	5.47	5.03	3.80	2.93	58.37	150.43
10			1.37	2.68	6.30	48.33	37.88	10.90	5.55	5.35	3.18	3.35	52.27	165.02
20			1.35	2.55	7.05	52.33	37.03	10.68	5.43	5.25	4.05	3.10	58.08	153.93
30			1.57	2.78	6.02	45.42	40.63	11.12	5.77	5.35	3.57	2.93	60.90	159.18
Vitamin C treatment														
Vitamin C			1.26	3.09	6.59	50.39	35.81	11.12	5.71	5.41	3.47	3.31	57.70	160.39
No Vitamin C			1.60	2.26	6.32	47.00	41.22	10.68	5.46	5.22	3.73	2.94	56.47	158.50
Statistical significance														
Treatment			0.13	0.06	0.87	0.54	0.04	0.51	0.50	0.48	0.74	0.40	0.88	0.80
Level			0.55	0.73	0.53	0.68	0.44	0.78	0.66	0.78	0.36	0.63	0.19	0.77
Treatment* Level			0.08	0.16	0.92	1.00	0.13	0.12	0.77	0.22	0.18	0.13	0.42	0.31

Repro. = Reproductive organ; Gizd = Gizzard

The interaction of fumonisin B_1 with Vitamin C was found to have non-significant ($p \geq 0.05$) higher values for pancreas, heart, right lung, and intestine while spleen and liver were observed to have higher weight ($p \geq 0.05$) due to the interaction between the fumonisin and no vitamin C.

Relative organ weight of Laying Hens

Table 4 shows the relative organ weight of the laying hens fed dietary fumonisin B_1 with or without Vitamin C. There were no significant differences ($p > 0.05$) in the relative organ weight due to the levels of fumonisin B_1 inclusion. However, the relative weight of pancreas was noticed only to be higher in the control while the right lungs and intestinal weight were increased in hen given 10 and 20 mg fumonisin B_1. Relatively, hens on diet 20 mg fumonisin had higher mean weights of the heart, reproductive organ and left lungs as the spleen, liver, kidney, left kidney and gizzard had higher mean relative weight under diet 30 mg fumonisin B_1 compared with all other levels of fumonisin B_1. There were no mean differences in the relative weight of the organs due to the dietary treatment of fumonisin B_1 supplemented with or without Vitamin C with the only significant difference ($p \leq 0.05$) observed in the right kidney. Laying hens with no Vitamin C were seen to have higher relative mean for spleen, liver, left lungs and the intestine. Pancreas, reproductive organ, kidney, left and right kidney, right lungs and gizzard were relatively higher in hens fed diet with Vitamin C.

There was no significant ($p \geq 0.05$) variation in the relative organ weight due to the interaction of the different levels of fumonisin B_1 with or without the vitamin treatment except in the right kidney ($p \leq 0.05$). The weights of the right kidney were relatively higher in the interaction between the different levels of fumonisin with Vitamin C than the interaction of the different levels of fumonisin without Vitamin C. The relative weights of pancreas and right lung were reduced ($p > 0.05$) by the interaction of increasing levels of fumonisin B_1 with no Vitamin C while this interaction caused increase in the relative weight of gizzard ($p > 0.05$). Also, there were increments ($p \geq 0.05$) in the relative weights of pancreas and gizzard as a result of the interaction of increasing levels of fumonisin B_1 with Vitamin C.

Discussion

Performance characteristics of Laying Hens

The group of laying hens fed 30 mg/kg of FB_1 with vitamin C had the lowest weight. It was also noticed that increasing the dietary fumonisin with Vitamin C led to a decrease in the weight of the laying hens. This was in contrast to Kubena *et al.* (1999) who observed that the body weights of laying hens were not decreased when the hens were fed 100, 200 mg fumonisin B_1 per kilogramme feed for four hundred and twenty (420) days.

The hens were producing more eggs with increased dietary fumonisin with Vitamin C but without Vitamin C, the egg production decreased. This was in support of Kubena *et al.* (1999) who noticed decreased egg production when laying hens were fed FB_1. It means that the Vitamin C had an ameliorative effect on the fumonisin B_1 fed to the hens. Although the total feed intake by the hens increased, poor feed conversion ratio was observed in the study to cause a reduction in the body weight; this might be due to the toxin hindering the availability and utilisation of feed nutrients by the animals. It agreed with Kubena *et al.* (1999) that weight gain and feed conversion were reduced depending on the dose of toxin exposure.

Organ weight

Among the internal organs examined, the liver weight was the only one that was significantly influenced by the administration of fumonisin B_1 and Vitamin C supplementation. Being the target organ for fumonisin, the weight of the liver was found to increase by the administration of fumonisin B_1 alone. It was in contrast to Kubena *et al.* (1987) that likewise observed no changes in the organs. Furthermore, the weight of most of the organs studied were discovered to increase when the dietary fumonisin B_1 was increased to 30 mg/kg feed. Meanwhile, the supplementation of Vitamin C had ameliorative effects as the weights were adjusted towards the group without both fumonisin and Vitamin C.

Table 4. Relative organ weight (%) of Laying Hens fed dietary fumonisin B_1 with or without Vitamin C.

Diets	Level of Fumonisin(mg)	Vitamin C treatment	Spleen	Pancreas	Heart	Repro.	Liver	Kidney	Kidney		Lungs		Gizd	Intestine
									Left	Right	Left	Right		
Control	0		0.08	0.21	0.41	2.35	2.40	0.69	0.36	0.33	0.25	0.19	3.82	9.85
10FB	10	No Vitamin C	0.09	0.17	0.42	3.10	2.69	0.73	0.37	0.36	0.24	0.23	3.31	11.48
20FB	20	No Vitamin C	0.09	0.15	0.45	2.94	2.75	0.65	0.33	0.32	0.28	0.18	3.85	9.86
30FB	30	No Vitamin C	0.13	0.13	0.38	3.27	2.72	0.73	0.38	0.36	0.22	0.17	4.01	10.03
10FB	10	Vitamin C	0.09	0.18	0.41	3.27	2.30	0.70	0.36	0.35	0.18	0.21	3.57	10.26
20FB	20	Vitamin C	0.08	0.19	0.48	3.96	2.13	0.76	0.39	0.37	0.25	0.23	3.81	10.42
30FB	30	Vitamin C	0.08	0.24	0.36	2.33	2.63	0.72	0.38	0.34	0.25	0.21	3.85	9.73
+ SEM			0.02	0.05	0.07	1.29	0.28	0.06	0.03	0.03	0.05	0.04	0.41	1.34
Mean separation														
Level of Fumonisin effect														
0			0.08	0.21	0.41	2.35	2.40	0.69	0.36	0.33	0.25	0.19	3.82	9.85
10			0.09	0.18	0.42	3.18	2.50	0.72	0.37	0.35	0.21	0.22	3.82	10.87
20			0.09	0.17	0.46	3.45	2.44	0.71	0.36	0.35	0.27	0.20	3.83	10.14
30			0.11	0.17	0.37	2.89	2.68	0.73	0.38	0.35	0.23	0.19	3.95	9.96
Vitamin C treatment														
Vitamin C			0.08	0.20	0.42	3.29	2.32	0.73	0.37	0.36	0.22	0.22	3.73	10.26
No Vitamin C			0.11	0.15	0.42	3.10	2.72	0.70	0.36	0.34	0.25	0.19	3.72	10.46
Statistical significance														
Treatment			0.18	0.11	0.17	0.11	0.96	0.56	0.03	0.53	0.68	0.47	0.93	0.80
Level			0.36	0.75	0.36	0.75	0.25	0.66	0.47	0.80	0.39	0.54	0.23	0.64
Treatment* Level			0.23	0.26	0.22	0.25	0.67	0.53	0.30	0.05	0.25	0.14	0.43	0.32

Repro. = Reproductive organ; Gizd = Gizzard

Relative organ weights

The apparent lack of significant effect of dietary fumonisin B_1 on the relative weight of the liver and spleen in this study were consistent with the observations of Weibking *et al.* (1993), Bermudez *et al.* (1995), Restum *et al.* (1995) and Ewuola *et al.* (2003) but contrary to those of Espada *et al.* (1997). Also in agreement with observations of this experiment were the reports (Weibking *et al.*, 1993; Bermudez *et al.*, 1995; and Restum *et al.*, 1995) that the relative weights of the lung and heart of chickens, ducklings and minks respectively fed diets treated with varying levels of fumonisin B_1 were not statistically different from those on control diet. However, this is at variance with Ogunlade and Egbunike (2013) that relative weight of the heart increased significantly as the dietary FB_1 levels increased. They also added that the significant reduction in relative weights of the kidney and gastro-intestinal tract (GIT) may be an indication of fumonisin B_1 toxicity to the organs. However, the result of this research was not in consonance with Ogunlade and Egbunike (2013) as it showed a significant increase in both right and left kidney. Moreover, Gelderblom *et al.* (1988) maintained that FB_1 is nephrotoxic and similar results were obtained by Voss *et al.* (1993), Restum *et al.* (1995) and Ewuola *et al.* (2003). The results of this study are, however, contrary to those of Sreemannarayana *et al.* (1989) that reported an increase in the relative weights of various sections of GIT of growing chicks fed ochratoxin. It can be concluded that fumonisin B_1 had a remarkable effect on the weight of the hens and relative weight of liver and kidney respectively while Vitamin C made a beneficial impact on these organs. It is suggestive that fumonisin could cause hepatotoxicity and nephrotoxicity. This study therefore has shown clearly that vitamin C can effectively ameliorate the toxic effect of the Fumonisin B_1

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