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Effects of Toxin Binder Supplementation via Drinking Water on The Growth Performance of Broiler Chickens

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Abstract. A four-week feeding trial was conducted to determine the effect of liquid toxin binder supplementation on the production performance of broiler chickens. A total of 400 seven-day-old Cobb broiler chicks were randomly distributed to four treatments following a Complete Randomized Design (CRD). The treatment groups consisted of control group, continuous liquid toxin binder supplementation, and reduced feed toxin binder inclusion, continuous liquid toxin binder supplementation, and intermittent liquid toxin binder supplementation. Each treatment was replicated four times with 25 chicks per replicate. The feeding trial was conducted from the age of 8th to 35th days of age. The acidifier used was a blend of activated charcoal, selenium, vitamin E, probiotics, prebiotics, mannan oligosaccharides, and bacterial cell wall components. The results showed significant effects ($P<0.05$) on the broilers' body weight gain, average daily gain, and feed efficiency from 8 to 14 days of age. Income over feed, chick, and medication cost of broilers was increased with continuous supplementation of liquid toxin binder and reduced feed toxin binder. This study indicates that continuous supplementation of liquid toxin binder and reducing the feed toxin binder is economically more advantageous to use in broiler production.

Keywords: broiler production, feed efficiency, income over feed, chick and medication cost, liquid toxin binder, weight gain

Introduction

Mycotoxins, usually found in cereal grains, leguminous seeds, and industrial by-products (Coppock et al., 2018), have a wide range of host susceptibility and cause lower growth rate, weight loss, and increased mortality due to immune suppression (Pitt and Miller, 2017). Mycotoxicosis negatively affects the poultry industry as it causes economic losses in feed ingredients and poultry production (Murugesan et al., 2015). It also poses a threat to the consumers due to residues in animal products such as milk, eggs, and meat (Adegbeye et al., 2020; Wang et al., 2018)

Mycotoxin contamination is a growing problem faced by feed producers. The warm, wet, tropical, or subtropical climates predispose chickens to mycotoxin contamination (de Freitas et al., 2018). The Philippines is in the subtropical region of the globe, so the climatic conditions of the country with elevated temperatures and high relative humidity favor the development of fungi belonging to the genera *Fusarium*, *Aspergillus*, *Alternaria*, and *Penicillium* (Haque et al., 2020) in the poultry feed and ingredients. Poultry industry is an important part of livestock sector having a 38.16% (BAS, 2014) share in the animal production economy of the country in 2014. However, massive utilization of fishmeal for animal feeding poses severe environmental issues (Sjofjan and Adli, 2021; Sjofjan et al., 2021).

Furthermore, cereal grains like maize constitute a huge bulk of feed formulations harvested during the rainy season, increasing the moisture content of grain and cereal residue. Feed mills also tend to store ingredients for several months due to instability of both ingredient supplies and prices (Purnamasari et al., 2020). Climate conditions in tandem with improper storage favor mold growth in grains. While several approaches have been developed for decontamination, a practical approach for decontamination of mycotoxins in poultry is by using mold inhibitors and mycotoxin binders, serving as a preventive measure, and acting to reassure consumers (Guo et al., 2019; Maki et al., 2017; Adegbeye et al., 2020).

It is crucial to continue research to control or minimize its prevalence, and to produce a more effective and economical toxin binder that would inhibit systemic absorption of mycotoxins. Likewise, it should also promote growth and protection in broiler chickens during disease challenges, thus producing a bigger profit. The present study was conducted to evaluate the effect of drinking water toxin binders on the production performance of broiler chickens.

Materials and Methods

A total of 400 seven-day-old broiler chicks of unsexed strain Cobb were used in the study. The birds were weighed in batches and randomly assigned into four treatment groups (T1, T2, T3, and T4) in a Completely Randomized Design (CRD). There were four replicates per treatment and 25 chicks per replicate in one cage. Table 1 shows four treatment groups were shown in Table 1.

Feeds and water were given ad libitum, and artificial light was provided at night to stimulate the chicks to feed. The chicks were vaccinated against Newcastle's Disease, Infectious Bursal Disease, and Infectious Bronchitis. Diets were formulated based on the nutritional requirements for broiler starter and broiler finisher rations (Table 2). Feed samples were collected and subjected to aflatoxin, T-2 toxin, and zearalenone mycotoxin analysis. Feed analysis exhibited toxins in the ingredient, namely aflatoxin (40 ppb) and zearalenone (27 ppb), but T-2 toxin was not detected.

A liquid toxin binder solution used in the study was a mixture of activated charcoal, selenium, vitamin E, probiotics, prebiotics, mannan oligosaccharides, and bacterial cell wall components. The manufacturer recommended the use of the liquid toxin binder at 1 mL per liter of water and was given 8 hours a day.

Ethical Approval

The care and use of animals in this experiment were done by the guidelines set by the University of the Philippines Los Baños and approved by the Institutional Animal Care and Use Committee (IACUC).

Growth Performance

Chicks were weighed once a week in batches of 10 birds per treatment to determine body weight gain. Daily feed intake and feed efficiency were determined by recording feed supply and leftover feed in each pen every day. The number of live chicks throughout the feeding trial was monitored and recorded.

Table 1. Experimental design for diet treatments

Treatments	Diets
Treatment 1 (T1)/Control	Basal diet*
Treatment 2 (T2)	Basal diet with reduced feed toxin binder (1kg/ton) + continuous supplementation of liquid toxin binder given at 1mL per liter of water twice a day
Treatment 3 (T3)	Basal diet + continuous supplementation of liquid toxin binder 1mL per liter of water given twice a day from day 7 to day 35
Treatment 4 (T4)	Basal diet + intermittent supplementation of liquid toxin binder given 1mL per liter of water twice a day (day 7 to day 11, day 16 to day 19, day 24 to day 28)

*Normal inclusion of feed toxin binder (2kg/ton) in the basal diet

Table 2. The nutrient composition (%) of broiler basal diets used in the experiment

Item	Basal Pre-starter	Basal Starter	Basal Finisher
Ingredients			
Maize	54.9	58.4	63.9
Soybean meal	34.1	31.6	27.2
Corn gluten meal	4.5	3.8	2.9
Soybean oil	2.5	2.5	2.5
Limestone	1.1	1.0	1.0
Dicalcium phosphate	1.3	1.25	1.1
Salt	0.25	0.25	0.25
Vitamin-mineral premix*	1.0	1.0	1.0
L-lysine HCl	0.1	0.1	0.1
DL-Methionine	0.25	0.2	0.15
Nutrient composition			
ME (kcal/kg)	3052	3104	3154
CP (%)	23.1	21.3	19.4
Lysine (%)	1.22	1.1	1.0

*Provided per kilogram of the complete diet: vitamin A (from vitamin A acetate), 12,500 IU; vitamin D_3, 2,500 IU; vitamin E (from DL-α-tocopheryl acetate), 20 IU; vitamin K_3, 2 mg; vitamin B_2, 5 mg; vitamin B_6, 3 mg; vitamin B_{12}, 18 µg; calcium pantothenate, 8 mg; folic acid, 1 mg; biotin, 50 µg; niacin, 24 mg; Zn (as ZnO), 60 mg; Mn (as $MnSO_2 \cdot H2O$), 50 mg; Fe (as $FeSO_4 \cdot 7H_2O$), 50 mg; Cu (as $CuSO_4 \cdot 5H_2O$), 6 mg; Co (as $CoCO_3$), 250 µg; I [as $Ca(IO_3)2 \cdot H2O$], 1 mg; Se (as Na_2SeO_3), 150 µg

Economic Analysis

The actual cost based on the price of feed, chicks, and liquid toxin binder supplementation per chick was monitored for the entire duration of the study. The production cost (feed, chick, and medications) was deducted from the selling price to obtain the profit per bird.

Data Analysis

All data gathered were summarized and subjected to statistical analysis using General Linear Models (SAS) in a Completely Randomized Design (CRD). Means of value in treatments were compared using a one-way Analysis of Variance (ANOVA). Duncan Multiple Range Test (DMRT) was applied to measure the statistical significance of the means. The following model was used:

$$Yij = \mu + Ti + eij$$

Where Yij is the parameters observed, µ is the overall mean, Ti is the effect level of toxin binder, and eij is the number of error (Ardiansyah et al., 2022).

Results and Discussion

The parameters of production performance of broiler chickens with no supplementation of liquid toxin binder, continuous supplementation of liquid toxin binder with reduced feed toxin binder inclusion, continuous supplementation of liquid toxin binder, and intermittent supplementation of toxin binder during the starter period are presented in Table 2.

The results revealed that the average initial body weight of the control group was not significantly different ($p > 0.05$) from that of T4. In the starter periods (8 – 21 days), body weight gain and average daily gain of the Control group (T1) were numerically higher than that of other treatments. The means of T1 and T2 were significantly different ($P< 0.05$) from those of T3 and T4. As of feed consumption, there was no significant difference ($P>0.05$) across treatments. The computed feed conversion efficiency at the end of the starter period showed the control group was significantly the most feed efficient ($P<0.05$) and T4 was the least efficient.

Table 3. Effect of liquid toxin binder supplementation on the production performance of broiler chickens during the starter period

Parameters		Treatments			
		Control	T2	T3	T4
Initial body weight, (g)	8 days	131.29[a]	128.88[b]	127.83[b]	130.29[a]
Final body weight (g)	Starter (21 days)	522.46[a]	447.02[b]	420.38[b]	435.50[b]
	Finisher (35 days)	1,187.66	1,227.44	1,154.44	1,173.37
Body weight gain, (g)	8 – 21 days	391.17[a]	318.15[a]	292.54[b]	305.21[b]
	22 - 35 days	665.20	780.42	734.07	737.87
	8 – 35 days	1,056.66	1,098.44	1,026.44	1,043.37
Average daily gain, (g)	8 – 21 days	18.63[a]	15.15[a]	13.93[b]	14.53[b]
	22 - 35 days	95.03	111.49	104.87	105.41
	8 – 35 days	37.74	39.23	36.66	37.26
Feed consumption, (g)	8 – 21 days	653.99	653.52	609.45	647.86
	22 - 35 days	1,427.80	1,422.95	1,349.45	1,439.80
	8 – 35 days	2,081.788	2,076.471	1,958.896	2,087.658
Feed Conversion Ratio (FCR) (g/g)	8 – 21 days	1.67[a]	2.05 [b]	2.08[b]	2.12[b]
	22 - 35 days	2.15	1.82	1.84	1.95
	8 – 35 days	1.97	1.89	1.91	2.00
Livability (%)	8 – 21 days	99	99	99	99
	22 - 35 days	98.99	97.98	95.96	97.97
	8 – 35 days	98	97	95	97

[ab] – means with different superscripts within the row are significantly different (P<0.05)

During the finisher period (22 – 35 days) and throughout the experiment (8 – 35 days). The initial body weight was seen to be significantly highest (P<0.05) in the Control group. The final body weight, body weight gain, average daily gain, feed consumption, and feed conversion efficiency did not vary significantly (p > 0.05) among the four treatment groups. As for the percent livability, the control group had the highest livability (98%), followed by T2 and T4 (97%), and last by T3 (95%). However, the data gathered were found to be insignificant (P>0.05).

Although there were no significant differences (p > 0.05) in the final body weight throughout the study, numerically, T2 had the highest body weight gain throughout the clinical trial, and they also had a relatively lower feed consumption, indicating that they were the best performers with regards with feed efficiency. Feed efficiency is the ratio between the resulting body weight gain and the amount of feed consumed (Isabelle et al. 2020). On the other hand, there was no statistical significance (p > 0.05) in the overall feed efficiency among the four treatments, suggesting that the inclusion of the product whether the feed toxin binder was reduced or not had the same effects as the current toxin binder that is being used. It could be concluded that the liquid toxin binder would be a suitable alternative to feed toxin binders.

Several factors might have contributed to the positive outcome of the production parameters of the study especially the components of the product: adsorbents, antioxidants, growth promotants, and immunostimulants. The addition of the product in the feed ration was done as a prophylactic assurance against unforeseen contamination and infections in the feed and farm, the disease occurrence was unlikely because there were no neighboring farms, and no disease outbreak was observed in the past years and this was the first trial done in the farm. There were also no indicators of disease outbreak during the study.

The feed analysis exhibited that aflatoxin levels in the ingredient were 40 ppb. The limit for aflatoxin B1 in poultry feed was 20 ppb for young chicks and 50 ppb for laying hens (Zaki et al., 2012). Furthermore, zearalenone concentrations in the feed ingredient were found to be 27 ppb. Concentrations higher than 100 ppb can cause vent enlargement and enhanced secondary characteristics (Plumlee, 2004; Devegowda and Murthy, 2005; Khan, 2010). The standard limit for zearalenone in feed was 150 – 500 ppb (Ma et al., 2018). On a positive note, T-2 toxin was not detected in the ingredient. T-2 toxin can stimulate and inhibit the immune system, a low dose of T-2 toxin increases serum IgA and IgE, can damage intestinal mucosa, and impair absorption of nutrients (Koppenol et al., 2019; Dazuk et al., 2020). Had it been that a disease outbreak occurred during the study, the results might have been different. Mycotoxicosis is a factor in low production performance in chickens. Ingestion of mycotoxins may cause liver damage that may alter its functions related to digestion, metabolism, immunity, and storage of nutrients leading to decreased utilization of feed, and immunosuppression (Hassan et al., 2020). Increased mycotoxins such as aflatoxin B1 from 0 to 400 ppb resulted in significant chicken weight gain in each age group (Purnamasari et al., 2019).

The beneficial effects of the high level of antioxidants in the diet were observed through the improvement of the feed conversion ratio. Antioxidants in the diet contributed by regulating the liver functions thus having more efficient production of bile which results in better fat digestion. The enhanced functions of the liver also enhance Vitamin A usage which decreases aflatoxin's toxicity (Alpsoy and Yalyac, 2011). Furthermore, immune functions are also improved by increasing the immunoglobulin concentrations in the blood which improves the antibody titters (Dvorska et al., 2007; Plumb, 2008; Upton et al., 2008).

Selenium and Vitamin E are antioxidants and acts as a cellular antioxidant and inhibits the formation of free radicals. Its action against oxidative stress results in efficient conversion of feed to energy thus improving the feed conversion ratio of the birds. The studies of Bobade et al., (2009), and Mubarak et al. (2009), accentuate that simultaneous Vitamin E and selenium supplementation improved production performance, especially it increased the body weight and feed consumption, and feed conversion improved. This simultaneous supplementation protects the red blood cell from hemolysis and prevents the action of peroxidase on unsaturated bonds in tissues (Plumb, 2008). However, excess supplementation of selenium may cause the death of the animal.

The addition of activated charcoal at 10% of the diet would reduce ochratoxin uptake (Plumlee, 2004). Adsorbents increase body weight by coating mycotoxins and other toxic metabolites. Systemic absorption of mycotoxins and toxic metabolites, that may cause hepatic dysfunction, and are prevented and are excreted via the fecal material.

Table 3. Economic Analysis of Broilers with or without liquid toxin binder supplementation

Parameters	Treatments			
	Control	T2	T3	T4
Feed Cost (Php)	50. 23	45.54	46.55	49.00
Water Medication Cost (Php)	0	3.00	3.00	1.20
Chicks Cost (Php)	24.00	24.00	24.00	24.00
Total Cost to Produce (Php)	74.23	72.54	73.55	74.2
Average Weight (Kg)	1.2	1.2	1.2	1.2
Live Weight Price (Php)	73	73	73	73
IOFCMC (Php)	13.38	15.06	14.05	13.4

However, excess supplementation of activated charcoal and other toxin binders would lead to sequestration of essential nutrients, vitamins and minerals, and enzymes in the gut if mycotoxin levels in the feed are too low thus decreasing the availability of essential nutrients needed for the animal's growth. (Plumb, 2008: Huwig et al., 2001).

Mannan oligosaccharides, probiotics, and prebiotics are growth promoters. Their beneficial effects may be observed in the improved feed conversion efficiency and body weight gain by selectively nourishing beneficial bacteria and altering the gut to improve nutrient absorption and utilization (Panzhanivel and Balachandran, 2014; Mehdi and Hasan, 2012). It also affects the livability of the birds by improving the immune system of the animal using competitive exclusion by inhibiting the entry and proliferation of pathogenic bacteria in the gastrointestinal tract such as Escherichia coli, Salmonella species, and Clostridium perfringens by preventing access to nourishment (Stanley et al., 1993), especially during disease outbreaks.

The income over feed, chick, and medication costs was also computed as presented in Table 3. It showed that the cost of production per bird was numerically lowest in T2. This is due to the lower feed consumption and better FCE of T2. T2 had the highest income generated among all treatments it had 6.57%, 10.90%, and 11.16% higher profit than T3 and T4 and the control group respectively.

Conclusions

Based on the result, the production performance parameters of broiler chickens supplemented with liquid toxin binder via drinking water and those without liquid toxin binder supplementation were not significantly different from one another in this disease-free study. However, continuous liquid toxin binder supplementation with reduced feed toxin binder inclusion (1kg/ton) is economically more advantageous to use in broiler production. The feed analysis exhibited that level toxins in the ingredient were 40 ppb aflatoxin, non-detected T-2 toxin, and 27 ppb zearalenone. It is recommended that more feeding trials be conducted using feeds with mycotoxin levels above the toxic dose, and further reduction of the feed toxin binder inclusion.

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