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Growth Performance of Broilers in Response to Increasing Concentration of Multiple Mycotoxins in Contaminated Corn

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Growth Performance of Broilers in Response to Increasing Concentration of Multiple Mycotoxins in Contaminated Corn

Abstract

Mycotoxins in grains are a result of mold or fungal growth from environmental stressors and cause detrimental impacts to poultry production. Thus, the objective of this experiment was to determine the effects of increasing concentration of a combination of mycotoxins on growth performance of broiler chicks. A total of 250 one-day-old male broilers (Cobb 500; initial BW 0.092 lb) were used in a 15-d study. Broilers were housed in 3 Petersime batteries with *ad libitum* access to feed and water. Treatments were randomly assigned to 1 of 50 cages within location block, resulting in 10 cages per treatment with 5 broilers per cage balanced by BW. For this experiment, the sourced contaminated corn contained 8.2 ppm fumonisin (FUM), 8.0 ppm deoxynivalenol (DON), and 551 ppb zearalenone (ZEA). Dietary treatments consisted of 0%, 25%, 50%, 75%, and 100% of the mycotoxin contaminated corn replacing non-contaminated corn. The resulting complete diet mycotoxin concentrations were 1.5 ppm, 1.4 ppm, 2.3 ppm, 2.9 ppm, and 3.9 ppm for FUM; < 0.6 ppm, 1.0 ppm, 1.4 ppm, 2.3 ppm, and 3.0 ppm for DON; and < 51.7 ppb, 94.5 ppb, 180.5 ppm, 294.6 ppb, and 364.1 ppb for ZEA, respectively. Data were analyzed as a completely randomized design with cage as the experimental unit using the GLIMMIX procedure of SAS 9.4 (Cary, NC). Results were considered significant at $P \leq 0.05$. Total body weight gain (BWG) decreased (linear, $P = 0.007$) and feed intake (FI) tended to decrease (linear, $P = 0.093$) in broilers fed diets with increasing concentration of mycotoxin contaminated corn in the diet. The increase in mycotoxin concentration in diets fed to broilers also resulted in poorer (linear, $P = 0.010$) feed conversion ratio (FCR). In conclusion, increasing concentrations of FUM, DON, and ZEA in broiler feed negatively impacted BWG, FI, and FCR even when the mycotoxin levels were below acceptable limits for individual mycotoxins.

Keywords

broiler growth, broiler nutrition, mycotoxins, mycotoxin contamination

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Growth Performance of Broilers in Response to Increasing Concentration of Multiple Mycotoxins in Contaminated Corn

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Summary

Mycotoxins in grains are a result of mold or fungal growth from environmental stressors and cause detrimental impacts to poultry production. Thus, the objective of this experiment was to determine the effects of increasing concentration of a combination of mycotoxins on growth performance of broiler chicks. A total of 250 one-day-old male broilers (Cobb 500; initial BW 0.092 lb) were used in a 15-d study. Broilers were housed in 3 Petersime batteries with *ad libitum* access to feed and water. Treatments were randomly assigned to 1 of 50 cages within location block, resulting in 10 cages per treatment with 5 broilers per cage balanced by BW. For this experiment, the sourced contaminated corn contained 8.2 ppm fumonisin (FUM), 8.0 ppm deoxynivalenol (DON), and 551 ppb zearalenone (ZEA). Dietary treatments consisted of 0%, 25%, 50%, 75%, and 100% of the mycotoxin contaminated corn replacing non-contaminated corn. The resulting complete diet mycotoxin concentrations were 1.5 ppm, 1.4 ppm, 2.3 ppm, 2.9 ppm, and 3.9 ppm for FUM; < 0.6 ppm, 1.0 ppm, 1.4 ppm, 2.3 ppm, and 3.0 ppm for DON; and < 51.7 ppb, 94.5 ppb, 180.5 ppm, 294.6 ppb, and 364.1 ppb for ZEA, respectively. Data were analyzed as a completely randomized design with cage as the experimental unit using the GLIMMIX procedure of SAS 9.4 (Cary, NC). Results were considered significant at $P \leq 0.05$. Total body weight gain (BWG) decreased (linear, $P = 0.007$) and feed intake (FI) tended to decrease (linear, $P = 0.093$) in broilers fed diets with increasing concentration of mycotoxin contaminated corn in the diet. The increase in mycotoxin concentration in diets fed to broilers also resulted in poorer (linear, $P = 0.010$) feed conversion ratio (FCR). In conclusion, increasing concentrations of FUM, DON, and ZEA in broiler feed negatively impacted BWG, FI, and FCR even when the mycotoxin levels were below acceptable limits for individual mycotoxins.

Introduction

Mycotoxins are toxins produced by fungi in grain and other feed ingredients. Several factors such as climate, region, harvesting times, and storage can affect mycotoxin production by these molds and concentration in the grain. Mycotoxins can impact the growth and production of poultry when the animals consume contaminated feed. At high enough levels, mycotoxins in feed can cause toxicity, resulting in organ damage,

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vomiting, and even an increased risk of other diseases due to suppression of the immune system. Due to this risk, the FDA has put guidelines in place for aflatoxin, deoxynivalenol, and fumonisin.[2] Both deoxynivalenol and fumonisin have advisory levels of 5 ppm and 50 ppm, respectively, that are recommended maximum levels of these toxins in poultry feed. The action level for aflatoxin is a maximum amount of aflatoxin in corn for immature and mature poultry at 20 ppb and 100 ppb, respectively. Levels of aflatoxin above this threshold cannot be fed to poultry without regulatory action.

Although guidance has been put in place to help prevent mycotoxin toxicity and limit the chance of harm to the birds, more information is needed to understand how low levels of multiple mycotoxins in the diet affect the growth performance of poultry. Therefore, the objective of this study was to determine how an increase of mycotoxin concentration in the diet, below FDA guidance levels, affects the BWG, total FI, and FCR of young broilers.

Materials and Methods

The protocol used in this study was approved by the Kansas State University Institutional Animal Care and Use Committee. This experiment was conducted at the Tom Avery Poultry Research Farm at Kansas State University. Birds were housed in 3 Petersime batteries with *ad libitum* access to feed and water through the entire study period.

Animals and diets

A total of 250 one-day-old, male broiler chicks (Cobb 500, Cobb-Vantress, Siloam Springs, AR) with an initial BW of 0.092 lb were randomly assigned to cages of 5 chicks, balanced by weight. Treatments were then randomly assigned to 50 cages within location block, resulting in 10 cages per treatment with 5 chicks per cage for a 15-d feeding trial.

A total of five dietary treatments consisted of increasing amounts of mycotoxin contaminated corn (MC; 1, 25, 50, 75, and 100%) used to replace clean corn (CC) on a weight/weight basis (Table 2). Representative samples of the sourced MC and the diets were sent to be analyzed for mycotoxin content via liquid chromatography tandem mass spectrometry (LC-MS/MS) at Romer Labs in Union, MO. A corn-soy broiler starter diet was formulated to meet or exceed the nutritional requirements of Cobb 500 nutrient recommendation. Formulation was the same across treatments with corn source being the only change between treatments. Diets were sent to Ward Laboratories (Kearney, NE) for proximate analysis. The diets were provided to chicks in mash form.

Chicks were maintained on a 24-h lighting schedule in an environmentally controlled room with *ad libitum* access to feed and water. Each cage measured approximately 39.4 × 28.7 in. and was fitted with a single bulk feeder and waterer. Initial pen weight and feed addition were recorded on d 0, and feed disappearance and pen weights were recorded on days 7 and 15 and were used to determine BWG, FI, and FCR. Culls and mortalities were tracked and recorded daily.

[2] FDA Mycotoxin Regulatory Guidance, August 2011. https://www.aflatoxinpartnership.org/wp-content/uploads/2021/05/NGFAComplianceGuide-FDARegulatoryGuidanceforMycotoxins8-2011.pdf (accessed on August 1, 2022).

Statistical analysis

Data were analyzed as a completely randomized design with cage as the experimental unit using the GLMMIX procedure of SAS v. 9.4 (SAS Institute, Inc., Cary, NC). Single degree-of-freedom contrasts were constructed to test the linear and quadratic effects of increasing mycotoxin concentration in the diets. Results were considered significant at $P \leq 0.05$.

Results and Discussion

The analyzed concentrations of mycotoxins in the MC were well above detectible levels for fumonisins B1, B2, and B3; deoxynivalenol; and zearalenone (5.4 ppm, 2.1 ppm, 0.7 ppm, 8 ppm, and 550.6 ppb; respectively). The diet containing 0% MC contained lower levels of each of these mycotoxins (1.2 ppm, 0.2 ppm, 0.1 ppm, < 0.6 ppm, and < 51.7 ppb, respectively). As the concentration of MC in the diet increased, the concentrations of these mycotoxins in the diets also increased. It should be noted that although the concentration of mycotoxins in the feed increased with a larger inclusion of MC, the levels of fumonisin and deoxynivalenol in the 100% MC feed are still lower than the advisory levels laid out by the FDA with the diet containing 3.7 ppm and 3.0 ppm, respectively.

Although the diets contained a lower concentration of mycotoxins than is considered acceptable, the higher MC-content diets resulted in decreased performance by the broilers. At d 15, total BWG decreased (linear, $P = 0.007$) and FI tended to decrease (linear, $P = 0.093$) in broilers fed diets with increasing concentration of MC corn in the diet. The increase in mycotoxin concentration in diets fed to broilers also resulted in poorer (linear, $P = 0.010$) FCR.

In conclusion, increasing the concentrations of fumonisin, deoxynivalenol and zearalenone up to 3.9 ppm, 3.0 ppm, and 364 ppb, respectively, in starter broiler feed negatively impacted BWG, FI, and FCR, even when the individual mycotoxin levels were below acceptable limits for the poultry industry. The 100% MC diet contained the highest concentrations of fumonisins and deoxynivalenol (3.7 ppm and 3.0 ppm, respectively), but these levels were still below the FDA guidance of 50 ppm and 5 ppm, respectively. This demonstrates that while the mycotoxin level in poultry feed may be low enough to avoid causing harm to the animal, it can still influence broiler growth performance.

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Table 1. Mycotoxin content of the mycotoxin contaminated corn and experimental diets, as-fed basis[a,b]

		MC replacement of CC,[c] %				
Toxin	MC	0	25	50	75	100
Fumonisin B1, ppm	5.4	1.2	1.1	1.7	2.1	2.9
Fumonisin B2, ppm	2.1	0.2	0.2	0.4	0.6	0.7
Fumonisin B3, ppm	0.7	0.1	0.1	0.2	0.2	0.3
Deoxynivalenol, ppm	8.0	<0.6	1.0	1.4	2.3	3.0
Zearalenone, ppb	550.6	<51.7	94.5	180.5	294.6	364.1

[a]A total of 250 one-day-old male broiler chicks (Cobb 500) with initial BW of 0.092 lb were used in a 15-d growth trial with 5 chicks per pen and 10 replicates per treatment.
[b]Samples analyzed at Romer Labs (Union, MO).
[c]Dietary treatments consisted of an incremental increase in mycotoxin contaminated corn (MC) replacing clean corn (CC) on a weight/weight basis.

Table 2. Ingredient and nutrient content of experimental diets, as-fed basis[a,b]

	MC replacement of CC,[c] %				
Ingredient, %	0	25	50	75	100
CC	58.407	43.805	29.2035	14.602	---
MC	---	14.602	29.2035	43.805	58.407
Soybean meal	35.946	35.946	35.946	35.946	35.946
Limestone	0.991	0.991	0.991	0.991	0.991
Dicalcium	1.423	1.423	1.423	1.423	1.423
Salt	0.465	0.465	0.465	0.465	0.465
L-Lysine	0.206	0.206	0.206	0.206	0.206
DL-Methionine	0.327	0.327	0.327	0.327	0.327
L-Threonine	0.129	0.129	0.129	0.129	0.129
Quantum Blue[d]	0.01	0.01	0.01	0.01	0.01
Choline chloride	0.04	0.04	0.04	0.04	0.04
NB 3000	0.25	0.25	0.25	0.25	0.25
Soy oil	1.806	1.806	1.806	1.806	1.806
Total	100	100	100	100	100
Analyzed values, %					
NE maintenance, kcal/lb	765.6	765.9	764.6	769.8	764.0
DM	89.11	88.92	88.88	89.53	89.40
CP	16.1	16.5	16.6	16.4	17.3
Crude fiber	1.8	2.0	1.9	2.0	2.0
Ether extract	3.2	3.6	3.5	3.5	3.3

[a]A total of 250 one-day-old male broiler chicks (Cobb 500) with initial BW of 0.092 lb were used in a 15-d growth trial with 5 chicks per pen and 10 replicates per treatment.
[b]Samples analyzed at Ward Laboratories (Kearney, NE).
[c]Dietary treatments consisted of an incremental increase in mycotoxin contaminated corn (MC) replacing clean corn (CC) on a weight/weight basis.
[d]Quantum Blue 5G (AB Vista Inc., Plantation, FL).

Table 3. Effects of increasing mycotoxin contaminated corn replacing clean corn on growth performance of chicks[a]

	MC replacement of CC,[b] %						Probability, P =	
Item	**0**	**25**	**50**	**75**	**100**	**SEM**	**Linear**	**Quadratic**
BW, lb								
d 0	0.093	0.089	0.093	0.093	0.093	0.0020	0.504	0.692
d 15	1.27	1.29	1.24	1.21	1.17	0.0324	0.009	0.495
d 0 to 15								
BWG, lb	1.13	1.160	1.07	1.09	1.02	0.035	0.007	0.509
FI, lb	1.28	1.30	1.26	1.26	1.21	0.032	0.093	0.464
FCR	1.13	1.12	1.18	1.17	1.20	0.021	0.010	0.979

[a]A total of 250 one-day-old male broiler chicks (Cobb 500) with initial BW of 0.092 lb were used in a 15-d growth trial with 5 chicks per pen and 10 replicates per treatment.
[b]Dietary treatments consisted of an incremental increase in mycotoxin contaminated corn (MC) replacing clean corn (CC) on a weight/weight basis.
BWG = body weight gain. FI = feed intake. FCR = feed conversion ratio.