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Original research article

Impacts of low level aflatoxin in feed and the use of modified yeast cell wall extract on growth and health of nursery pigs

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ABSTRACT

This study was to investigate the effect of corn naturally contaminated with aflatoxins (AF) under the regulatory level on the growth performance and health of nursery pigs, and the efficiency of yeast cell wall based feed additive (YC) mainly composed of β-glucans and mannan oligosaccharide (MOS) (Integral A+, Alltech, Lexington, KY) in prevention of mycotoxicosis. Pigs (60 barrows and 60 gilts at 6.02 ± 0.83 kg BW) were randomly allotted to 4 treatments in a randomized complete block design based on a 2 × 2 factorial arrangement with 10 pens (5 barrow and 5 gilt pens) per treatment and 3 pigs per pen. Pigs were fed experimental diets for 5 wk. First factor was AF (0 or 20 μg/kg in feed) and the second factor was YC (0 or 2 g/kg in feed). Feed intake and body weight were measured weekly, and blood samples were used to measure blood cell counts, immunoglobulin G (IgG), tumor necrosis factor-α (TNF-α), oxidative damage status, and serological evaluation related to liver health. Aflatoxin decreased ($P < 0.05$) the number of platelet count (247.4 to 193.5 × 10^3/μL), and it also tended to increase the level of albumin ($P = 0.055$, 3.46 to 3.63 g/dL), albumin:globulin ratio ($P = 0.050$, 2.09 to 2.37), and Ca ($P = 0.080$, 10.79 to 10.97 mg/dL). Yeast cell wall based feed additive increased ($P < 0.05$) ADG (493 to 524 g/d), and ADFI (796 to 846 g/d) of pigs whereas G:F was not affected, and it also tended to increase ($P = 0.055$) albumin level (3.46 to 3.63 g/dL). Interactions ($P < 0.05$) on hemoglobin, hematocrit, and platelet count indicated that YC further increased their levels when pigs were eating AF contaminated feed. Interactions ($P < 0.05$) on urea nitrogen and blood urea N to creatinine ratio indicated that YC further decreased their levels when feed were contaminated with AF. In conclusion, low level of 20 μg AF/kg under the regulatory level had minor effects on hematology without affecting growth performance, however the supplementation of 2 g/kg YC as a source of β-glucans and MOS in feed can improve feed intake and therefore the growth of pigs.

1. Introduction

Corn is the most commonly used energy feed for pigs. However, corn is commonly contaminated with mycotoxins especially when corn is grown under high temperature and drought condition in breeding season and cool and damp condition in harvesting season (Binder et al., 2007; Chaytor et al., 2011a). Among 300 existing mycotoxins, aflatoxin (AF) is the only mycotoxin regulated by the US Food and Drug Administration (Dersjant-Li et al., 2003; Richard, 2007). Aflatoxin is also one of the most common mycotoxins found in foods processed for human consumption, such as corn, cotton seeds, nuts, peanuts, pistachios, spices, and dry fruits (CAST, 2003). Ingestion of AF by animals can result in many problems, including decreased growth rates, liver damage, immune suppression, and death (CAST, 2003). Pigs are one of the most susceptible commodity species to AF with damages to the gut and the liver (Hussein and Brasel, 2001; Weaver et al., 2013). Most countries limit AF concentration in the corn with different levels. The US is relatively more stringent on AF limitation which is 20 μg AF/kg in corn. The regulatory level for nursery pigs in US is also 20 μg AF/kg in corn whereas it is higher for finishing pigs and breeding pigs. Usually multiple mycotoxins are contaminated in corn and grains (Dersjant-Li et al., 2003). Contaminated corn used in this study also contained fumonisin (FUM). At the high level, FUM can damage the brain, lungs, kidneys, and liver (CAST, 2003).

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The yeast cell wall based feed additive (YC) mainly containing β-glucans and mannan oligosaccharide (MOS) was used in this study and commercially available in the US (Kogan and Kocher, 2007; Ringot et al., 2005; Yiannikouris et al., 2004). Green algae are another component of YC which is a large group of algae that embryophytes are emerged. The green algae are classified into 6 clades, and 4 of them include the composition of β-glucans or MOS (Becker et al., 1991, 1994; Ciancia et al., 2012; Sørensen et al., 2011, 2012). β-glucans and MOS were shown to have binding capabilities to AF, deoxynivalenol (DON), and zearafenone (ZEA) (Huwig et al., 2001; Kogan and Kocher, 2007; Spring et al., 2000) and thus reducing the damaging effects of mycotoxins on pigs. In addition to the possible binding effects of β-glucans and MOS to mycotoxins, it is also shown that β-glucans can alter the balance of interleukin-1 and interleukin-1 receptor antagonist to reduce inflammatory cytokine production (Dritz et al., 1995) and MOS can alter the immune response by binding to mannose receptors on the macrophage cell surface which will enhance macrophage function (Davis et al., 2004).

The main hypothesis of this study was that growth and health of nursery pigs could minimally be affected by AF in the diets below the regulatory level and YC including β-glucans and MOS would help the growth and health of pigs fed these diets.

2. Materials and methods

The protocol for the use of animals in this study was approved by the North Carolina State University Animal Care and Use Committee.

2.1. Animals

One hundred twenty newly weaned pigs (60 gilts and 60 barrows, Smithfield Premium Genetics, Rose Hill, NC) had an acclimation period with phase 1 diet (Table 1) for 12 d. Pigs were then grouped based on their BW with a same sex and randomly allotted to 4 treatments based on a randomized complete block design with their BW and sex as blocks. Four treatments had 2 × 2 factorial arrangement. The first factor was AF (0 or 20 μg/kg in feed) and the second factor was YC (0 or 2 g/kg in feed). Each treatment had 10 pens (5 barrow pens and 5 gilt pens) with 3 pigs per pen.

Table 1
Composition of experimental diets (as-fed basis).[1]

Item	Phase 1	Phase 2				Phase 3			
	No AF	No AF		AF		No AF		AF	
	No YC	No YC	YC	No YC	YC	No YC	YC	No YC	YC
Ingredient, %									
Yellow corn	42.1	53.8	53.6	52.8	52.6	65.42	65.22	64.42	64.22
Soybean meal	25	30	30	30	30	30	30	30	30
DairyLac 80	20	9	9	9	9				
Blood plasma	8	2.5	2.5	2.5	2.5				
L-Lys HCl	0.05	0.15	0.15	0.15	0.15	0.1	0.1	0.1	0.1
DL-Met	0.05	0.05	0.05	0.05	0.05				
Salt	2	0.22	0.22	0.22	0.22	0.3	0.3	0.3	0.3
Vitamin premix[2]	0.22	0.03	0.03	0.03	0.03	0.15	0.15	0.15	0.15
Mineral premix[3]	0.03	0.15	0.15	0.15	0.15	0.03	0.03	0.03	0.03
Dicalcium P	0.15	1.4	1.4	1.4	1.4	1.4	1.4	1.4	1.4
Limeston, ground	1.8	0.7	0.7	0.7	0.7	0.6	0.6	0.6	0.6
poultry fat	0.6	2	2	2	2	2	2	2	2
YC			0.2		0.2		0.2		0.2
Corn AF[4]				1	1			1	1
Calculated composition									
DM, %	91.3	90.5	90.5	90.5	90.5	89.8	89.8	89.8	89.8
ME, Mcal/kg	3.45	3.42	3.42	3.42	3.42	3.42	3.42	3.42	3.42
CP, %	22.4	21.1	21.1	21.1	21.1	19.7	19.7	19.7	19.7
Lys, %	1.45	1.34	1.34	1.34	1.34	1.15	1.15	1.15	1.15
Cys + Met, %	0.84	0.76	0.76	0.76	0.76	0.66	0.66	0.66	0.66
Trp, %	0.3	0.26	0.26	0.26	0.26	0.23	0.23	0.23	0.23
Thr, %	0.98	0.83	0.83	0.83	0.83	0.74	0.74	0.74	0.74
Lactose sugar	16	7.2	7.2	7.2	7.2				
Ca, %	0.91	0.8	0.8	0.8	0.8	0.72	0.72	0.72	0.72
Available P, %	0.56	0.4	0.4	0.4	0.4	0.33	0.33	0.33	0.33
Total P, %	0.89	0.72	0.72	0.72	0.72	0.64	0.64	0.64	0.64
AF, μg/kg				20	20			20	20
YC, %			0.2		0.2		0.2		0.2
Analyzed composition, %									
DM	92.7	91.6	91.4	91.6	91.8	90.5	91.1	90.4	90.5
CP	21.5	20.2	19.6	21.8	19.5	19	20.3	18.6	18.6
ADF	3.15	2.75	2.21	3.48	2.92	2.91	3.35	3.7	3.47
Ca	0.79	0.74	0.83	0.66	0.83	0.73	0.69	0.66	0.69
P	0.86	0.68	0.74	0.67	0.73	0.64	0.64	0.64	0.63
AF[5], μg/kg				27	39			36	29

AF = aflatoxin; YC = yeast cell wall based feed additive; ADF = acid detergent fiber.

[1] Factor AF with the presence of 20 μg AF/kg. Factor YC with the supplementation of 2 g Integral A+/kg (Integral A + was a product of Alltech, Lexington, KY).

[2] Vitamin premix provided the following per kilogram of complete diet: 22,045,000 IU of vitamin A; 3,306,900 IU of vitamin D_3; 66,138 IU of vitamin K; 88 mg of vitamin B_{12}; 15,432 mg of riboflavin; 88,184 mg of niacin; 61,729 mg of d-pantothenic acid; 8,818 mg of menadione; 220 mg of biotin.

[3] Mineral premix provided the following composition: 1.10% of Cu; 198.0 mg/kg of I; 11.02% of Fe; 2.64% of Mn; 198.4 mg/kg of Se; 11.02% of Zn.

[4] Corn AF was corn naturally contaminated with 20 μg AF/kg and 1.6 mg fumonisin/kg.

[5] Aflatoxin in diets were analyzed by a commercial laboratory (Food and Drug Protection Division Laboratory, NC).