Animal Nutrition 2 (2016) 186–191

Contents lists available at ScienceDirect

Animal Nutrition

journal homepage: http://www.keaipublishing.com/en/journals/aninu/

Original research article

Effects of aflatoxins on growth performance and skeletal muscle of Cherry Valley meat male ducks

Wenhuan Chang [1], Qing Xie [1], Aijuan Zheng [1], Shu Zhang, Zhimin Chen, Jinquan Wang, Guohuo Liu*, Huiyi Cai

The Key Laboratory of Feed Biotechnology of the Ministry of Agriculture, Feed Research Institute, Chinese Academy of Agricultural Sciences, Beijing 100081, China

ARTICLE INFO

Article history:
Received 22 March 2016
Received in revised form
29 May 2016
Accepted 14 June 2016
Available online 23 June 2016

Keywords:
Aflatoxin
Cherry Valley duck
Skeletal muscle
Gompertz equation

ABSTRACT

This study aims to evaluate the effects of aflatoxins on growth performance and skeletal muscle of Cherry Valley meat male ducks as they grow and develop. One-day-old healthy meat male ducks ($n = 180$) were randomly divided into 2 groups; there were 6 replicates in each group and 15 ducks in each replicate. The control group was fed a basic diet, and the experimental group was fed a mold-exposed cottonseed meal diet containing aflatoxins instead of normal cottonseed meal. The experimental period was 35 days, and divided into two stages of 1 to 14 days (early stage) and 15 to 35 days (late stage). During the experimental period, live weight, breast muscle weight and thigh muscle weight of meat male ducks were measured weekly. Results showed as follows: 1) aflatoxins contained in the mold-exposed diet significantly reduced daily weight gain and feed intake, and increased feed-to-gain ratio of meat male ducks at different ages ($P < 0.05$); 2) the Gompertz equation ($W_t = W_m \exp\{-\exp[-B(t - t^*)]\}$) could successfully fit the growth curve and growth and developmental patterns of skeletal muscles of Cherry Valley meat male ducks ($R^2 \geq 0.97$); 3) the relationship between chest muscle and live weight was the best described by a power regression and polynomial regression ($R^2 = 0.99$); the relationship between live weight and thigh muscle weight was the best described by linear regression, polynomial regression, and power regression ($R^2 = 0.99$); 4) aflatoxins in the mold-exposed diet significantly reduced live weight, breast muscle weight and thigh muscle weight of Cherry Valley meat male ducks at various ages; and 5) aflatoxins delayed the age at peak in growth of meat male ducks, and reduced weights at the peak for breast muscle, thigh muscle and whole body as well as the maximal daily weight gain. In summary, aflatoxins delayed growth of Cherry Valley meat male ducks and development of skeletal muscle.

1. Introduction

The Food and Agriculture Organization of the United Nations (FAO) estimates that 25% of grain is contaminated with mycotoxins globally each year, and, on average, 2% is not edible. Ingestion of such contaminated grain can result in poisoning, disease and even death in a large number of animals, causing huge economic losses to the food industry and animal husbandry. Among these mycotoxins, the most serious contamination is caused by aflatoxins (AFs) (Feng et al., 2014). Aflatoxins are the secondary metabolite produced by *Aspergillus flavus*, *Aspergillus parasiticus*, *Aspergillus nomius* and *Aspergillus pseudotamarii*, is extremely toxic, mutagenic and carcinogenic, and is recognized to be the most harmful mycotoxin. In recent years, AFs contamination in poultry feed have become increasingly serious, and severely affects the development

* Corresponding author.
E-mail address: liuguohua@caas.cn (G. Liu).
Peer review under responsibility of Chinese Association of Animal Science and Veterinary Medicine.

Production and Hosting by Elsevier on behalf of KeAi

[1] These authors contributed equally to the work.

http://dx.doi.org/10.1016/j.aninu.2016.06.002

of animal husbandry in China (Liu et al., 2015; Huang et al., 2014a, 2014b). Meat duck is one of the animals most sensitive to AFs. High levels of AFs can cause acute death in meat-type ducks, and prolonged exposure to low levels of AFs can induce chronic toxicity, resulting in their slow growth and reduced production performance (Shi et al., 2010; Lv et al., 2013; Xie et al., 2015). There are a vast number of ducks raised in China. According to FAO's statistical data, the worldwide inventory of meat ducks in 2013 reached 1.186 billion; and of these, 1.045 billion were in Asia and 695 million in China, accounting for 58.60% and 66.51% of the world duck inventory and Asian duck inventory, respectively. Duck carcass muscle is mainly distributed in breast and thigh, and the quality and yield of breast and thigh muscles constitute important factors affecting poultry production performance, and are primary characteristics to consider in poultry breeding. The present study aims to study the effects of AFs on growth performance and skeletal muscle of meat male ducks as they age and develop.

2. Materials and methods

2.1. Materials

Cherry Valley meat ducklings were purchased from the hatchery of Xianghe Chia Tai Co., Ltd., and feeding trial was conducted in test base of Chinese Academy of Agricultural Sciences.

The AFs in the mold-exposed diet were from moldy cottonseed meal, and high performance liquid chromatography-fluorescence detection (HPLC-FLD) was used for the determination of AFs content in mold-exposed cottonseed meal. The basal diet was corn-soybean meal, with nutritional value and diet type typical for a commercial Cherry Valley meat duck in China, and this was used as the reference; the diet was designed based upon the nutrient requirements published by the National Research Council (NRC) (2012) for meat ducks. The composition and nutrient content of the diet are shown in Table 1. The cottonseed meal in control diet was normal cottonseed meal, and the cottonseed meal in the test diet was mold-exposed cottonseed meal. The amounts of added cottonseed meal were all 8%, and diets were fed in the form of pellets.

The experimental results showed that AF content of the mold-exposed cottonseed meal used in this experiment was 1,337.21 μg/kg; while AF contents of control group at early and late stages were 0.65 and 0.62 μg/kg, respectively. The contents of AFs (B_1, B_2, G_1, and G_2) of the experimental group at early and late stages were 80.59, 20.60, 0.83, 0.34 μg/kg and 81.02, 20.65, 0.91, 0.36 μg/kg, respectively; no other mycotoxins were detected. The AF content of the diet for the experimental group was higher than the limit for meat ducks per in the "Hygienical standard for feeds" (2001) in China, whereas AFB_1 contents at the early and late stages did not exceed 10.0 and 20.0 μg/kg, respectively.

2.2. Experimental design and feeding management

A total of 180 one-day-old Cherry Valley meat ducklings (male duck) were randomly divided into 2 treatment groups, and there were 6 replicates for each treatment and 15 male ducks for each replicate. The control and experimental groups were fed a basal diet and a mold-exposed diet, respectively, and initial body weight was not significantly different between the groups ($P > 0.05$). The ducklings were raised in battery cages, and warm air was used for brooding ducklings. During the trial period, male ducks had free access to food and water, regular desludging and sterilization were conducted, and a 24-h light was provided. The survival ratios of ducks in control and test group were 96.67% and 95.56%, respectively.

2.3. Determination of indicators

2.3.1. Production performance

The replicates were used as a unit to measure weights on days 7, 14, 21, 28, and 35 of the trial, and feeding was stopped 12 h before weighing; free access to water was provided. Live weight (LW) and feed consumption were recorded at various ages, and the average daily (weight) gain (ADG), average daily feed intake (ADFI) and feed-to-gain ratio (F:G) were calculated.

2.3.2. Determination of AF amounts

The contents of AFs (B_1, B_2, G_1, and G_2) in feed and feed raw materials were analyzed by HPLC-FLD, and results were expressed in total amounts of 4 AFs. Derivatization was performed using a post-photochemical derivatization column, which was purchased from Beijing Huaan Magnech Bio-Tech Co., Ltd.

2.3.3. Data collection

On 1, 7, 14, 21, 28, and 35 days of age, 1 male duck of average BW from each replicate was chosen, weighed and slaughtered by bleeding the left jugular vein after fasting for 12 h. Live weight, breast muscle weight (BMW), and thigh muscle weight (TMW) were recorded.

2.4. Data processing and analysis methods

The cumulative growth factors and average values of LW, BMW, and TMW in different treatment groups were calculated, and cumulative growth factors were actual values for all ages. The nonlinear regression method in SPSS 19.0 (2010, SPSS Inc., Chicago, IL 60606-6307) was used to estimate parameters in the Gompertz model. The relationship between LW of meat male ducks and

Table 1
Composition and nutrient levels of basal diets (air-dry basis).

Item	Weeks 1 to 2		Weeks 3 to 5	
	control	treatment	control	treatment
Ingredients, %				
Corn	58.91	59.37	63.89	63.84
Soybean meal	23.32	22.68	15.12	14.58
Soybean oil	0.95	1.33	1.69	2.23
Corn protein meal	2.00	2.00	3.00	3.00
Cottonseed meal	8.00	8.00	8.00	8.00
Rapeseed meal	2.00	2.00	4.00	4.00
$CaHPO_4$	1.80	1.91	1.70	1.82
Limestone	1.23	0.91	0.93	0.85
NaCl	0.30	0.30	0.30	0.30
L-lysine	0.28	0.29	0.22	0.23
DL-methionine	0.21	0.21	0.15	0.16
Premix[1]	0.50	0.50	0.50	0.50
Choline chloride	0.10	0.10	0.10	0.10
Zeolite	0.40	0.40	0.40	0.40
Total	100.00	100.00	100.00	100.00
Nutrient level, %[2]				
ME, MJ/kg	12.14	12.14	12.54	12.54
CP	19.98	20.03	18.11	18.23
Ca	0.95	0.91	0.89	0.85
Available P	0.42	0.44	0.44	0.42
Lysine	1.12	1.10	0.89	0.93
Methionine	0.50	0.47	0.45	0.42
Threonine	0.77	0.82	0.75	0.71
Tryptophan	0.24	0.28	0.26	0.22

[1] The premix provided the following per kg of diets: VA 5,000 IU, VD 800 IU, VE 10 IU, VK_3 1 mg, VB_1 1.5 mg, riboflavin 6 mg, nicotinic acid 22 mg, D-pantothenic acid 20 mg, VB_6 2 mg, VB_{12} 0.03 mg, folic acid 0.8 mg, Cu (as copper sulfate) 20 mg, Fe (as ferrous sulfate) 90 mg, Mn (as manganese sulfate) 70 mg, Zn (as zinc sulfate) 60 mg, I (as potassium iodide) 0.40 mg, Se (as sodium selenite) 0.30 mg.

[2] Metabolizable energy was a calculated value, and the others were measured values.