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Original Research Article

Effects of ammonia exposure on carcass traits and fatty acid composition of broiler meat

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ABSTRACT

We aimed to study the effects of ammonia on carcass traits, organ indices and fatty acid composition of broilers. Four hundred 21-d-old male Arbor Acres broilers with initial weight 563.52 ± 2.82 g were randomly allotted to 1 of 4 groups treated with ammonia at <3 mg/kg (control), 25 ± 3, 50 ± 3, and 75 ± 3 mg/kg concentrations. Each group consisted of 4 replicates of 25 birds. Broilers from 21 to 42 d were reared on the net floor in the respiration-metabolism chambers where similar environmental conditions were maintained. At 32 and 42 d of age, carcass traits and organ indices were determined for 4 birds per pen. At 42 d of age, fatty acid composition in the breast and thigh muscle of broilers was measured. Results showed as follows: 1) At 32 d, the dressing percentage of broilers exposed to 25 and 75 mg/kg ammonia were lower than those in the control group ($P < 0.05$); eviscerated yield percentage of broilers in the 25 mg/kg ammonia group was also lower ($P < 0.05$). At 42 d, the dressing percentage of broilers in the ammonia treatments and the thigh muscle percentage of broilers in the 50 and 75 mg/kg ammonia groups were lower ($P < 0.05$) than those in the control. Breast muscle percentage of broilers exposed to 25 and 50 mg/kg ammonia and eviscerated yield percentage exposed to 50 mg/kg ammonia were lower than those in the control ($P < 0.05$). 2) The kidney index of broilers (d 32) exposed to ammonia was greater ($P < 0.05$) than that of the control. At 42 d, hepatic index of broilers exposed to ammonia was increased ($P < 0.05$), and spleen index was decreased ($P < 0.05$). 3) At 42 d, stearic (C18:0) and saturated fatty acids (SFA) in the thigh muscle of broilers were higher, while the unsaturated fatty acid:saturated fatty acid (U:F) ratio and unsaturated fatty acid (UFA) were lower in the 50 mg/kg ammonia treatment than in the control group ($P < 0.05$). In conclusion, ammonia over 25 mg/kg could decline carcass traits and immune organ indices and increase the kidney and hepatic indices. Further, exposure to 50 mg/kg ammonia could also decrease breast and thigh muscle yield percentage while increasing SFA content and decreasing UFA content in the thigh muscle of broilers.

1. Introduction

The living environment of poultry is an important factor, along with standardization, scale, and intensive process of animal husbandry, affecting their development and restricting fulfillment of their genetic potential (Fang, 2009). Ammonia, a colorless, water-soluble gas that is a strong irritant (Jacobson, 2010), is known to negatively influence the growth, immunity, and meat quality of chicken (Beker et al., 2004). Studies on the effect of ammonia on broiler carcass traits and organ development are very important to improve breeding environment and food safety. Birds are more sensitive to ammonia than other animals (Wathes et al., 1983). Ammonia can damage heart and tracheal tissues, cause secondary infection of air sacculitis (Moum et al., 1969), Newcastle disease (Anderson et al., 1964), coccidiosis (Quarles & Caveny, 1979) and abdominal swelling (Kristensen & Wathes, 2000), resulting in increased mortality of broilers, a decrease in performance, and, consequently, a reduction in farming benefit. Broilers reared in an environment with ammonia concentration more than 25 mg/kg showed a reduction in antioxidant capacity (Wei et al., 2012) and an increase in malonaldehyde (MDA) content in the blood (Aziz &

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Barnes, 2009) which can result in changes to the structure and physiological function of the cell membrane (Lawrie, 1998).

Body fat content has a close connection with nutrient value, taste, flavor, and shear force of the meat (Liu & Yu, 1981; Skrivan et al., 2000). Unsaturated fatty acids (UFA) are easily oxidized by free radicals to form saturated fatty acids (SFA), which changes the composition of volatile flavor components, and the taste and quality of meat was declined (Hou, 2000). When exposed to ammonia, free radicals accumulate rapidly in the animal's body, causing damage due to peroxidation of phosphatide in the cell membrane. Currently there was little research on the effect of atmospheric ammonia on the content and composition of fatty acid in broilers. Information about the effects of different levels of ammonia on meat quality was limited. Therefore, the goal of the current research was to evaluate the effect of exposure to different ammonia concentration (<3, 25, 50 and 75 mg/kg) on carcass traits, organ indices, and fatty acid composition of broiler meat, and to provide fundamental data for the control of environment in a poultry house.

2. Materials and methods

2.1. Birds and housing

The experiment was conducted in 4 respiration-metabolism chambers (4.5 m × 3.0 m × 2.5 m each) at the State Key Laboratory of Animal Nutrition (Changping in Beijing, China). Arbor Acres (AA) male broilers, 21 d old, obtained from Huadu Broiler Breeding Corporation in Beijing, were used in the experiment. Birds were vaccinated for Marek's disease, Newcastle disease, and infectious bronchitis at the hatchery. To exclude the effects of sex, only male birds were used. With 1 group for 1 chamber, a total of 400 broilers (initial BW 563.52 ± 2.82 g) were randomly divided into 4 groups with 4 replicates in each group and 25 broilers in each replicate. All birds were raised on the net floor and provided with continuous light. Room temperature was maintained at 24°C. All broilers were allowed *ad libitum* access to water and feed and were handled in accordance with the guidelines prescribed for AA broilers. The experiment was conducted for a period of 21 d: the first phase was 21 to 31 d, and the later phase was 32 to 42 d. The environmental conditions of the chambers were controlled by a computer with an accuracy of ±1°C for temperature, ± 7% for relative humidity, ≤0.1% for ventilation rate, and ±3 mg/kg for ammonia concentration.

2.2. Ammonia treatments

Ammonia (purity ≥ 98%) and ammonia bottles were provided by the Beijing Beiwen Gas Factory. The ammonia bottle was connected to a pressure regulator (BRE-A1E1F1A11, BVF International), and a flow meter (LZQ-3WMF) in sequence to keep ammonia concentration stable. The latter was connected to the chamber by a silicone tube. The following concentrations of ammonia were set for the 4 groups: <3 mg/kg (control group), 25 ± 3, 50 ± 3, 75 ± 3 mg/kg, respectively. In order to maintain the lowest concentration of ammonia (<3 mg/kg), the chamber housing of the control group was cleaned twice a day to keep the floor dry and tidy. The other three chambers (the experimental groups) were also cleaned twice a day and were pumped with ammonia of different concentrations. Each respiration-metabolism chamber was equipped with Innova 1412 photo-acoustic field gas-monitor to test the concentration of ammonia. In addition, to ensure that the ammonia concentration was consistent across a given chamber, the concentration was monitored at different locations within the chamber using a Gastec detector tube pump (kit 800, Japan) every 2 h.

2.3. Diets

A corn-soybean diet was formulated to meet requirements of AA broilers for all nutrients. The dietary composition and nutrition levels are presented in Table 1.

2.4. Sampling and measurements

At 32 and 42 d of age, 4 broilers were randomly selected from each replicate and weighed after 12 h of fasting (water was provided *ad libitum*). The birds were exsanguinated by cutting the jugular vein, and the heart, liver, kidney, spleen, thymus, and bursa of Fabricius, left breast muscle, left thigh muscle and abdominal fat were then removed by trained personnel and weighed. The muscle was stored at −20°C for further analysis. The dressing percentage, semi-eviscerated yield percentage, eviscerated yield percentage, breast and thigh muscle percentage were measured according to Yang (2010). All organ indices were expressed as a percentage of BW.

$$\text{Organ index } (\%) = 100 \times \text{Weight of organ}/\text{Body live weight}.$$

2.5. Fatty acid analysis

Samples of approximately 20 g were collected from the left breast muscle and left thigh muscle. The fatty acid compositions were measured using the gas chromatographic method (G B/T 9695.2-2008, 2008).

2.6. Statistical analysis

Firstly, data were under the test of homogeneity of variance. If they meet homogeneity of variance, data were subjected to statistical analysis using one-way ANOVA procedure of SAS9.2 (SAS Institute, Inc., 2003) and Duncan's test was used to compare the treatment means. If not, data were subjected to statistical analysis using NPAR1WAY procedure of SAS9.2 (SAS Institute, Inc., 2003). A significant difference level of $P < 0.05$ was used to determine statistical significance, and a level of $P > 0.05$ was considered no significance. The data were reported as average ± SD.

Table 1
Dietary composition and nutrient levels (air-dry basis, %).

Ingredient	Content	Nutrient level[2]	Content
Corn	58.00	ME, MJ/kg	12.70
Soybean meal	33.40	CP	19.93
Vegetable oil	4.00	Ca	0.90
Limestone	1.15	AP	0.40
$CaHPO_4$	1.64	Lys	1.14
Lysine	0.18	Met	0.50
Methionine	0.32	Met + Cys	0.69
Choline chloride (50%)	0.06		
NaCl	0.25		
Premix[1]	1.00		
Total	100		

[1] The premix provided the following per kg of diets: VA 6,000 IU, VD 1,000 IU, VE 75.0 mg, VK_3 18.8 mg, VB_1 9.8 mg, VB_2 28.8 mg, VB_6 19.6 mg, VB_{12} 0.1 mg, calcium pantothenate 58.8 mg, nicotinic acid 196.0 mg, folic acid 4.9 mg, biotin 2.5 mg, Cu 4.0 mg, Fe 40.0 mg, Zn 37.6 mg, Mn 50.0 mg, Se 0.2 mg, I 0.2 mg.
[2] Metabolizable energy was a calculated value. The other nutrient levels were measured values.

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