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 decrease 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.

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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 \( \times \) 3.0 m \( \times \) 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 ± 2°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.

Organ index (%) = 100 × Weight of organ/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 19695.2-2008, 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

| Ingredient | Content | Nutrient level1 | 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    |
| CaHPO4     | 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    |                  |         |
| Premix2    | 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, VK3 18.8 mg, VB2 9.8 mg, VB3 28.8 mg, VB6 19.6 mg, VB12 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 1.02 mg.
2 Metabolizable energy was a calculated value. The other nutrient levels were measured values.
3. Results

3.1. Carcass traits

The carcass traits of broilers in different groups are shown in Table 2. After 10 d of exposure to ammonia (at 32 d), compared with the control group and the other two ammonia treatment groups, the eviscerated yield percentage of broilers in the group exposed to 25 mg/kg was significantly lower (*P* < 0.05). The dressing percentage of broilers in the groups exposed to 25 and 75 mg/kg were significantly lower (*P* < 0.05) than those in the control group and the experimental group treated with 50 mg/kg ammonia. The percentage of semi-eviscerated yield, breast muscle and thigh muscle did not differ significantly among the groups (*P* > 0.05). After 20 d of exposure to ammonia (at 42 d), the dressing percentage of birds and thigh muscle percentage in birds housed at 50 and 75 mg/kg ammonia were markedly lower on comparison with the control group and the experimental group treated with 75 mg/kg ammonia (*P* < 0.05). The ammonia treatment had no significant influence on semi-eviscerated percentage (*P* > 0.05).

Table 3 details the organ indices of broilers in the different groups. After 10 d of exposure to ammonia (at 32 d), the kidney index of broilers in all 3 experimental groups did not differ from each other but was increased significantly when compared with the control group separately (*P* < 0.05). Heart index, spleen index, thymus index and bursa of Fabricius index did not differ significantly among the groups (*P* > 0.05). After 20 d of exposure to ammonia (at 42 d), the hepatic index of broilers in the 3 experimental groups was increased (*P* < 0.05) while the spleen index was decreased significantly (*P* < 0.05). The heart index, kidney index, thymus index, bursa of Fabricius index did not differ significantly among the groups (*P* > 0.05).

3.2. Fatty acid composition in muscle

The fatty acid composition of breast and thigh muscles is presented in Tables 4 and 5, respectively. Our results showed that after 20 d of exposure to ammonia (at 42 d), the fatty acid content in breast meat was not significantly different among the 4 groups (*P* > 0.05). Compared with the control group and the experimental group exposed to 75 mg/kg ammonia, the stearic acid (C18:0) and SFA content in the thigh meat of the birds exposed to 50 mg/kg ammonia increased significantly (*P* < 0.05), while the ratio of U:F ratio and UFA content in the thigh meat decreased significantly (*P* < 0.05). Palmitoleic acid (C16:1), oleic acid (C18:1N9C) and monounsaturated fatty acid (MUNA) contents in the thigh meat had no significant difference among the 4 groups (*P* > 0.05).

Table 2
Effect of ammonia on slaughter performance (%) of broiler chickens.

| Item                     | Ammonia concentration, mg/kg | P-value |
|--------------------------|-------------------------------|---------|
|                          | <3                           | 25 ± 3  | 50 ± 3  | 75 ± 3  |         |
| **32 d of age**          |                               |         |         |         |         |
| Dressing percentage      | 92.93 ± 0.40a                 | 91.27 ± 1.27b | 92.78 ± 0.39a | 91.58 ± 1.29b | 0.005 |
| Semi-eviscerated yield percentage | 85.95 ± 1.07                | 85.62 ± 3.52 | 82.29 ± 5.04 | 85.32 ± 4.01 | 0.182 |
| Eviscerated yield percentage | 72.95 ± 0.99a              | 69.28 ± 1.11b | 71.70 ± 1.28a | 71.48 ± 3.314a | 0.013 |
| Breast muscle percentage | 23.19 ± 3.29                 | 21.81 ± 1.60  | 20.78 ± 1.31  | 21.54 ± 1.41  | 0.079 |
| Thigh muscle percentage  | 18.06 ± 5.13                 | 15.68 ± 2.32  | 15.06 ± 4.37  | 17.44 ± 4.30  | 0.497 |
| **42 d of age**          |                               |         |         |         |         |
| Dressing percentage      | 91.96 ± 0.35a                 | 89.38 ± 1.73b | 89.72 ± 1.19b | 89.23 ± 3.22b | 0.047 |
| Semi-eviscerated yield percentage | 85.74 ± 0.82                | 84.28 ± 1.46  | 83.74 ± 1.43  | 84.31 ± 1.44  | 0.052 |
| Eviscerated yield percentage | 73.00 ± 0.86a              | 72.34 ± 1.57ab | 70.97 ± 1.31b | 72.62 ± 1.26a | 0.035 |
| Breast muscle percentage | 23.61 ± 1.06a                | 16.11 ± 2.47a  | 19.84 ± 2.64ab | 22.09 ± 2.28ab | <0.001 |
| Thigh muscle percentage  | 20.16 ± 1.82a                | 19.34 ± 1.24ab | 18.36 ± 1.48ab | 18.02 ± 1.08ab | 0.040 |

*abc* Values with the same or no lower case letter in the same row are not significantly different (*P* > 0.05); values with different lower case letters in the same row are significantly different (*P* < 0.05).

Table 3
Effect of ammonia on the organ index (%) of broiler chickens.

| Item                     | Ammonia concentration, mg/kg | P-value |
|--------------------------|-------------------------------|---------|
|                          | <3                           | 25 ± 3  | 50 ± 3  | 75 ± 3  |         |
| **32 d of age**          |                               |         |         |         |         |
| Heart index              | 5.42 ± 0.43                   | 5.70 ± 1.13  | 5.57 ± 0.52  | 5.54 ± 0.63  | 0.916 |
| Kidney index             | 2.33 ± 1.21b                  | 6.38 ± 1.26a  | 5.48 ± 0.95a  | 5.90 ± 2.78b  | <0.001 |
| Hepatic index            | 24.41 ± 2.73                  | 27.24 ± 2.28  | 24.63 ± 1.39  | 25.51 ± 1.87  | 0.079 |
| Spleen index             | 1.19 ± 0.40                   | 0.98 ± 0.22  | 0.86 ± 0.19  | 1.16 ± 0.28  | 0.116 |
| Thymus index             | 1.82 ± 0.90                   | 1.48 ± 0.46  | 1.00 ± 0.79  | 1.46 ± 0.77  | 0.260 |
| Bursa of Fabricius index | 1.19 ± 0.40                   | 0.98 ± 0.22  | 0.86 ± 0.19  | 1.16 ± 0.28  | 0.116 |
| **42 d of age**          |                               |         |         |         |         |
| Heart index              | 4.33 ± 0.35                   | 4.51 ± 0.29  | 4.56 ± 0.38  | 4.87 ± 0.79  | 0.953 |
| Kidney index             | 2.58 ± 1.55                   | 4.31 ± 1.04  | 4.26 ± 1.80  | 3.85 ± 1.88  | 0.179 |
| Hepatic index            | 18.27 ± 1.41b                 | 20.29 ± 1.41a  | 21.04 ± 1.82a  | 21.00 ± 2.01a  | 0.017 |
| Spleen index             | 1.30 ± 0.18b                  | 1.04 ± 0.18b  | 0.98 ± 0.17b  | 1.00 ± 0.20b  | 0.011 |
| Thymus index             | 3.15 ± 1.33                   | 2.17 ± 1.02  | 2.51 ± 1.19  | 2.04 ± 0.90  | 0.274 |
| Bursa of Fabricius index | 2.01 ± 0.84                   | 1.45 ± 0.21  | 1.46 ± 0.26  | 1.72 ± 0.41  | 0.138 |

*abc* Values with the same or no lower case letter in the same row are not significantly different (*P* > 0.05); values with different lower case letters in the same row are significantly different (*P* < 0.05).
The effect of ammonia on the carcass traits of broilers at 42 d of age.

| Item                          | Ammonia concentration, mg/kg | P-value |
|-------------------------------|-----------------------------|---------|
|                               | <3             | 25 ± 3       | 50 ± 3       | 75 ± 3       |
| Myristic (C14:0), %           | 0.33 ± 0.03    | 0.32 ± 0.03  | 0.34 ± 0.04  | 0.39 ± 0.09  | 0.381   |
| Palmitic (C16:0), %           | 20.48 ± 0.47   | 21.29 ± 1.34 | 20.18 ± 0.76 | 20.22 ± 0.47 | 0.258   |
| Palmitoleic (C16:1), %        | 1.99 ± 0.24    | 2.26 ± 0.26  | 1.41 ± 0.31  | 1.96 ± 0.80  | 0.599   |
| Stearic (C18:0), %            | 10.06 ± 0.93   | 10.52 ± 1.29 | 10.83 ± 0.97 | 11.07 ± 1.82 | 0.941   |
| Oleic (C18:1N9C), %           | 23.22 ± 0.77   | 23.62 ± 2.19 | 22.26 ± 1.06 | 23.11 ± 3.69 | 0.854   |
| Linoleic (C18:2N6C), %        | 26.63 ± 2.59   | 25.47 ± 3.00 | 28.87 ± 3.24 | 26.51 ± 0.91 | 0.554   |
| Linolenic (C18:3), %          | 2.28 ± 0.39    | 2.37 ± 0.73  | 2.57 ± 0.59  | 2.42 ± 0.23  | 0.886   |
| Arachidonic (C20:4N6), %      | 5.48 ± 0.91    | 5.89 ± 1.28  | 5.25 ± 0.61  | 5.99 ± 1.85  | 0.818   |
| Saturated fatty acids (SFA), %| 35.92 ± 1.44   | 36.36 ± 3.15 | 35.60 ± 2.52 | 35.81 ± 2.57 | 0.978   |
| Unsaturated fatty acid, %     | 63.73 ± 1.35   | 63.55 ± 3.2  | 64.07 ± 2.77 | 64.09 ± 2.61 | 0.988   |
| Monounsaturated fatty acid, % | 26.24 ± 1.00   | 27.08 ± 1.97 | 24.75 ± 1.03 | 26.21 ± 4.28 | 0.616   |
| U/F ratio                     | 1.78 ± 0.11    | 1.76 ± 0.23  | 1.81 ± 0.21  | 1.86 ± 0.20  | 0.985   |

U:F = unsaturated fatty acid:saturated fatty acid.

4. Discussions

4.1. The effect of ammonia on the carcass traits of broilers

The dressing percentage and breast meat percentage of broilers are two important indexes of meat production (Xu et al., 2013; Liao et al., 2014). The dressing percentage of high-quality chickens is about 85% to 91% (Zhang et al., 2004; Chen et al., 2009). The present experiment showed that the ammonia decreased the dressing percentage and the meat production of broilers. This is in agreement with a previous study (Miles et al., 2004) which reported that percentage yield of deboned meat of bird decreased slightly with increasing exposure to ammonia. The main factors affecting ammonia concentration in poultry house are ventilation, litter conditions and humidity (Estevez, 2002). It has been shown that high ammonia concentration in poultry housing reduces ADG, ADFI, and feed conversion, resulting in decrease of broiler productivity (Li et al., 2014). The current study showed that the semi-evaporated yield percentage, breast and thigh muscle percentage of broilers decreased by 4.3%, 10%, and 16%, respectively, particularly in birds exposed to 50 mg/kg ammonia for 10 d. At this level of ammonia, after 20 d, the broilers showed the lowest semi-evaporated percentage and eviscerated percentage. The slaughter performance and thigh muscle percentage of broilers were the lowest in the group treated with 75 mg/kg ammonia. It was noted that the carcass traits were poor when the birds were treated with 50 mg/kg ammonia. When challenged with 75 mg/kg ammonia for 10 d, the birds may have a compensatory response as an adaption to the high ammonia level explaining the observed raise in some carcass traits compared to a reduction when exposed to lower concentrations of ammonia. However, with an increase in the number of days of exposure to the higher concentration of 75 mg/kg ammonia, the upper respiratory tract and the other visceral organs were damaged and the dressing percentage was decreased, indicating that the degree of damage was increased with the extension of time of exposure at higher concentration of ammonia. The organ indices are considered parameters for organ health and function (Liu, 1994; Ma et al., 2014). Low temperatures and low levels of oxygen are reported to induce cardiac hypertrophy in broilers, with secondary infection of ascites syndrome (Liu et al., 2005). The human liver is reported to swell after inhalation of ammonia of 1 mg/kg concentration over long durations (Tang, 1987). In 20 d broilers, an exposure to 770 mg/kg ammonia in the poultry house induced symptoms of acute poisoning (Zhang et al., 2006). Pericardial effusion, liver swelling, cardiac fibroblasts proliferation, hepatic cell necrosis, and organ weight increase have also been reported (Zhang et al., 2006). Atmospheric ammonia at high concentrations elevated lactate dehydrogenase (LDH) level in the blood of broilers (Curtis et al., 1975), resulted in severe injury of the myocardial tissue and kidney, and increased organ indices (Luo & Yang, 2012; Liu et al., 2010). Curtis et al. (1975) suggests that the heart may be enlarged to provide oxygen to the body for maintaining the metabolism when the respiratory system is damaged after long-term exposure to...
high ammonia levels. In the present study, the kidney and hepatic indices were increased when the birds were exposed to 25 mg/kg ammonia for 10 d. After 20 d exposure to ammonia, the hepatic indices were increased significantly. With the increase of concentration and treatment time of ammonia, the organ indices were increased to different extents. The data showed that liver, kidney, heart, and other organs of broilers were damaged to different extents at different levels of ammonia. This was similar with the results of previous studies. Broilers exposed to 80 mg/kg ammonia were more susceptible to ascites (Wang et al., 2008). Tracheal mucus membranes were damaged and lung atrial wall thickness was increased by atmospheric NH₃ (Al-Mashhadani & Beck, 1985). Further, our study showed that the kidney was sensitive to exposure to ammonia, which is probably associated with less movements under high level of ammonia. Lacking of exercise easily induced kidney dropy in broilers (Zhang et al., 2014).

Spleen, thymus, and bursa of Fabricius are immunity organs of birds and have the crucial role in both humoral and cellular immunity (Zhang et al., 1992; He et al., 2008). Development of tissue and the proliferation of cells resulted in a higher immune organ index (Ma et al., 2004). The development of immune organ was inhibited when animals were raised in bad environment. The relative weight of the spleen, thymus, and bursa of Fabricius were reduced when the broilers were exposed to high temperature (Guo et al., 1998). In this study, when birds were exposed to ammonia at 50 mg/kg for 10 d, the spleen, thymus, and bursa of Fabricius indices were decreased by 27%, 45%, and 27%, respectively. With prolonged treatment (for 20 d), the immune organ indices were reduced to different degrees (24%, 20% and 27%, respectively) indicating that ammonia at 50 mg/kg influenced the growth of immune organ. The severity of damage to the immune organ depended on the concentration of ammonia in the environment and duration of exposure.

4.2. The effect of ammonia on fatty acid in meat

The fatty acid proportion of meat is considered an important index for meat quality and the flavor of meat (Wood et al., 2008). There is no information available for the effects of ammonia on chicken meat fatty acid. A large proportion of fatty acids (often as high as 70%) found in chicken meat included cetylic acid, octadecanoic acid, oleic acid, and linoleic acid (Dong, 2007). In the present study, the ammonia in the environment had no significant effect on fatty acid content of breast muscle. The content of free radicals in organisms increased when the broilers were exposed to ammonia, which converted UFA to SFA. The low level of UFA in the breast meat may be the reason that ammonia had no influence on fatty acid in breast meat (Wang et al., 2004).

In our experiment, the SFA content in thigh muscle increased while the U:F ratio decreased in response to treatment with ammonia. The results showed that ammonia in poultry housing affected the meat quality of birds. Ammonia as an environmental factor could influence the fatty acid composition of broilers meat. Similarly, it was reported that the SFA content was increased in heat stressed quails (Durairaj, 1971). Upon exposure to constant heat stress, SFA content in the intramuscular fat of the broilers was significantly higher, while C18:3, polyunsaturated fatty acid, and U:F ratio were significantly lower (Ain, 1996). The immunological stress of broilers generated by intraperitoneal injection of lipopolysaccharide (LPS) resulted in an increase in the SFA content, especially C14:0 and C18:0, in the breast meat and a significantly decreased content of C18:3 and C18:2N6C in the thigh meat (Durairaj, 1971). It was reported that the SFA content in breast muscle of broilers raised on the floor were lower than those that were raised in cages, and the U:F ratio was significantly increased because of the greater movement of the birds raised on the floor (Zhou et al., 2010). In the present study, the ammonia damaged the cornea of the eyes, swelling and reddening of the eyelids, the eyelids were often closed shut, which limited the movement of the birds. As a result, the SFA content in the thigh meat of the birds exposed to ammonia increased. Several factors (color, pH, flavor, tenderness et al.) affect the meat quality of birds. Fatty acid proportion is not the only index to judge the quality of meat. Further studies are needed to explore in detail how exposure to ammonia affects the meat quality of broilers.

5. Conclusion

The study shows that higher concentration of ammonia exposure has a negative influence on meat quality and growth performance of chickens: 1) 25 and 75 mg/kg level of ammonia could induce a significant decrease of dressing percentage and eviscerated yield percentage of broilers aged 21 d and 50 mg/kg ammonia could induce a significant decrease of eviscerated yield percentage, breast and muscle percentage of broilers age 42 d. 2) Ammonia over 25 mg/kg could increase kidney and hepatic indices and decrease spleen indices. 3) Ammonia exposure at 50 mg/kg could significantly decrease the content of UFA and increase the content of SFA in thigh in broilers age 42 d.

Conflict of interest

The authors have no financial conflicts of interest.

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References

Ain Baziz. Effet d’une temperature ambiante elevee sur le metabolisme lipidique du poulet en croissance. 1996.
Al-Mashhadani EH, Beck MM. Effect of atmospheric ammonia on the surface ultrastructure of the lung and trachea of broiler chicks. Poult Sci 1985;64(11):2056–61.
Anderson DP, Beard CW, Hanson RP. The adverse effects of ammonia on chickens including resistance to infection with Newcastle disease virus. Avian Dis 1964;8(3):369–79.
Aziz Tahseen, Barnes H John. Harmful effect of ammonia on birds. World Poult 2009;26(1):28–30.
Beker A, Vanhooser SL, Swartzlander JH, Teeter RG. Atmospheric ammonia concentration effects on broiler growth and performance. J Appl Poult Res 2004;13:5–9.
Chen M, Wang MZ, Song L, Fu ZM, Chen B. Study on dressed characters and meat quality of Xingyi Bantam and yellow Bantam chicken. Jiangsu Agric Sci 2009;2:184–8.
Curtis SE, Anderson CR, Simon J, Jensen AH, Day DL, Kelley KW. Effects of aerial ammonia, hydrogen sulfide and swine-house dust on rate of gain and respiratory-tract structure in swine. J Anim Sci 1975;41(3):735–9.
Dong XL. Effects of immunological stress on blood indexes and meat quality of broilers. Beijing: Chinese academy of agricultural science; 2007.
Durairaj G. Effect of temperature and diet on the fatty acid composition of Japanese quail, Coturnix coturnix japonica. 1971.
Estevez I. Ammonia and poultry welfare. Poult Perspect 2002;4(1):1–3.
Fang R. Influence of chronic ambient high temperature and corresponding control measures on growth, welfare and meat quality in AA broilers. Huhehaote: Neimenggu University; 2009.
G 8/1 9695.2–2008. Meat and meat products determination of fatty acids. 2008.
Guo YM, Liu CZ, Yu P. Impact of heat stress on broilers and the effects of supplemental yeast chromium. Acta Vet Zootech Sin 1998;29(4):339–44.
He XJ, He CY, Wang JF, Zhang M, Ou HL, Yang KL, et al. Study on the effects of fish oil on visceral index and intestinal flora in weaned rats. Chin J Microecol Dec. 2008;20(6):555–7.

Hou SZ. The research progress of intramuscular fat. Gansu Anim Vet Sci 2000;30(3):30–1.

Jacobson LD. Animal structure: air quality. Encyclopedia of agricultural, food, and biological engineering. 2010. p. 55–7.

Kristensen HH, Wathes CM. Ammonia and poultry welfare: a review. World’s Poult Sci J 2000;56(3):235–45.

Lawrie RA. The conversion of muscle to meat. Meat Sci 1998:96–118.

Li C, Lu QP, Tang XF, Zhang JZ, Ding ZM, Zhang HF. Influence of ammonia concentration on growth performance and meat quality of broilers. Sci Agric Sin 2014;47(22):4516–23.

Liao YY, Huang YF, Wei FY, He RC, Wu L, Tan SS, et al. Effects of different probiotic-preparation on growth performance, slaughter performance and meat quality of yellow-feathered broiler. Chin Poult 2014;36(23):29–32.

Liu YG. Health toxicology basis. Beijing: People’s Medical Publishing House; 1994.

Liu ZC, Yu SY. Nutrition and food hygiene. Beijing: People’s Medical Publishing House; 1981.

Liu WJ, Qiao J, Ou DY, Fan CY, Yang Y, Li J, et al. Effect of two histamine receptor antagonists on pulmonary hypertension in broiler chickens. Acta Vet Zootech Sin 2005;36(4):407–11.

Liu P, Huang CF, Li L, Ruan Y. Effects of monkshood and fritillary on heart, liver, kidney of rat. Li Shizhen Med Mater Medica Res 2010;21(7):1801–3.

Miles DM, Branton SL, Lott BD. Atmospheric ammonia is detrimental to the performance of modern commercial broilers. Poult Sci 2004;83(10):1650–4.

Ma DY, Shan AS, Li QD. Effects of Chinese medical herbs on chickens growth and immunization. Acta Zoonutritiona Sin 2004;16(2):36–40.

Ma TJ, Zhang L, Zhang ZH, Liu N, Ren L, Zhang YP, et al. Mechanism of brevicaudine in reducing cisplatin-induced kidney damage and apoptosis of kidney cells in rats. J Chin Pract Diaq Ther 2014;28(3):251–3.

Tang XL. Effects of long-term intake of low concentration ammonia on liver. Occup Med 1987;14(5):38.

Wang AX, Liu JG, Li TS. The comparison of the fatty acid composition in muscle of yellow feather broilers. Feed Rev 2004;3:1–3.

Zhang K, Zhang HY, Wei DQ. Comprehensive prevention measures for colibacillosis of broilers in Xishuangbanna. Livest Poult Ind 2014;2:10–1.

Zhou XJ, Zhu NH, Zhang RJ. Effects of breed, age and feeding regime on inosine-5'-monophosphate and intramuscular fat contents in broilers. Chin J Anim Nutr 2010;5:125.