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Assessment of ammonia and carbon dioxide concentrations in a breeding hen building under Portuguese winter

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Abstract

Excessive ammonia (NH_3) and carbon dioxide (CO_2) in the housing of breeding hens can cause various negative effects on the health of hens and the welfare of the workers who care for them. The aim of this study was to evaluate the NH_3 and CO_2 concentrations in the first month of housing the breeding hens during Portuguese winter. The study was conducted on a commercial hen breeding farm located in central Portugal (Soure, Portugal). One modern building equipped with climate control system, automatic feeding and drinking systems and minimum transitional tunnel ridge system was selected. New litter material made with rice hulls was used in the building, and the breeding sample comprised five months old 6864 female and 720 male birds housed in the building on 7 November 2016. The outdoor and indoor environmental conditions and indoor gas concentrations were measured continuously from 10 November to 30 November 2016. Ammonia and CO_2 concentrations were measured with a photoacoustic field gas monitor and air samples collected through 4 sampling points located indoor, by a multipoint sampler. Results showed that the CO_2 concentrations did not exceed 3000 parts per million (ppm) during the first month of housing the breeding hens and under winter environment. However, the NH_3 concentrations exceed 20 ppm on most measurement days. For a good indoor air quality, the study suggests the use of mitigating measures for maintaining NH_3 concentration below 10 ppm

Keywords: Breeding hens, CO_2, Gas concentration, Mediterranean Portugal, NH_3, Poultry husbandry, Winter environment.

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Excessive ammonia (NH_3) and carbon dioxide (CO_2) in the housing of breeding hens can cause various negative effects on the health of hens and the welfare of the workers who care for them. International and national regulations have been published in order to protect animals and workers health, with short period exposure limits of 20 and 3000 parts per million (ppm) for NH_3 and CO_2, respectively (CIGR, 1992, 1994; Kilic and Yaslioglu, 2014). Ammonia and CO_2 coming from the decomposition and fermentation of the litter and excreta can damage indoor air quality. The nitrogen compounds (uric acid and urea) of excreta are hydrolysed into NH_3 and CO_2 and consequently the concentrations of these gases are increased at in-house (Wathes et al., 1997; Pereira and Trindade, 2014; Alberdi et al., 2016; Lin et al., 2017). In addition, the hens' respiration as well as the aerobic and anaerobic decomposition of the litter material enhances the CO_2 levels at in-house (Sommer et al., 2006; Ni et al., 2012). High NH_3 concentrations (>20 ppm) in hen buildings are related with negative health and welfare concerns (Portejoie et al., 2002). A decrease in egg production, feed intake and growth rate has been reported due the presence of NH_3 (Kristensen and Whates, 2000, Xin et al., 2011; Costa et al., 2012). In terms of health, NH_3 causes damage in the respiratory tract and increases the incidence of respiratory diseases (Nahm, 2005). Also, high NH_3 levels have also been associated with the increase of pathogens concentrations in the litter material and the increase of morbidity and mortality (Kristensen and Whates, 2000; Miles et al., 2004). It could be hypothesised that breeding hens have high nitrogen excretion rates and NH_3 and CO_2 concentrations are particularly damaging to the hens during periods of minimum ventilation like winter. Thus, the aim of this study was to evaluate the NH_3 and CO_2 concentrations in the first month of housing the breeding hens during Portuguese winter.

I. Material and Methods

The study was conducted in the commercial breeding hen farm Quinta da Cruz (latitude: 40.024176, longitude: -8.629285) located in central Portugal (Soure, Portugal) (Figure 1). The selected building (length = 80 m, width = 16 m, ridge = 4.0 m and sidewall height = 2.7 m) is a steel construction with insulation, equipped with climate control system (model F37, Fancom), automatic feeding and drinking systems (Roxell). Ventilation was made by minimum transitional tunnel ridge system being controlled with one differential pressure (0-100 Pa, Fancom), and two sensors of temperature (model SF7, Fancom) and two sensors of relative humidity (model RHM.17 for inside and model RHO.17 for outside, Fancom) located indoor and outdoor the building.

Figure 1. Location of the hen building where measurements were made (photo taken in 2016; latitude: 40.024176°, longitude: -8.629285°; https://www.google.pt/maps/place, accessed: 18-01-2017) (no scale).

New litter material made with rice hulls was used in the building, and the breeding sample comprised five months old 6864 female and 720 male birds housed in the building on 7 November 2016.

The NH_3 and CO_2 concentrations at indoor building were measured continuously from 10 November to 30 November 2016. The concentrations of these two gases were measured with a photoacoustic field gas monitor (model INNOVA 1412i-5, Lumasense Technologies) and air samples collected, in sequence (2 minute intervals), through 4 sampling points located indoor, by a multipoint sampler (model INNOVA 1409-12, Lumasense Technologies). Sampling points were made using Teflon tubes (3 mm internal diameter) equipped with PTFE-filters (0.001 mm pore size, Whatman) to protect from dust.

The outdoor and indoor temperatures and levels of relative humidity were taken from the climate control system of the building. The average NH_3 and CO_2 concentrations were defined as the average of the hourly mean concentrations measured. All data obtained from the monitored building were analysed by Excel spreadsheet using descriptive statistics.

II. Results and Discussion

The climate data as well as the NH3 and CO_2 concentrations are shown in Figure 2. During measurement, the outdoor temperature ranged from 4 °C to 15 °C whereas indoor temperature was higher and varied between 17 °C and 20 °C (Figure 2A). The indoor relative humidity varied between 64% and 78%, being observed lower values in almost all measurement relative to indoor relative humidity (Figure 2A).

The NH_3 concentration increased from 10 November to 16 November 2016, with maximum values lower than 13 ppm (Figure 2B). Up this date (16 November 2016), NH_3 concentration increased continuously and reached values higher than 20 ppm until the end of the measurement, with maximum values that ranged from 20 ppm to 35 ppm except in 10 November 2016 (Figure 2B).

The CO_2 concentration had a similar evolution than NH_3 concentration, with maximum values always lower than 3000 ppm during whole measurement (Figure 2 °C).

The negative effects of NH_3 on hens and farm workers themselves begin at 25 ppm and become very serious at 50 ppm, being more deleterious a short period exposure rather than a continuously exposition (CIGR, 1992, 1994). Humans can generally smell NH_3 at concentrations between 20 ppm and 30 ppm, being an irritant to mucous membranes (cilia and epithelium) of the respiratory tract and causes conjunctivitis and damages the cornea of the eyes (CIGR, 1994; Kristensen and Whates, 2000). The damage of the mucous membranes of the respiratory system increases the susceptibility of hens to respiration infection by *Escherichiacoli* (Kristensen and Whates, 2000; Miles et al., 2004). The severity of damage depends on the concentration of NH_3 and duration of exposure (Miles et al., 2004).

The indoor air humidity and temperature could affect the NH_3 concentration. The principal factors affecting indoor NH_3 concentration in hen houses are litter conditions and airflow rate (Wathes et al., 1997; Ni et al., 2012; Lin et al., 2017). Therefore, outdoor air humidity and temperature affect indoor environmental conditions. Thus, the increase of indoor air humidity and temperature will increase the moisture and temperature of the litter material and consequently will enhance the NH_3 volatilisation (Sommer et al., 2006; Pereira et al., 2010, 2012; Alberdi et al., 2016). Previous studies recommend a limit of 20 ppm of NH_3 but in some European countries such as Sweden the exposure limit for hens is 10 ppm (Ni et al., 2012; Kilic and Yaslioglu, 2014).

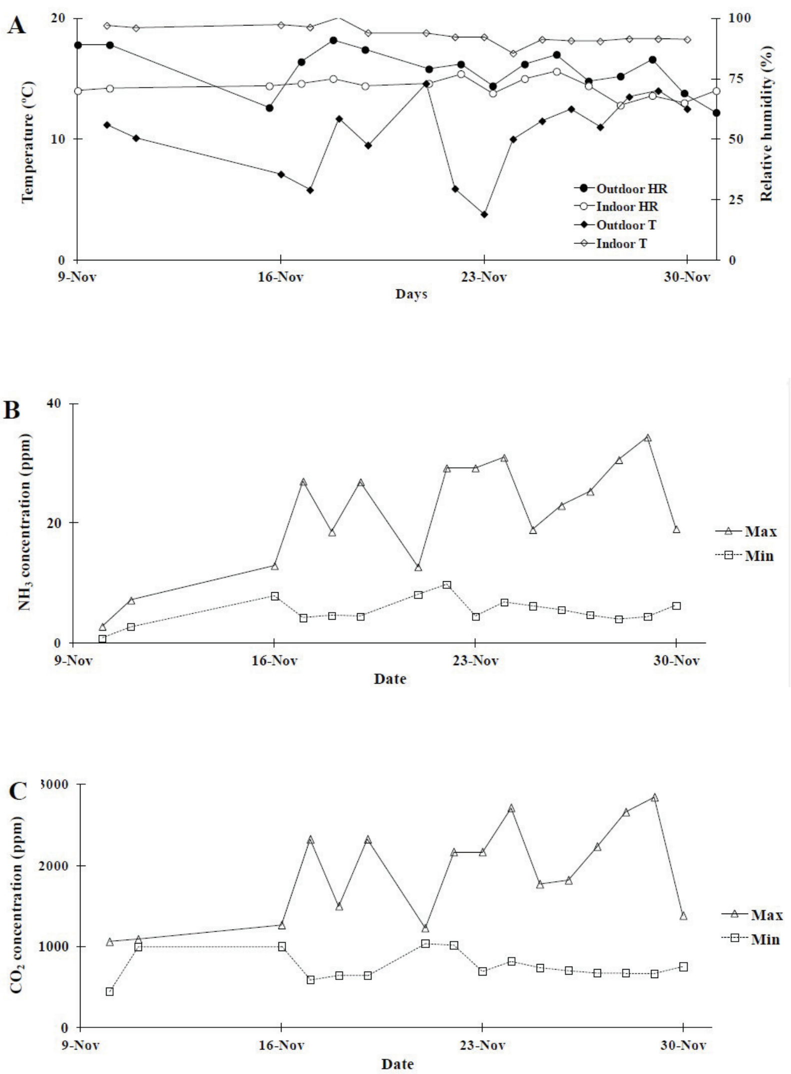

Figure 2. Outdoor and indoor temperature and relative humidity (A) and ammonia (B) and carbon dioxide (C) concentrations during the measurement in the hen building.

The harmful effects of NH_3 on hens have direct consequences on the health and welfare, and indirectly in the economic result of the activity, especially in the cold season. In order to obtain fertile eggs, the breeding of hens should begin when they are 20 weeks old and end when they are 40 weeks old. The breeding hens should have high excretion rates and larger amounts of bedding material will be accumulated on the concrete floor of the buildings. Hence, high amounts of NH_3 and CO_2 should be emitted from manure until 40 weeks old. More studies are needed to fully evaluate NH_3 and CO_2 concentrations during the whole cycle, and are recommended the use of mitigating measures for maintaining NH_3 concentration below 10 ppm. This needs additional research.

III. Conclusions

The NH_3 concentrations exceed 20 ppm during the first month of housing the breeding hens and under winter environment, leading to potential negative effects on the health of hens and the welfare of the farm workers. However, long term studies are required to properly assess the NH_3 and CO_2 concentrations during whole cycle. In addition, further research is needed in order to evaluate additives such as clinoptilolite or aluminium sulphate as mitigating measures for maintaining NH_3 concentration below 10 ppm.

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