Caderno de Ciências Agrárias
Agrarian Sciences Journal

CADERNO DE CIÊNCIAS AGRÁRIAS
Agrarian Sciences Journal

ICA
INSTITUTO DE CIÊNCIAS AGRÁRIAS

UFMG

Assessment of air quality in poultry facilities

Leonardo França da Silva[1]*, Irene Menegali[2], Fabiana Ferreira[2], Erika Viviane Santos[3], Djesihre Nathalie Rippel[4], Letícia Benites Albano[5], Leonardo Barros de Pinto[6], Ramom Stéfano de Souza[3], Ana Karoline de Jesus Vieira[7]

Abstract

The intensive animal production and confinement increase the potential for intoxication gas, with incidences of carbon monoxide (CO), carbon dioxide (CO_2) and ammonia (NH_3), which alter the ideal characteristics of the air, adversely affecting poultry production. This research aimed to diagnose the influence ofNH_3 indoor air quality of three poultry laying sheds with birds of different ages. Randomized blocks design (RBD), were performed being the blocks represented by plants of birds of different ages, in factorial 4x2 arrangement (number of weeks evaluated x concentration reading schedules gasses). Readings were carried out by means of sensors for 28 days, where they were measured twice a day (9:00 and 15:00 h) instant concentrations of ammonia (NH_3) and carbon dioxide (CO_2). It was observed that the concentration of NH_3 andCO_2 obtained do not represent values that are harmful to the performance of the birds showed during the entire trial period within the recommended values in the literature.

Keywords: Ammonia; laying hens; carbon dioxide.

Avaliação da qualidade do ar em instalações avícolas

Resumo

A produção intensiva de animais e o confinamento destes aumentam o potencial de intoxicação por gases, com a presença mais comum de monóxido de carbono (CO), dióxido de carbono (CO_2) e amônia (NH_3), os quais alteram as características ideais do ar, afetando negativamente a produção avícola. Com base nessas considerações, objetivou-se com o presente estudo diagnosticar a influência da qualidade do ar no interior de três galpões avícolas de postura, com aves de diferentes idades. Utilizou-se delineamento em blocos casualizados (DBC), sendo os blocos representados pelas instalações com aves de diferentes idades, em arranjo fatorial 4×2 (número de semanas avaliadas x horários de leitura da concentração de gases). Foram realizadas leituras por meio de sensores durante 28 dias, onde foram mensuradas duas vezes ao dia (9:00 e 15:00h) as concentrações instantâneas de amônia (NH_3) e dióxido de carbono (CO_2). Observou-se que as concentrações de NH_3 e CO_2 obtidas não representaram valores prejudiciais para o desempenho das aves, apresentando-se dentro dos valores recomendados na literatura e com base no período experimental considerado.

Palavras-chave: Amônia; avicultura de postura; dióxido de carbono.

[1]Engenheiro Agrônomo, Mestrando em Agronomia Universidade Estadual Paulista, *campus* Botucatu. Rua Dr. José Barbosa de Barros, 1780 - Jardim Paraiso, Botucatu - SP, 18610-307.
[2]Docente do Instituto de Ciências Agrárias da Universidade Federal de Minas Gerais, *Campus* Regional Montes Claros.
[3]Graduando em Zootecnia no Instituto de Ciências Agrárias da Universidade Federal de Minas Gerais, *Campus* regional Montes Claros.
[4]Mestranda em Zootecnia da Universidade Federal de Minas Gerais, *Campus* - Belo Horizonte - MG.
[5]Engenheira Ambiental egressa da Universidade Sagrado Coração, Bauru- SP
[6]Docente da Universidade Estadual Paulista, *Campus* Botucatu - SP
[7]Mestranda em Produção Animal no Instituto de Ciências Agrárias da Universidade Federal de Minas Gerais, *Campus* regional Montes Claros.
*Autor para correspondência. e-mail: franca.leonardo@yahoo.com.br

Recebido para publicação em 11 de abril de 2018. Aceito para publicação em 10 de junho de 2018
ISSN: 2447-6218

Introduction

The poultry industry has grown exponentially and genetic improvement has provided a high development of poultry production, providing increase eggs production, nutrition development, management, sanity, ambience and air quality, thus enabling large-scale production. (Damasceno, 2010; Ferreira, 2016).

The high productive indexes presented by the poultry industry, which places Brazil in a prominent position, is the country's leader in the export ranking, and it is consecrated as the third largest chicken producer in the world (UBABEF, 2017).

In poultry production, in the year 2015, about 39.51 billion egg units were produced, placing Brazil among the ten largest egg producers. The Brazilian states with the highest production were São Paulo, having 33.24% of production, followed by the states of Minas Gerais, that registers 11.50% and Espírito Santo, with 9.61% (UBABEF, 2017).

One factor that must be respected during the production process is the air quality, which can be considered an important factor for the success of the poultry industry. Air is a source of oxygen that is critical to animal metabolic rate, in addition to assisting in the dissipation of heat. Aerosols, gases, vapors, and dust are the most air pollutants that are found inside a poultry industry. Ammonia (NH_3), carbon monoxide (CO) and carbon dioxide (CO_2) are the common pollutants there were found in the aviaries, which cause a huge damage to animals and workers. (Lima *et al*., 2004; Miragliotta, 2005; Nääs *et al*., 2007).

The pollutants alter the ideal characteristics of the air, causing damage to the productive performance, animals that are exposed to high gas concentrations begin to present greater sensitivity to respiratory diseases tract, with this the zootechnical index becomes compromised (Baêta; Souza, 2010; Furtado *et al*., 2010).

The high gas concentrations in the premises act primarily in the respiratory system of birds and mucous membranes that are in direct contact with the air. NH_3 gas is characterized as the primary agent, causing physiological changes, whereas CO_2 is characterized as an asphyxiant. These high concentrations reduce significantly oxygen concentration, leading to a decrease in air quality (Curtis, 1983).

Therefore, in view of these arguments, the purpose of this study was to perform the diagnosis and analysis of the air quality, regarding CO_2 and NH_3 concentrations, in sheds with commercial laying hens of different ages in production.

Material and methods

Geographical location and characteristics of experimental facilities

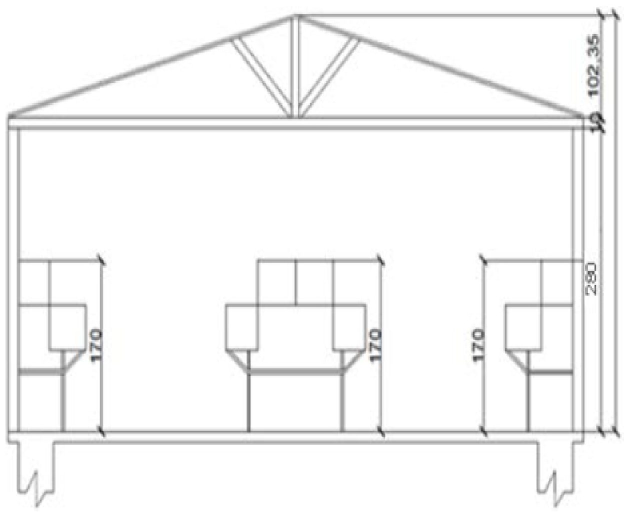
The experiment was developed during a period of 28 days in the experimental farm Prof. Hélio Barbosa from the Veterinary School of UFMG, in Igarapé-MG, Belo Horizonte – MG metropolitan region. The climate according to the classification of Köppen is cwa - humid type, with well-defined seasons, presenting annual averages 22°C, with rains in the summer. Three poultry facilities (sheds) of 55.5 x 8.20 m dimensions were studied, totaling a total area of 455.1 m² (Figure 1).

Figure1 – Top view of the array of aviaries at the experimental farm

The facilities were open on the sides and oriented to the east-west. It didn'thave side curtains or artificial air-conditioning system. The breeding system adopted was the use of cages, located on two floors, with the first floor being at a height of 0.70 m from the ground, and the second floor at 1.70 m, arranged in three rows of 47 m in length (Figure 2). The cages had the following dimensions of 48cm in length x 32cm height x 26cm in depth, with the capacity to accommodate from 3 to 4 animals per cage.

Each shed had different densities and stages of birds breeding. In the shed number 01, 4783 birds that were in the thirty-fourth week of laying were confined. In the shed number 02, there where 4000 birds in the nineteenth week of laying, and in the shed number 03, 3302 birds in the sixty-eighth week of production were confined. The birds confined in the three experimental sheds were of Hy-Lyne w-36 lineage.

Figure 2 – Aviary cross section, with the row arrangement and height cages representation (dimensions in cm, E: 1/100)



Data collection

The instantaneous concentrations of ammonia and carbon dioxide gases measurements were performed at the facilities' center point, approximately 1.30m high, between the two cage levels, at the mean bird breathing height. The data collection schedules adopted were 09 and 15h, which is quite representative in analogy to the daily behavior of the gas concentrations.

To read the ammonia concentrations, a sensor of the brand BW Technologies, Alert Extreme Gas model of electrochemical principle, with a resolution of 1 ppm and accuracy of ± 1ppm was used to detect the instantaneous concentration in a measurement range of 0 to 100ppm.

For CO_2, the Instrutemp brand, model AZ-77535 portable digital infrared USB output, with a resolution of 1ppm and accuracy of ± 50ppm that detects the instantaneous concentration in a measurement range of 0 to 10.000ppm.

Experimental design

A randomized complete block design (RBD) was used in factorial arrangement 4 x 2, with reference to the number of weeks of the experiment and the reading times of the gas concentration.

The data were analyzed with the aid of the System for Statistical Analysis and Genetics-SAEG. The data were submitted to variance analysis, and the means averages were compared using the Tukey test, adopting the level of 5% of probability (SAEG, 2009).

Results and discussion

The measurement schedules of ammonia (NH_3) and carbon dioxide (CO_2) gases of the present study were not significant. Table 1 shows the average results of carbon dioxide and ammonia gas concentrations in the three evaluated poultry houses.

Table1 – Average concentrations of CO_2 and NH_3 gases observed inside installations

Sheds	CO_2	NH_3
Shed 1	891, 76 A	4, 25 B
Shed 2	769, 86 B	2, 56 C
Shed 3	888, 67 A	6, 01A
CV (%)	10, 30	50, 51

*Averages followed by the same letter in the column do not differ from each other by the Tukey test at 5%.

It was observed that in shed number 1 and 3 they did not differ statistically in terms of carbon dioxide concentration, presenting average values with little variation and averages of 891.7ppm and 888.67ppm, respectively, presenting the worst air quality when compared to the installation 2. The values found in this study were lower than those reported by Menegali *et al.* (2009), which in works carried out in winter chicken facilities varied between 2.65 ppm and 8.79 ppm.

The results were also lower than those found by Vigoderis *et al.*, (2010) and Cordeiro *et al.*, (2010) who studied the effect of different levels of minimum ventilation velocities on air quality and on the zootechnical performance of broilers, these authors state that the problems caused by poor air quality must be corrected in order to improve the internal situation of the air in the installation, for this it becomes imperative corrections in the ventilation systems.

Among the factors that may have contributed to a higher concentration of gases in these facilities, it can be inferred that the density of the animals, the life stage and the accumulation of manure may have contributed significantly to the higher gas concentration averages.

Another factor that should be mentioned in the surroundings of shed number 1 was a dense vegetation barrier that made it difficult to satisfactorily renovate the air inside the installation. The aviaries analyzed did not have any artificial ventilation system, only natural ventilation.

In the shed number 2, a better air quality was observed, which is justified by the fact that the animals confined in this place are in a lower stage of life than the other facilities and thus have less accumulated waste inside the facility. According to França *et al.,* (2017) a number of factors, such as biological and meteorological, directly interfere with the formation and production of ammonia and carbon dioxide gases. For the author, the high concentration of these gases in the aviary depends on the local climatic conditions, the age of the animal and the composition of the feed provided.

It is worth noting that the average values found in the three facilities were within the recommended limits. It is accepted by the literature that according to Wathes (1999), the recommended limit concentration of carbon dioxide inside the poultry facilities is 3, 000ppm. In this study, the concentration ranged from 769.58 to 891.71 ppm, although the maximum values did not reach the harmful limits to the development of the birds and did not cause damage to the health of the aviary workers, allowing the conclusion of the respective values of the safety limit.

About the ammonia concentration, there was a statistical difference (P <0.05) between the sheds analyzed. The shed number 3 showed the highest ammonia concentration, these results can be explained since the ammonia emission rate in the aviary is related to internal temperature outside the aviary, relative air humidity and live weight of the animals, thus the installation number 3 housed the animals with the highest ages consequently with greater live weight.

Even the highest NH_3 gas averages are within the range of acceptable limits that according to Wathes (1998), which are 20 ppm, for continuous exposure, values higher than this concentration can directly affect the development of birds and behavior changes can be observed. In addition to physiological changes, a significant drop in feed conversion and feed intake. Direct contact of this gas with animals may alter respiratory conditions and cause irritation to mucous membranes and eyes.

When more excreta deposition occurs on the ground the chances of poisoning increase, therefore, absorption can occur continuously and with this, triggers reactions in the animal (Curtis, 1983).

Table 2 presents the mean values of CO_2 and NH_3 concentration in relation to the observed periods.

Table 2 – CO_2 and NH_3 gas Concentration, for the evaluated period

Periods	**CO_2**	**NH_3**
1 - (1 – 7days)	838, 66 B	2, 69 B
2 - (8 – 14 days)	824, 74 B	3, 11B
3 - (15 – 21 days)	847, 52 AB	5, 97 A
4 -(22 – 28 days)	889, 48 A	5, 32 A
CV (%)	10, 30	50, 51

*Averages followed by the same letter in the column do not differ from each other by the Tukey test at 5%.

At weeks 3 and 4 the carbon dioxide concentration was higher than the in initial weeks, statistically. The lowest NH_3 concentration averages were at weeks 1 and 2, differing statically from weeks 3 and 4 which had the highest concentrations, this may be due to higher accumulation of waste.

It should be emphasized that even the periods with higher average incidence were in the limit acceptable range according to the literature.

Conclusion

The air quality based on the ammonia (NH_3) and carbon dioxide (CO_2) in the conditions of this study did not present high values as they were within acceptable limits for the development of the birds.,

References

Baêta, F. C.; Souza, C. F. 2010. Ambiência em edificações rurais: conforto térmico animal. Viçosa: UFV.

Cordeiro, M. B.; Tinôco, I. F. F.; Silva, J. N.; Vigereis, R. B.; Pinto, F. A. C.; Cecon, P. R. 2010. Conforto térmico e desempenho de pintos de corte submetidos a diferentes sistemas de aquecimento no período de inverno. Revista Brasileira de Zootecnia, 39: 217-224. Doi: http://dx.doi.org/10.1590/S1516-35982010000100029.

Curtis, S. E. 1983. Environmental management in animal agriculture**.** Ames: The Iowa State University Press.

Damasceno, F. A.; Schiassi, L.; Saraz, J. A. O.; Gomes, R. C. C.; Baêta, F. C. 2010. Concepções arquitetônicas das instalações utilizadas para a produção avícola visando o conforto térmico em climas tropicais e subtropicais. PUBVET 4:Art.986-991.

Ferreira, R. A. 2016. Maior produção com melhor ambiente: para aves, suínos e bovinos. 3. ed. Viçosa: Aprenda Fácil.

Furtado, D. A.; Rocha, H. P.; Nascimento, J. W. B.; Silva, J. H. V. 2010. Índices de conforto térmico e concentração de gases em galpões avícolas no semiárido paraibano. Engenharia Agrícola, 30: 993-1002. Doi: http://dx.doi.org/10.1590/S0100-69162010000600001.

Lima, A. M. C.; Nääs, I. A.; Baracho, M. S.; Miragliotta, M. Y. 2004. Ambiência e Bem-estar. In: Mendes, A. A.; Nääs, I. A.; Macari, M. Produção de frangos de corte. Campinas: FACTA.

Menegali, I.; Tinôco, I. F. F.; Baêta, F. C.; Cecon, P. R.; Guimarães, M. C. C.; Cordeiro, M. B. 2009. Thermal environment and gás concentrations in poultry houses during heating. Revista Brasileira de Engenharia Agrícola e Ambiental 13: 984-990. Doi: http://dx.doi.org/10.1590/S1415-43662009000700022.

Miragliotta, M. Y. 2005. Avaliação das condições do ambiente interno em dois galpões de produção comercial de frangos de corte, com ventilação e densidade populacional diferenciados. Tese de Doutorado - Universidade Estadual de Campinas – UNICAMP.

França, L.G. F. 2017. Excreção de nitrogênio por galinhas poedeiras submetidas a diferentes temperaturas e níveis de energia metabolizável na ração. Tese de doutorado - Universidade Federal de Viçosa – UFV.

Nääs, I. A.; Miragliotta, M. Y.; Baracho, M. S.; Moura, D. J. 2007. Ambiência aérea em alojamento de frangos de corte: poeira e gases. Engenharia Agrícola 27:326-335. Doi: http://dx.doi.org/10.1590/S0100-69162007000300001.

União Brasileira de Avicultura - UBABEF. 2017. Relatório anual. Disponível em: <https://goo.gl/snzn2L>.

Vigoderis, R. B.; Cordeiro, M. B.; Tinôco, I. F. F.; Menegali, I.; Souza Júnior, J. P.; Holanda, M. C. R. 2010. Avaliação do uso de ventilação mínima em galpões avícolas e de sua influência no desempenho de aves de corte no período de inverno. Revista Brasileira de Zootecnia 39: 1381-1386. Doi: http://dx.doi.org/10.1590/S1516-35982010000600030.

Wathes, C. M. 1999. Strive for clean air in your poultry house. World Poultry 15: 17-19.

Wathes, C. M.; Phillips, V. R.; Holden, M. R.; Sneath, R. W.; Short, J. L.; White, R. P. P. 1998. Emissions of aerial pollutants in livestock buildings in Northern Europe: Overview of a multinational project. Journal of Agricultural Engineering Research 70: 3-9. Doi: http://dx.doi.org/10.1006/jaer.1998.0278.