MODELING AND SIMULATION OF INTERNAL ENVIRONMENT CONDITIONS IN HIGH-DENSITY POULTRY HOUSES WITH VENTILATION USING COMPUTATIONAL FLUID DYNAMICS
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• INTRODUCTION
The poultry industry in Brazil, in terms of technology and production efficiency, is equal any other in the world, especially regarding advances in health and nutrition, in conjunction with exhaustive research in specific areas with difference in climate, social and economic development. It is known that the birds require specific environmental conditions of temperature, relative humidity, pressure, light, sound level, oxygen content, carbon dioxide, and nitrogen for their development.

The adult bird is an animal best suited to cold environments because its thermoregulatory system is more suited to retain heat than loose it. When exposed to heat stress by high temperatures, the bird presents decreased feed intake and consequently, a reduction in weight gain (Borges et al., 2003). The success or failure of raising of broilers is directly related to the environmental conditions to which these animals are subjected, where high values of ambient temperature and the accumulation of gases, such as ammonia, cause a decrease in the production and increased mortality.

Computational methods provide a good alternative for modeling and evaluating the present problem and can be used to explore the physical relationships existing at the macroscopic level, in order to represent satisfactorily the dynamics of flows and their effects. Thus, the possibility of performing the modeling and simulation with computational fluid dynamics (CFD), mapping the animal husbandry thermal environment, the air flows, the ammonia concentration inside the open broiler facilities, and making use of natural ventilation, is an extremely important and pressing issue for animal production and the type of construction practiced in tropical and sub-tropical countries.

The aim of this work was the detailed modeling considering the effects of fluid interactions, including the coupling between the mathematical equations of heat and mass transfer of the fluid-fluid phases. Additionally, it was intended to predict the temperature distribution in the broilers production environment, as well as the ammonia concentration and variation of the air velocity in a typical poultry house with natural ventilation and without surrounding vegetation.

• METHODOLOGY
This work was developed at the Laboratory of Numerical Processing in the Center for Research on Ambience & Engineering Systems of Agribusiness (AMBIAGRO) of the Agricultural Engineering Department, at the Federal University of Viçosa, Minas Gerais State, Brazil.

To conduct this study, a typology of poultry houses was used, representing a large part of Brazilian poultry production, and typical of tropical and sub-tropical countries, which generally use natural ventilation systems. The type of poultry shed considered was wide by in length with a ceiling height and wall thickness, containing broilers in high-density (18 birds per) at 39 days of age (approximate age of slaughter), characterizing the period of maximum gas emission from the bed.

A real-time data acquisition system was used in this work by adapting the STRADA system developed by Rocha, 2008.

Due to the complexity of the geometry, the ANSYS ICEM CFD software was chosen to build a computational tetrahedral mesh for the object of the study. The tetrahedral volume element is very useful in maintaining the high quality for a region in different ways, enabling complex geometry to be molded to the region of interest, even though it requires more nodes than the elements of the hexahedral mesh, and results in a larger file size and longer computation time (Rocha et al., 2013; Rocha et al., 2014).

• RESULTS AND DISCUSSION
Based on the animal surface temperature distribution, a simulation was performed to characterize the temperature distribution in poultry houses with natural ventilation and inlet air at a temperature of 20°C. Based on this result, a control volume with an area of was established, which housed 432 broilers with a density of 18. This is illustrated in Figure 1 with horizontal colored scales representing the temperature values in the range of 20 to 35°C, and vertical colored scales representing the air velocity in the range of 0.0 to 2.0 m s⁻¹.

As observed in Figure 1, it is verified that there is a small turbulence at the level of the birds in the region close to the shorter wall at one side where the air intake provides the natural ventilation, but the temperature there is maintained within the poultry’s thermal comfort zone (18 to 28°C for adult birds), as cited by Curtis (1983), Abreu & Abreu (2004), and Menegali et al. (2009).

However, the temperature increases considerably in the control volume with increasing distance from the air inlet towards the shorter wall on the opposite side, at the air outlet. This is explained by an increase of the amount of heat occurring due to the heat dissipated from the animals themselves. Therefore, additional heat is transported from the inlet towards the outlet. A significant agreement was found between the experimental and simulated temperature inside the poultry house, as can be observed by the coefficient of determination .

• CONCLUSIONS
This methodology could be used as a basis for initial design of poultry houses with natural ventilation to optimize the airflow inside the building. The boundary layer located at the height of the birds along the shed could influence significantly the comfort of the animals housed in natural ventilation.

The results obtained from simulations of temperature presented a good agreement with experimental data , which indicates that the model is appropriate for use in improving poultry housing.

The simulated ammonia concentration in the poultry house is acceptable for both the animals and the workers.

• ACKNOWLEDGEMENTS
The authors would like to thank the Foundation for Support to Research of the State of Minas Gerais – FAPEMIG, Brazil; the National Council of Scientific and Technological Development – CNPq, Brazil; and Coordination of Improvement of Higher Education Personnel – CAPES, Brazil, for their financial support, and Federal University of Viçosa – UFV, Brazil, for the great opportunity.

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Figure 1 - Variation of air temperature in a 0.20 m thickness wall and transversal section velocity in a poultry house.

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