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AMMONIA AND CARBON DIOXIDE EMISSIONS IN TUNNEL-VENTILATED BROILER HOUSES IN SAO PAULO STATE - BRAZIL

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ABSTRACT Ammonia and carbon dioxide emissions were evaluated in broiler houses with different ventilation systems and litter conditions (new and built-up). Emission data were calculated on a weekly basis and averaged per flock. Annual emissions were then estimated for the 6 flocks produced per year in both house types. Two houses (1 and 2) were tunnel ventilated, negative pressure, and two houses (3 and 4) were tunnel ventilated, positive pressure. The NH_3 emission data in 1 with built-up litter had a higher average ammonia emission when compared to 2 with new litter. The results for the positive pressure 3 (new litter) and 4 (reused litter) had the lowest average ammonia emission since the number of birds in these houses was 13,000 and 28,000 for both 1 and 2. Therefore, it was observed that both houses with reused litter showed higher average emissions by bird. This is in agreement with the literature, indicating that the ammonia emissions from reused litter can be six times higher than the ammonia emissions from new litter during the first weeks of the flock. Carbon dioxide emission showed differences in comparison with ammonia emission, since the highest values were found in positive pressure barns. It is related to the high temperature found in these barns compared to the negative pressure 1 and 2 houses showed and their average temperature was lower, demonstrating the efficiency of the system in the establishment of thermal comfort.

Keywords: Ventilated tunnel, poultry, air quality

INTRODUCTION With the production of 11,038.000 tons of chicken meat in 2009, Brazil spends 70% of all production for the export market, ranking 1st in the exporting countries of poultry meat (UBA, 2009). Because of this position, it is crucial to fit the requirements of international quality standards. Both the European Union and Japan, two major importers of chicken meat from Brazil, placed as requirements to Brazil to adjust to European standards of quality in production including the use and reuse of poultry litter in broiler houses. It is known that broiler flocks are more productive and have fewer health problems when raised on a good quality litter, subject to the requirements of animal welfare and environmental issues.

Moreover, the international negotiations to mitigate greenhouse gases and ammonia emissions have been discussed among the countries to develop inventories based on data from these issues, as well as their sources and main areas of occurrence. Among the different sources of methane and ammonia, animal production and agriculture are the most important accounting for 40% of methane and nitrous oxide and 90% of the ammonia emitted. These factors make it important to understand the relationship between ventilation systems widely used in commercial poultry production and the environment created inside the broiler houses for better air quality and the litter conditions and aiming to reduce health problems, condemnation of carcasses and thus manage the quality of chicken meat produced. This paper has aimed to evaluate ammonia and carbon dioxide emissions in broiler houses with different ventilation systems and litter conditions (new and built-up).

MATERIALS AND METHODS Four commercial tunnel ventilated broiler houses were monitored at two different farm sites in Sao Paulo State, Brazil. These houses presented two different types of air renovation ventilation by negative pressure, houses 1 and 2 and by positive pressure, 3 and 4. The houses 1 and 2 measuring 13.0 m × 125 m (43 × 410 ft). The houses featured insulated drop ceilings, 3.5m height sidewall, and eight 1.2 m (48 inch) diameter exhaust fans. Each house is also equipped with evaporative cooling pads in the opposite wall from the tunnel fans. The litter bedding material used in both houses was wood shavings.

Houses 3 and 4 measure 9.0 m × 120 m (30 × 394 ft). These houses featured insulated drop ceilings and 2.5m height sidewall and twelve 0.9 m (36 inch) fans. A mixture of coffee hulls and sawdust was used as litter bedding material. The data reported correspond to a built-up litter age of the second flock in houses 1 and 4 and a new litter in the houses 2 and 3.

Additional cooling is provided, as needed, with foggers distributed throughout the four houses. For all four houses two different ventilation schemes were used to maintain the target temperature in the house. They were, in increasing order of ventilation rate, natural ventilation, sidewall ventilation and tunnel ventilation. The natural ventilation rate was controlled by varying the area of the sidewall openings with the moveable curtains. When the tunnel exhaust fans are in use, the ventilation rate is controlled by operating the fans intermittently

Each house 1 and 2 had an initial placement of approximately 28,000 Cobb-Cobb straight-run (mixed sex) broilers, grown to 42-49 days of age at slaughter. Houses 3 and 4 had 13,000 Cobb-Cobb straight-run (mixed sex) broilers, grown to 42-49 days of age at slaughter. The broilers were fed a standard commercial diet and provided water from nipple drinkers throughout the grown periods.

The NH_3 concentration was measured by portable multi gas analyzer (BW Technologies®). It simultaneously monitors atmospheric levels of up to five gases including carbon monoxide (CO), oxygen (O_2), ammonia (NH_3), hydrogen sulphide

(H_2S), and combustibles (LEL). CO_2 concentration was measured by portable gas analyzer utilizing a non-dispersive infrared (NDIR) CO_2 sensor (BW Technologies®).

Ventilation rate measurements were made using a vane thermo-anemometer (Model 451126, EXTECH, Waltham, MA). Airflow rate for each exhauster/fan was calculated according to Redwine and Lacey, (2001). The emission data were calculated in a weekly basis and extracted the average emission per flock and from these values were simulated annual emissions considering the 6 flocks produced per year in both types of tunnel ventilated houses also the type of litter, if new or built-up.

RESULTS AND DISCUSSION As for the calculations of emission rates were considered the ventilation rate where negative pressure barns presented 300,000 m3/h average flow. In the barns with positive pressure, the average flow rate was 100,000 m3/h. According to Demers et al. (1999) in facilities for broilers the ventilation rate can be increased by 4000 m3/h a maximum of 42,000 m3 / h especially in periods of extreme summer temperatures. According Gates et al. (2007) the relationship between the gas emission, bird age, and litter condition, is reported in a linear fashion. The ammonia emission rates were presented with an increasing of bird age (Elwinger and Svensson, 1996, Redwine et al., 2002, Liu et al., 2006), this is due to increased excretion of nitrogen during the growth stages when birds are near market weight. This can also be attributed primarily to great ventilation rates required to achieve thermal comfort according to the bird age. This result agrees with Redwine et al. (2002) in their study evaluating the ammonia emission in broiler housings with mechanical ventilation system. These authors found the highest ammonia concentration in the winter, in spite of the highest emission rates had occurred during the summer, due to changes in ventilation.

House 1 had a higher average ammonia emission when compared to house 2, the t test for paired mean comparison between these barns obtained p-value < 0.05, there was a statistical difference between their emission data. The simulated data for the annual emission in negative pressure broiler housings 1 and 2 were below the demonstrated by Gates et al. (2007), where the authors simulated the annual emission in negative pressure broiler housings to 28,000 marked weight broiler of 2.5 kg, in new litter and built-up, considering the 6 flocks per year, emission was 3786 and 5560 respectively.

The results for the positive pressure tunnel ventilation, house 4 showed the highest values compared with the barn 3 with new litter. According to Wheeler et al. (2003) even gas emission evaluations from only one farm may have high variations in the house to house.

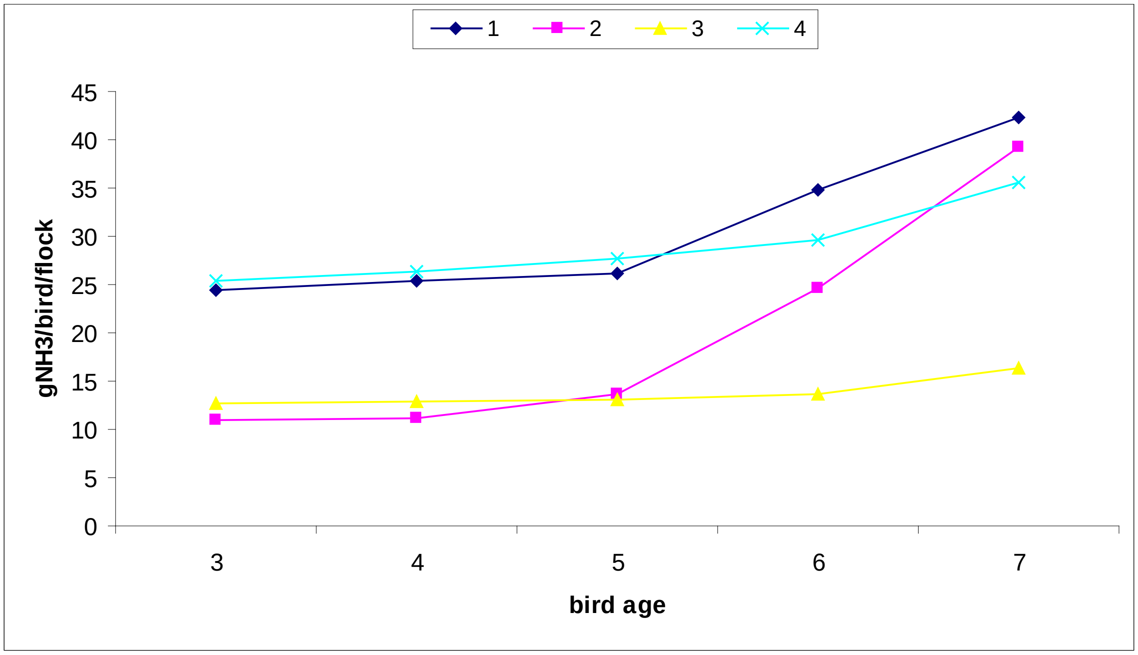

Figure 1. Ammonia emissions at 3rd to 7th week of flock housing.

The average data presented here were in a similar range found by Gates et al (2007), where they found a new litter for production 17.4-64 gNH_3/bird/flock and 25.4 gNH_3/bird/flock in built-up litter. Other values per bird per year are presented in Redwine et al (2002), 632 $mgNH_3$/bird/day and the National Research Council-NRC (2003) who calculated a factor of 0.22 $lbNH_3$/bird/year. The variability of ammonia emissions have been correlated with the age of the birds and the condition of the litter as well as nutrition that it is related to the amount of protein and amino acids in the diet (Casey et al., 2004 and Wheeler et al., 2006). Therefore, it was observed that both houses with built-up litter, houses 1 and 4, had higher average NH_3 emissions by birds. This is in agreement with the literature as built-up litter contains greater amount of nitrogen the ammonia flow from this type of litter can be 6 times greater than the ammonia flow from new litter during the first weeks of flock housing (Brewer and Costello, 1999). Elwing and Svensson (1996) measured the amount of nitrogen present in the litter that was 1.0 g N/ kg of dry wood shavings and 4.6 g N/kg dry matter for sawing. Also Nicholson et al. (2004) found higher ammonia emissions in litter of sawdust with an average 2.0 g NH_3/h/500kg body weight, while the wood shavings litter NH_3/h/500kg body weight.

The highest values of carbon dioxide emissions were found in broiler housings that had conventional ventilation system. Figure 2 shows that tunnel ventilated positive pressure barns had higher CO_2 emissions, it is related to the high temperature found in these houses compared to the negative pressure barns 1 and 2 that showed average temperature lower, demonstrating the system efficiency in the establishment of thermal comfort. The average temperature for houses 1 and 2 was 24 ^oC and houses 3 and 4 were 27 ^oC and 26 ^oC respectively. Kettlewell et al. (2000) in their work using a calorimeter from the CO_2 production by adult birds subjected to handling transport, found as CO_2 production values ranging from 0.35 to 0.49 ml/s. It can be seen in Figure 2 that the values found per bird per hour were below those found here by the authors. Since the production of CO_2 is influenced by temperature, the ventilation rate, bird age and mainly the condition where birds are submitted, these variations are possibly found (Jurkschat et al., 1986).

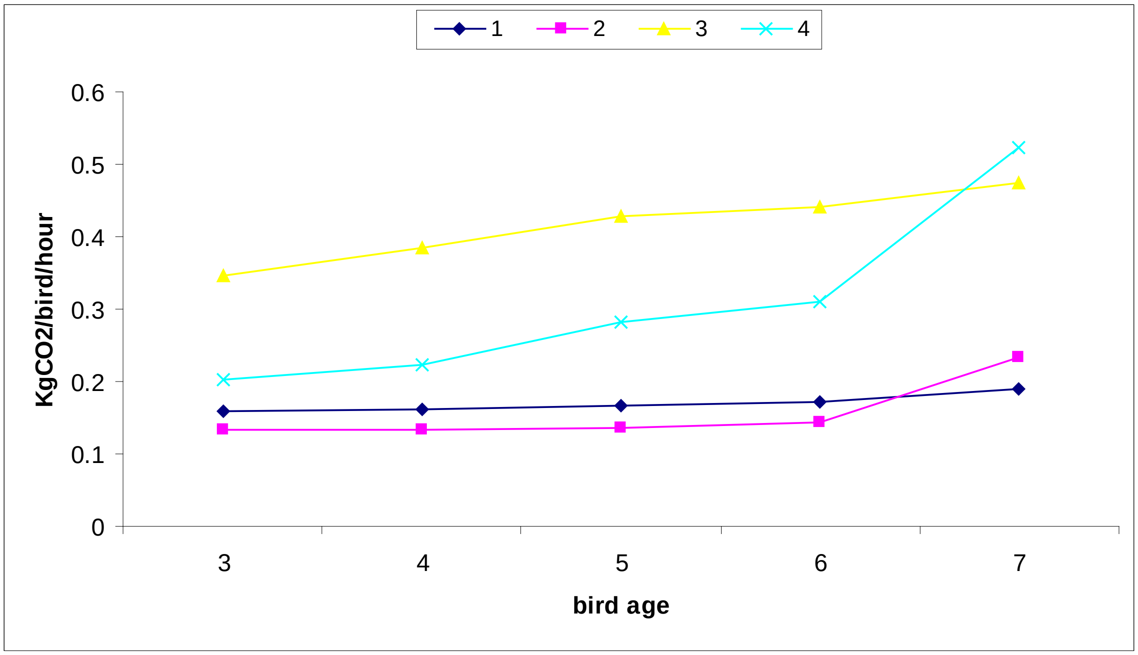

Figure 2 – Average CO_2 emission at 3rd to 7th week of flock housing.

The CO_2 is also a product of aerobic chemical reaction of uric acid excreted by birds and from decomposition of organic compounds. According to Ni et al. (2000), one of the great difficulties in characterizing the carbon dioxide production is to distinguish its release from the animal respiration and the CO_2 released by the decomposition of biomass presents in the barns for livestock. Miles et al. (2006) evaluated CO_2 flux on the first day of flock age in brood area the CO_2 flux was 6,190 mg/(m^2/h) compared with 5,490 mg/ (m^2/h) at the opposite end of the house. On the 21st day, these values increased to 6,540 and 9,684 mg/(m^2/h) for the brood and non-brood areas.

CONCLUSION The broiler houses with built-up litter showed highest ammonia emission. Negative pressure houses increased emissions which were correlated with the birds age. This could be related to the increase of ventilation rate in order of maintenance of thermal comfort during the last weeks. Once positive pressure houses also utilize the management curtain with the drive fans already from the fourth week of the flock, data showed only a slight increase in the last week of flock. But positive pressure houses showed the highest CO_2 emission due to conditions of the thermal environment, once these houses presented the higher temperature than negative pressure houses. So, the balance of gas emission during the housing of birds should include all factors such as house management, bird size and age, and amount of organic compounds. All factors should be considered in comprehensive models for emission rates as well methodologies based on scientific data, resulting from predictive models, must be applicable to a wide range of conditions.

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