Climate conditions in a broiler house in Molise: experimental and numerical analysis

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Abstract
Ventilation flow in livestock buildings can determine the indoor climate and air quality and so it affects the welfare of the reared animals. The experimental study was carried out in a poultry house located in Molise (Italy).
The objective of this study was to find the optimum ventilation system to improve the rearing conditions in broiler house.
Climate conditions were evaluated by mean of temperature, relative humidity and carbon dioxide concentration; the BABUC/A, connected with tree probes, the BSU102 for temperature, the BSV101 for air flow and the BSO 103.1 for CO2 concentration, was used to detect the investigated parameters; detections were measured at 3 different heights, at 20cm from ground level, 100cm and 150cm, every 10 m all along the length of building.
During experimental trials different configurations of the ventilation system were tested and even if a little influence was found on CO2 average concentration, an irregular distribution was detected due to a wrong activation of the fans in the ventilation system.

Keywords: ventilation, temperature, poultry

Introduction
To determinate animal's wellness is easy as to determinate the human's one.
Well being is "the condition of a person regarding his tries of adaptation to his habitat".
So well being can be defined the greatest reduction of uneasiness causes in the habitat were everyone lives. In the end the more pain causes are removed or avoided the more the well being increases.
In broilers breeding well being means that the animals live in a position to perform the maximum production capacity (quantity and quality) without running into so severe pathologies or mental disorders as to alter its physiologic balance.
The most of cattle breeders are careful to wealth and security of their animals. Not healthy broilers cause a smaller production, loss of time and require useless waste of money and medical treatments with less gains for the breeder.
The main elements to be considered are:
- the standard of broilers stalling
- the broilers’ number
- the quantity and quality of feeding
- the method of feed-dispensing
- the micro-environmental conditions (light, temperature, noise, velocity and quality of ventilation)
In the broilers breeding the contact with gaseous emissions produced by different factors is continuous, so it is necessary an appropriate ventilation in order to discharge them. During last years a lot of broilers breeding have been industrialized. A lot of money is saved through industrialization also thanks to skilled workers, large sized farms and an high density of broilers on quite small areas. A deterioration of the micro-environment, brought by unhealthy air-quality owing to high concentration of gas and microorganism, often happens in such places. (Kristensen and Whates, 2000; Quaglio et al., 1998).

In the broilers breeding the microclimate (temperature, humidity, air velocity and their interaction) helps to generate a microenvironment from which the broilers well being for the most part depends. The microclimatic control is essential so that the broilers are in perfect health and give the best productive performances. The same environmental conditions, with the addition of broilers movements, and stalling standards, affect the quality of dust in the air. (Takai et al., 1998).

Experimental tests are carried out in the agro-zoo-technical farm (Fig. 1) belonging to Anna Faiella, placed in S. Elia at Pianisi (CB Italy).

A broilers breeding has been located in two warehouses one of them newly built. This one is able to breed 30000 heads/cycle (9500 females and 20500 males). Every cycle goes on 80 ayes: 60 to grow animals (60 for males and 35 for females) and 20 needed to the health rest. The warehouse size is 13,00 x 14,20 metres with an inner surface of 1874,40 m² and an height of 2,65 m.

Inside the building 14 electric fans, that can be operated one by one, supply the change of air. These fans are set in motion by a 1.0 CV three-phase engine and a fixed speed of 1400 revolution per minute (rev/min).

An impeller with 6 blades and a diameter of 1270 mm whirls at a nominal speed of 368 rev/min. Every fan has a maximum capacity of 36000 m³/h. The cooling or pad climate system is a water cooling that uses latent heath of the water evaporation. Water circulates inside the system through a pump, goes across the delivery pipes, located in the superior part of the system, and finally is sprayed into the deflector. The air takes up the heath useful to water evaporation and, through a panel, gets cold and humid.
Two cooling systems (Fig. 2) are located on the sidewall of the warehouse near the service area: in this way the air entering through the cooling runs across the whole warehouse before being discharged outside. Each cooling is composed of two parts: the first one is longer and located in the middle part of the warehouse. The overall length is 30 m. This division helps to restrict heating air during the transit inside the warehouse. The warehouse switches on the cooling at 27 °C and switches off at 24 °C.

**Materials and methods**

A multichannel BABUC/A data logger has been used for the microclimatic remarks inside the building. The used feelers are:

- a psychrometer BSU 102 supplied with two thermometers: the first one, with a dry bulb, measures air temperature, the second one, which has a wet bulb and an hydrophilic sheath soaked in distilled water, measures the water temperature on contact with air. The psychrometer is provided with a little fan that sets up the testing at air velocity of 4 m/s.
- an anemometer BSV 101 with warm wire that measures the air velocity in every direction. The wire is platinum and is covered by a cylindrical bearing, let down during the testing so that the air flow is not obstructed. BABUC/A is able to calculate the number of the air changes, if the volume of the building is known.
- a infrared feeler BSO 103.1 to measure carbon dioxide with a range from 0 to 3000 ppm.
- To value the microclimate in the breeding, temperature, humidity, air velocity and carbon dioxide have been measured.
- The tests have been carried out during the whole breeding cycle, every week before midday in summertime when the maximum air quantity is requested.
- The barn has been separated into 14 vertical sections and 3 measuring at the height of 20,100 and 150 cm have been taken in the middle part of each one.
- In the sections 1, 5, 9, 13 two more sets of testing on the lateral positions of the same sections have been carried out; so the values of the parameters at the different heights have been obtained for each set.
- A schedule (model) shows the points where the measuring have been taken in the cattle breeding (Fig. 3).
Fig. 3 - points where the measuring have been taken
Results and discussion
Each test was carried out during June 2011 for a overall length of about 1 hour and 40 minutes each, with the storage of the mean values of the measured properties. The measurements of the environmental parameters and also the number and the location of the fans have been registered in function of each test. The following graphs (Fig.4) obtained allows a first evaluation of the microclimate in the farm.

![Graphs showing microclimate parameters measurements](image)

**Fig. 4 – Microclimate parameters measurements**

The graphs show the parameters trend considering the variation of height and length of the farm building. The air velocity mean value is higher at 150 cm from the floor with corresponding higher mean values of Humidity and Carbon Dioxide measured at 20 cm from the floor (animals height). The temperature values are higher at 100 and 150 cm from the...
floor respect to the values measured at 20 cm from the floor. The temperature values increase and the Relative Humidity values decrease moving towards the end of the building. This fact is due to the presence of the animals heating the air. The Carbon Dioxide concentration remains constant during the air flow. The Carbon Dioxide rate can be evaluated by mean of the following equation (rate of Carbon Dioxide which flows through a generic section in time unit):

\[ \dot{m}_{CO_2} = \omega_{CO_2} \rho_a v_a A \]

where:
\[ \dot{m}_{CO_2} = \text{Carbon Dioxide mass rate (mg/s)}, \]
\[ \omega_{CO_2} = \text{Carbon Dioxide concentration (ppm: mg (CO2) /kg (dry air))}, \]
\[ \rho_a = \text{air density (kg/m}^3\text{)}, \]
\[ A (\text{section}) = \text{area of the transverse section (m}^2\text{) in the point of measure,} \]
\[ v_a (\text{air}) = \text{air velocity (m/s)}. \]

![Carbon Dioxide delivery (ppm/s)](image)

**Fig. 5 – Amount of carbon dioxide delivered across each measurement point**

Fig. 5 shows the variation of the Carbon Dioxide rate along the air flow in the farm. The values used for the Carbon Dioxide concentration and for the air velocity were obtained from the average of the corresponding values measured at three different heights. The graph is subdivided in three parts:
- a first phase of CO2 increase, due to the animals presence without a further air change,
- a second phase of CO2 rate decrease, during the air change and due to the cooling (in the first part of the farm(1/3)),
- a third phase of CO2 increase (during the second inactive cooling).
The CO₂ increases linearly during the tests and shows a quite high gradient. The carried out tests showed a good quality of the air in the farm related with the Carbon Dioxide and the Relative Humidity. The fans put in are able to extract a high air rate causing, in some cases, a sudden variation of temperature. The values of the measured parameters, except for the temperature, are mainly included in the range considered as optimal for the welfare of the animals. The mean value of the CO₂ were calculated at three height of measure, to determine the CO₂ rate. Tests were carried out during summer when the worse conditions of microclimate are evaluated in the farm. In particular:

- The measured Carbon Dioxide never overcame the value of 800 ppm (value limit for the welfare of the animals), not even when the animals generated a higher amount of the gas. The low concentration of Carbon Dioxide and the low Relative Humidity, both due to a good ventilation, make us to think that the concentration of other polluting substances in the farm is low also in absence of specific monitoring.
- The temperature, before cooling, always were not higher than 3 °C respect to the outside temperature. The inside temperature, during cooling, lowered of 3 – 4 °C respect to the outside temperature. The temperature values measured during cooling tests ranged between 25 – 30°C, too high compared to that ones considered as optimal for the boiler growth up (range 20-21°C).
- The Relative Humidity values measured during the tests ranged between 40 and 60%. During the cooling some R.H. values are lower than that ones considered as optimal (range 60-70%) for animals. A low Humidity makes the temperature perceived by the animal not too high, partially compensating the highest tested temperature values.

During the last tests during this year (2012), (not presented in the paper), some sudden variations of temperature and R.H. were evaluated, owing to an inaccurate control of the fans and of the two cooling batteries.

**Conclusions**

Some conditions in the farm, regarding the environmental control, could be improved:

- A more homogeneous condition of temperature and R.H. in the farm could be reached working on a smoother ventilation and testing the cooling surface.
- The optimization of the ventilation system could be done changing the ON-OFF working with the VFD working. The VFD system guarantees a higher ventilation control and a higher energy saving.

**References**

