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EVALUATION OF DIFFERENT MINIMUM VENTILATION SYSTEMS IN THE PRODUCTION OF BROILER CHICKENS ON AIR QUALITY FOR PERIODS OF 1 TO 7 DAYS

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Abstract The objective of this work was to evaluate the efficiency of different minimal ventilation systems including positive pressure ventilation (SVMP), negative pressure ventilation (SVMN) and natural ventilation (SVMNat), associated with the thermal comfort environment, air quality and the influence of these factors on the productive performance of broiler chicken during the heating phase of hatchlings (1 to 7 days). Verification of different environmental variables such as air temperature, black globe temperature, relative humidity and air velocity at bird respiration level were evaluated. Ammonia, carbon monoxide and oxygen concentrations were verified at intervals of 3, 9 15 and 21 h. Minimal air renewal in the treatments with positive and negative pressures were controlled by means of timing devices, with differential air renewal for each week of life of the hatchlings. No statistical difference ($P<0.05$) was observed for the environmental variables. Average ITGU values in the first week were below the birds comfort levels, exposing them to cold stress for the majority the three minimal ventilation systems, indicating probable deficiencies in the heating systems and/or the insulation system for hatchlings in their initial growth phase. Average pollutant gas measurements did not surpass tolerable levels for the three minimal ventilation systems evaluated. However, minimal ventilation systems were adequately dimensioned in terms of minimal air renewal, presenting no negative influences in relation to ventilation rates applied for the two systems SVMN and SVMP and with air velocity at non-stressing levels to the hatchlings, inclusive for SVMNat.

Keywords: air quality, broiler chickens, minimal ventilation system

INTRODUCTION In order for environmental management and the increasing concern about the quality of life, there is a constant demand for measures enabling the identification and reduction of risks to the health of poultry and workers, and of the physical environment.

The problems of poor air quality inside an aviary can be solved, if it is guaranteed that the levels of each of the harmful pollutants are below the tolerance limits for the species in each of the different phases of life. For this it is necessary to promote the renewal of air in the intensity required, this can be achieved by means of ventilation. However, among the two types of ventilation, the sanitary character or minimum ventilation is the most difficult to plan for the conditions of Brazilian poultry, as these are open and without thermal insulation.

The options to ensure the renewal of air in winter and in early life stages of fowls, for the conditions of Brazilian poultry facilities may be positive pressure ventilation and negative pressure ventilation, both with fans and / or exhaust fans, respectively, placed in strategic parts of the growth area, and also naturally, conceiving strategic openings in the growth area.

The objective of this study was to evaluate different minimum ventilation (breathing positive, negative and natural) and effectiveness in promoting thermal comfort environment to the growth area and air quality in winter conditions, to commercial poultry houses.

METHODOLOGY The study was conducted in commercial poultry integrated property, and was conducted in three poultry broiler like the same core productive during the winter season. Guidance prepared from east to west, measuring 14 m wide and 55 m in length, ceiling height of 2.90 meters, positioned side by side and spaced approximately 8 m, covered with clay tiles.

The lining is made of canvas polyethylene yellow to 2.9 meters from the floor. All the cages were new bed of coffee hulls, with 5 cm thick.

Data collection was performed in the experimental area of growth stages (heating phase) of broiler chickens, located inside the poultry houses, including the period from 1 to 7 days.

Were used AVIAN broilers (males), originating from the same hatchery, with the amount of 8,500 fowls per shed, the first day of housing, density was 80 fowls/m2 (air volume of 589.96 m3) magnification of 3 m along the length of growth area, corresponding to an increase of more than 63.21 m3 of air inside every two days.
Each of the cages at random, was equipped with different ventilation systems at least, each one constituting a treatment: for SVMP - system of minimum ventilation by positive pressure, positioned fans in line with the ceiling and blowing the air contained between the roofs lining inside the growth area. The number of renewals of any air was programmed as suggested by Curtis (1983) for winter conditions, which is between 1 and 6 renewals per hour, using a timer on /off , for SVMN - system minimum ventilation by

negative pressure, with 1 to 6 renewals per hour, with hoods positioned at one end of the growing area, and SVMNat - system of minimum ventilation by natural means, through the management of curtains and also by very opening of the doors when the entry of workers during the surveys.

The minimum ventilation was based on data second ASAE (2003), system for poultry houses with heaters located inside the premises. Values were given in m3 of air exchange per hour, by age and animal. He set the required values and the average work flow of 0.23 m3/hours/animal the first 7 days of accommodation.

Thus, the two systems SVMN SVMP and were equipped with an exhaust fan and a fan. Respectively, both with a flow rate of 300 m3/minutes. To obtain a renewal of the air according to the ASAE standards (2003), proceeded to the intermittent operation of ventilation systems at least, with operation of ventilation systems for minimum negative pressure (SVMN) and positive pressure (SVMP) 1 minute on and off 7 minutes. The limits of air varied according to the velocity limit to ambient air at the level of young fowls, ranging from values of 0.1 to 0.5 m s-1. Were measured continuously in both a domestic and abroad, with selection of three points along the length of the shed, the environmental variables. The variables evaluated were black globe temperature and air temperature (dry bulb), relative humidity and air velocity at the level of fowls. Measurements were performed using a system of data acquisition, sensors, continuous playback (datalogger) at intervals of 15 minutes. For the air velocity, we used instruments digital anemometer hot wire.

To collect weather data from the external environment was used under the weather, at a height of approximately 1.5 m, equipped with sensors for continuous measurement of temperature and humidity. Near the shelter, about 1 m radius and 1.5 m high, was installed a black globe temperature for the acquisition of the external world. Were measured instant concentrations of ammonia, carbon monoxide and oxygen at the level of fowls in three points at 3, 9, 15 and 21 hours.

To evaluate the variables related to the environment (thermal comfort and air quality), the experiment was conducted in a randomized block design (RBD) in a split plot in time, the plots following treatments: SVMN, SVMP, SVMNat, and plots the time (weekdays). These environmental variables were analyzed by analysis of variance and means were compared using the Tukey test adopting the 5% level of probability using SAS® System.

RESULTS AND DISCUSSION The analysis of variance concerning the first week of life from fowls to environmental variables: air temperature (T), relative humidity (RH), index of black globe temperature and humidity index (ITGU) and air velocity are in Table 1. We decided to split the interactions ventilation x hours regardless of their significance, the effect of setting time, such as, we evaluated the treatment effect separately within each zone.

TABLE 1. Summary of analysis of variance which occur during the first week of accommodation in the internal environment of the plant for air temperature (º C), air velocity (m s^{-1}), relative humidity (%) and index of black globe temperature and humidity (ITGU)

Source of variation	G.L.	AVERAGE SQUARE			
		Air Temperature (ºC)	Air Velocity (m s^{-1})	Relative Humidity (%)	ITGU
Treatment	2	536.07*	3.045*	13392.13*	176,45$^{n.s}$
Day	6	167.91*	0.013$^{n.s}$	4719.85*	398,46*
Treatment*Day	12	32.42*	0.053*	206.85*	47,89**
Hours	95	279.75*	0.0016$^{n.s}$	755.46*	362,31**
Treatment*Hours	190	1.56$^{n.s}$	0.0016*	13.36$^{n.s}$	1,98$^{n.s}$

* Significant at 5% probability by F test;
** Significant at 1% probability by F test;
^{ns} not significant at 5% probability by F test

The interaction of ventilation systems by time was statistically significant (P <0.05) for the variable air velocity, the other variables of the thermal environment, temperature, relative humidity and the index of black globe temperature and humidity index (ITGU) was not significant by F test.

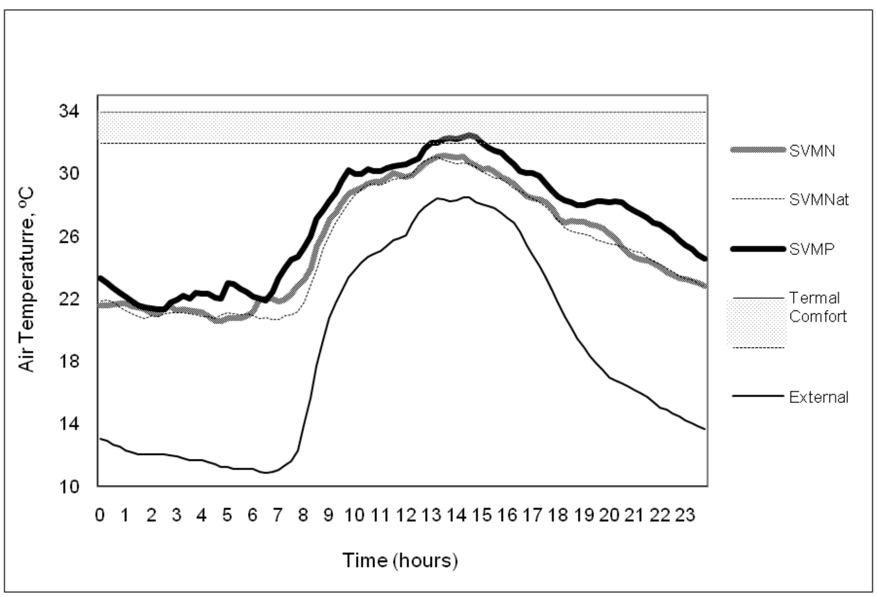

FIGURE 1. Averages of air temperature in the internal and external environment, from 1 to 7 days of life for fowls, for the three systems of minimum ventilation, negative pressure (SVMN), positive pressure (SVMP) and by natural (SVMNat), a function of time.

According to the data average air temperature recorded in the minimum ventilation SVMN, SVMP and SVMNat the first week of life for fowls, it is observed that it did not achieve satisfactory levels to be considered comfortable for any of the three treatments. Vigoderis (2006) observed similar behavior in surveys conducted with heating systems during winter, showing that in periods of intense cold has not reached the proper conditions of temperatures in the first weeks of life for fowls.

These results can be explained by the fact that the isolation (area of initial growth) is very weak and difficult to maintain air temperature within the thermal comfort.

It is observed that the amplitudes of the curves of air temperature inside a housing for all ventilation systems minimal compared to the temperatures of the external environment, presents far greater during the night (which is in agreement with the expected since this is the coldest period of the 24-hour cycle), with maximum range of 10 ºC observed for the system of natural ventilation by the time 5h45min. Evaluating the big difference between the ideal temperature and those obtained in the different treatments, it appears that the fowls were exposed to cold stress too severe for most of the time.

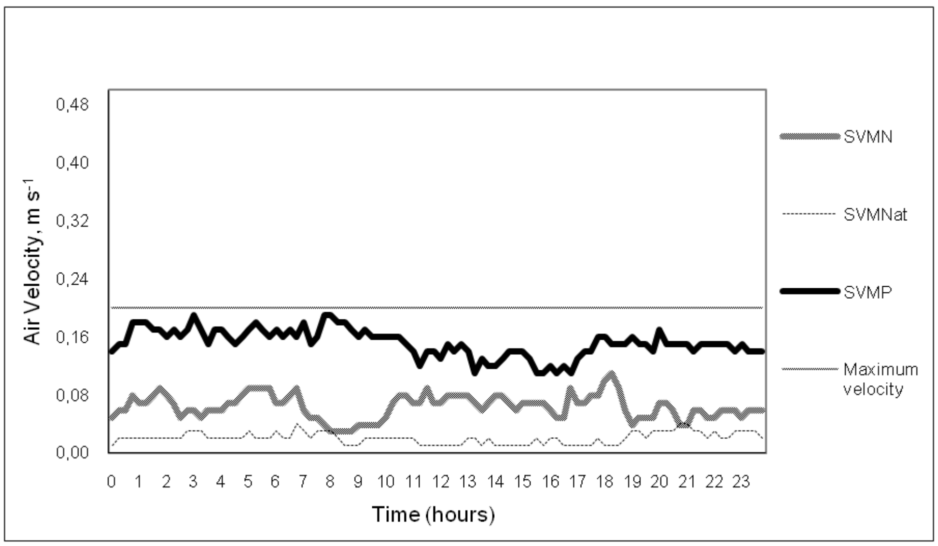

FIGURE 2. Averages of air velocity in the internal environment of poultry, from 1 to 7 days of life for fowls, for the three systems of minimum ventilation, negative pressure (SVMN), positive pressure (SVMP) and by natural (SVMNat), a function of time.

As illustrated in Figure 2, it appears that the ventilation system that provided minimal values of air velocities significantly increased and appropriate hygienic renewals and closer to those proposed by Moura (2001) and Cobb (2008) as ideal for first weeks of life of fowls, from 0.08 to 0.20 m s^{-1}, were found in SVMP, followed by SVMN. In the case of SVMP, it appears that were not considered excessive for this period of life for fowls, because once the levels of air temperature at the fowls were not affected by the process of ventilation, compared to other systems. That is, the higher air temperatures occurred in SVMP despite being the system with higher air velocity at the fowls.

It is therefore possible that there were fault in the heating system adopted (wood), because the measured temperatures inside the premises were similar in the three ventilation systems at least, that is, the air velocity between the systems composed of ventilation and exhaust in relation to natural ventilation were adjusted to maximum, which is not directly influenced the low average temperatures occurred mainly at night.

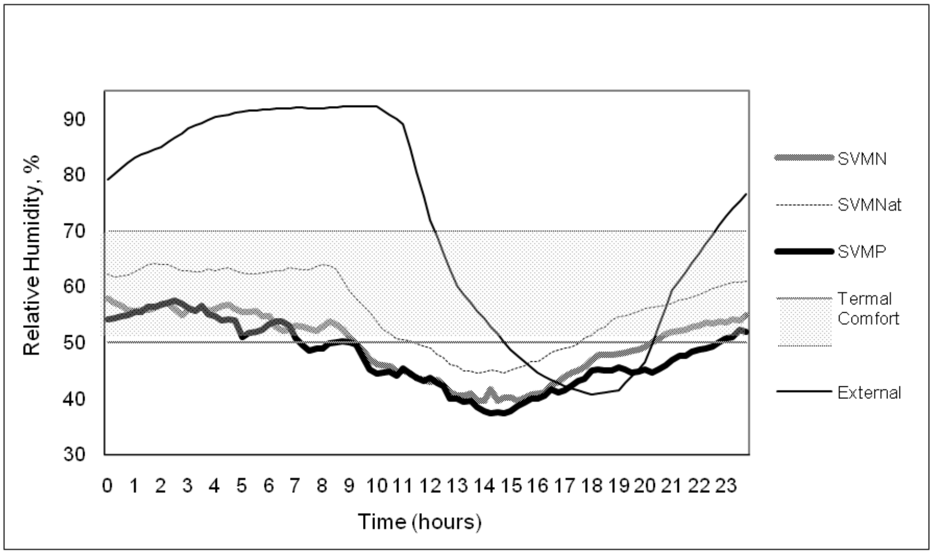

FIGURE 3. Averages of relative humidity in indoor and outdoor, from 1 to 7 days of life for fowls, for the three systems of minimum ventilation, negative pressure (SVMN), positive pressure (SVMP) and by natural (SVMNat), a function of time.

It is through in Figure 3, the average relative humidity are within the range considered adequate for a good bird, at times included in the evening, between 23 and 7 h for the three systems of minimum ventilation evaluated.

However, it is observed that in most times of day, the values of relative humidity were below those considered favorable to the optimum conditions for broiler chickens in first week of life. A similar condition was observed by Cordeiro (2007), in research conducted in aviaries for broilers in southern Brazil, with values below 50% in most times, these values can be harmful to chicks in their first week of life, as they can lead to dehydration of the animals.

Through Figure 3, it appears that compared to the external environment, the internal environment has kept the values of relative humidity more homogeneous, without significant variation throughout the day. The period between 15 and 20 hour outside air is maintained in conditions very similar to or lower than those found inside the premises. In light of these observations can be inferred that the mechanical ventilation systems (SVMN and SVMP) had lower mean relative humidity, while the dry air inside the premises. This event is justifiable due to the fact that the SVMN SVMP and the artificial ventilation system ensuring air renewal more controlled and efficient in relation to the aviary with natural ventilation.

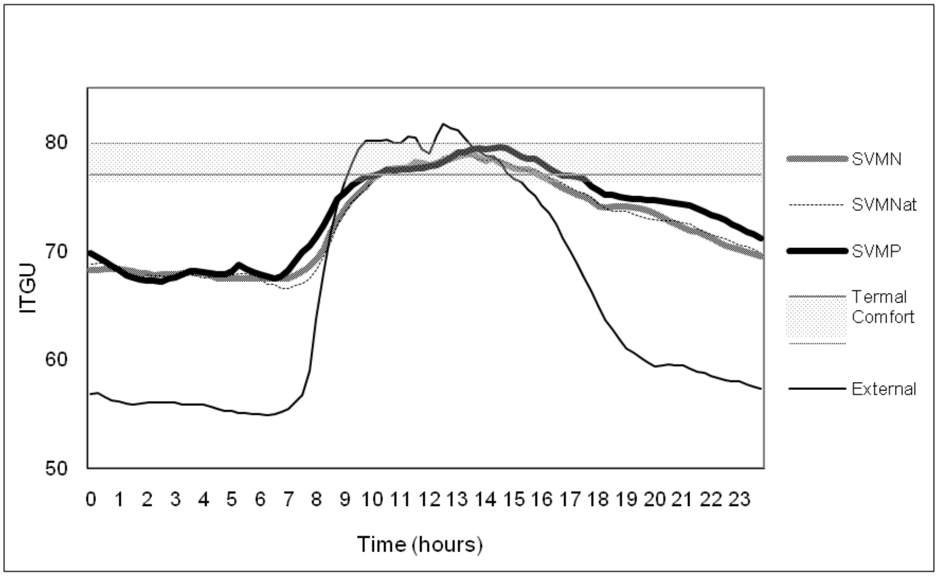

FIGURE 4. Index means black globe temperature and humidity index (ITGU) in internal and external environment, from 1 to 7 days of life for fowls, for the three systems of minimum ventilation, negative pressure (SVMN), positive pressure (SVMP) and by natural (SVMNat), a function of time.

It appears from Figure 4 that, relative to the minimum ventilation systems evaluated, the comfort conditions are reached only during the day between 10:15 and 15:30. The treatments did not differ between them ($P < 0.05$) compared with observed times. Since the values of ITGU for most of the period were below the values considered comfortable for the fowls, they were exposed to stress conditions by cold weather during most of the diurnal cycle.

The low average humidity index observed during the night, with emphasis to those obtained between 0 and 6 am, may have originated mainly from gaps in the supply of wood during the period of the lower temperatures. Similar behavior was observed by Cordeiro (2007).

The analysis of variance for the variables of air quality, ammonia (NH^3), carbon monoxide (CO) and oxygen (O^2) at the level of fowls are presented in Table 2.

TABLE 2. Summary of analysis of variance which occur during the first week of accommodation, from inside the premises for the concentration of ammonia (NH^3), carbon monoxide (CO), both in ppm and the oxygen (O^2), in %

Source of variation	G.L.	AVERAGE SQUARE		
		NH_3	CO	O_2
Treatment	2	$0.043^{n.s}$	$6.35^{n.s}$	$0,005^{n.s}$
Day	6	0.14*	$2.64^{n.s}$	0.010*
Treatment*Day	12	$0.03^{n.s}$	$1.915^{n.s}$	$0.002^{n.s}$
Hours	95	$0.02^{n.s}$	$17.08^{n.s}$	0.022**
Treatment*Hours	190	$0.01^{n.s}$	$0.65^{n.s}$	$0.003^{n.s}$

* Significant at 5% probability by F test;
** Significant at 1% probability by F test;
^{ns} not significant at 5% probability by F test

Table 3 represent the mean values of concentrations of ammonia, carbon monoxide and oxygen levels for the first week of fowls life.

TABLE 3. Weekly average concentrations of ammonia (NH^3), carbon monoxide (CO) and levels of oxygen (O^2), observed daily the second week of life for fowls at 4 different times (3, 9, 15 and 21 hours) treatments SVMN, SVMNat and SVMP

Periods *(hours)*	NH_3 (ppm)			CO (ppm)			O_2 (%)		
	SVMN	SVMNat	SVMP	SVMN	SVMNat	SVMP	SVMN	SVMNat	SVMP
03	0,0 a	0,1 a	0,2 a	0,1 a	0,1 a	0,0 a	20,9 a	20,9 a	20,9 a
09	0,0 a	0,1 a	0,1 a	1,6 a	2,6 a	1,2 a	20,8 a	20,8 a	20,9 a
15	0,1 a	0,1 a	0,2 a	1,4 a	2,5 a	1,3 a	20,9 a	20,9 a	20,9 a
21	0,1 a	0,1 a	0,1 a	0,1 a	1,0 a	0,0 a	20,9 a	20,9 a	20,9 a

Means followed by at least one same letter in row did not differ in the level of 5% probability by Tukey test.

Note that there was no statistical difference ($P < 0.05$) among the different ventilation systems at least the first week of fowls life to varying NH^3, CO and O^2. Considering the level of concentrations of NH^3 and CO found in the internal environment, it can be seen from Table 2 that the levels were low, not reaching the range considered dangerous to health and proper development of fowls.

The concentration of O^2 in the air ambient remained almost constant at around 20.9%, staying within the public health conditions. The presence of O^2 at appropriate level may be considered an indication that the minimum ventilation was correct and indicate lower risk for the presence of asphyxiating gas indoor (NR-15, 1978).

We have found the best conditions for the welfare of broilers under the conditions involving the ideal thermal environment with concentrations of ammonia in the atmosphere below 5 ppm (Owada et al., 2007). However, according to these authors values below 5 ppm in the sheds are rarely found.

In this case, the mean concentrations of NH^3 were less than 5 ppm in all treatments. However, new bed was used for the production of broilers, and also the levels of relative humidity in the first week were within the ideal range or below those with low values of RH, which contribute so positive thus avoiding a greater wetting the bed, and consequently lower production of ammonia gas. Levels of ammonia concentrations within the limits from 10 to 20 ppm, are eligible for a productive poultry (Wathes et al., 1997).

It appears that the highest concentrations of CO were found out between 9 and 15h, for the three systems of minimum ventilation. It was also observed that treatment SVMNat, was what had the highest average, showing a small difference compared to systems with forced ventilation SVMN and SVMP.

The average values of CO for the week does not pose a health risk of young fowls, since levels were found in concentrations below the maximum level for continuous exposure of animals, which is 10 ppm, as Wathes (1999).

The period in which there was a higher incidence of CO gas, was the day period in which the management of heather system was more frequent, when wood feeding being equal. Through the average temperatures recorded during the first week, we can infer that during the night it has not been satisfactorily supplied. As the CO gas comes from the incomplete burning of fuel is the more appropriate values have been detected during the day, as the night may have been less burning material.

CONCLUSION Renewal hygienic air was obtained with satisfactory levels in both minimum ventilation systems evaluated SVMN and SVMP with adequate oxygen levels within the premises, and also with concentrations of toxic gases, ammonia and carbon monoxide, at levels below those considered harmful to the health of broiler chickens so verifying good indoor air quality.

However, to maintain the hygienic conditions of the indoor air, according to the comfort conditions of the fowls, there was no negative influence over ventilation rates applied to both systems SVMN and SVMP and air velocity at levels no stressors the broiler chicken, including the SVMNat.

The average ITGU recorded in the three ventilation systems evaluated (SVMN, SVMP and SVMNat) characterized the thermal environment as uncomfortable for broiler, especially at night, subjecting them to cold stress.

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