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ANIMAL PRODUCTION

Broilers thermal comfort and performance utilizing two different wood-burning heating systems

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ABSTRACT. The objective of this study was to evaluate the thermal comfort and performance of broilers in their initial stage of development utilizing two different heating systems. The experiment was conducted in two sheds placed on a commercial farm. The heating systems were: indirect heating furnace and radiation heating drums. At the beginning of the heating phase the birds were confined in an area corresponding to 360 m² in shed 1 and 180 m² in shed 2, delimited by polyurethane curtains, allowing a density of 58.8 birds m^{-2}. The variables: dry bulb temperature (Tdb), relative humidity (RH%) and temperature and humidity index (THI) were calculated. Measurements were performed using continuous reading data loggers at 15-minute intervals throughout the experimental period, which was a complete productive cycle for males. Differences were detected in the environmental variables during the period evaluated, as well as differences in performance were found as a function of the two heating systems. The heating system of the furnace presented UR ranging from 47-59% in relation to the drum system (51-57%), besides providing a more constant temperature and providing a greater distribution of heating. On the other hand, the drum system provided greater weight gain in the animals.

Keywords: chicks; heating; poultry; animal comfort.

Conforto térmico e desempenho zootécnico de frangos de corte utilizando dois sistemas de aquecimento distintos

RESUMO. Objetivou-se comeste estudo avaliar o conforto térmico e desempenho zootécnico de frangos de corte em seu estágio inicial de desenvolvimento em função utilizando dois sistemas de aquecimento distintos. O experimento foi conduzido em dois galpões localizados numa propriedade comercial. Os sistemas de aquecimento foram: fornalha de aquecimento indireto e tambores de aquecimento por radiação. No início da fase de aquecimento as aves foram confinadas numa área correspondente a 360 m² no galpão 1 e 180 m² no galpão 2, delimitada por cortinas de poliuretano, possibilitando uma densidade de 58,8 aves m^{-2}. Foram avaliadas as variáveis Temperatura de bulbo seco (Tbs), umidade relativa do ar (UR%) e calculado o índice de temperatura e umidade (ITU). As medições foram realizadas com o uso de *dataloggers* de leitura contínua da marca Hobbo em intervalos de 15 minutos, durante todo o período experimental, que foi de um ciclo produtivo completo para machos. Foram detectadas diferenças nas variáveis ambientais durante o período avaliado como também foram encontradas diferenças no desempenho zootécnico em função dos dois sistemas de aquecimento. O sistema de aquecimento por fornalha apresentou UR variando de 47-59% em relação ao sistema de tambores (51-57%), além de proporcionar temperatura mais constante e proporcionar maior distribuição de aquecimento. Por outro lado, o sistema de tambores proporcionou maior ganho de peso nos animais.

Palavras-chave: frangos; aquecimento; avicultura; conforto animal.

Introduction

The importance of broiler chicken production in Brazil is growing both on a national and international scale, requiring more efficient and intensive production systems to produce greater yields (Saraz, Tinôco, Rocha, Martins, & Paula, 2011). When it comes to the production of any animals, their welfare must be considered. The guarantee of increased production is intrinsically related to the lower stresses suffered by them, and proper management has fundamental importance. The control of the thermo-environmental variables inside the sheds is necessary for the microclimate generated to maximize the productive potential of the broilers. For this, primary modifications (architecture and surrounding landscaping) and secondary modifications (heating systems, ventilation systems and nebulization) must work together to provide thermal comfort to animals at a modest cost of production (Vigoderis et al., 2014).

The optimum productivity is achieved with the use of energy for growth, while keeping the birds in a comfortable temperature range, without having to expend energy to compensate for the cold or hot temperatures (Abreu, Abreu, Coldebella, Jaenisch, & Paiva, 2011). Among the bird's environmental needs, thermal comfort is paramount for their efficient production performance of a broiler flock is affected by ambient temperature, humidity, heating or cooling system, and the environment of the broiler house (Choi et al., 2012). These factors may be critical in tropical and subtropical areas where temperature is very low during the winter season.

The birds maintain constant body temperature when the temperature ambient is thermoneutral (Welker et al., 2008). However, broilers, in their initial phase, are very sensitive to low temperatures, which may negatively affect their development, leading to huge financial losses, especially in conditions of harsh winters (Vigoderis et al., 2014).

In addition to temperature, other factors as a humidity are paramount for the good performance of broilers. This environmental variable influence under the amount of dust in the aviary, heat exchange between animals and environment and equipment oxidation. Among the environmental factors, the thermal factors, mainly represented by temperature and relative to the relative air, are those that affect more directly as birds, compromised the maintenance of homeothermia, a vital function achieved through Heat loss sensitive and latent processes (Medeiros et al., 2005).

In the early stages of development, birds almost always require additional heating, because due to their morphological characteristics and because they still have little Body mass, they cannot reach an ideal body temperature in an unfavorable thermal environment. In this way heating systems are used to provide it. The heating systems that have been most commonly used insemi-acclimatized facilities for broilers in southern Brazil are infrared gas heater, furnace with direct or indirect air heating and experimental radiant “drum” system (Cordeiro et al., 2010).

To better evaluate the environment production, it has been used indexes that combine environmental variables. Among these comfort indexes it can be mention the Temperature and Humidity Index (THI) developed by Thom (1958). According to Azevedo et al. (2005), the association of relative air humidity and air temperature provides an excellent indicator of thermal comfort, called Temperature and Humidity Index (THI).

In view of the above, the objective of this research was to evaluate the efficiency of heating, thermal comfort and performance of chicks under two wood-burning systems, using environmental variables and THI, as well as the animal performance values at the cycle end.

Material and methods

Experimental area description

The experiment was conducted on an integrated commercial agricultural property in two sheds, spaced 300 m apart, with differentiated heating systems in the two sheds (furnace and radiant heating drums). A total of 31,900 male Cobb Vantress chickens were used in the two sheds, with 21,300 and 10,600 housed in shed 1 and 2 respectively, during a complete cycle, reared under a rice bed straw. Although the total number of chicks was different among the sheds, a population density of chicks was standardized in both sheds.

The region climate, according to Köppen classification (Köppen, 1948), is As', which is characterized as a rainy tropical climate with dry summer season, with annual averages of temperature and precipitation of 20°C and 1,038 mm respectively. Latitude 8°46'04.2"South and Longitude 36°23'00.7" West.

Sheds

Shed 1 had a width of 12 m, a length of 125 m and a height of 2.5 m, a cemented floor, and masonry walls with a height of 0.20 m. The owls had a wall of 0.20 m in reinforced concrete, closed with a plastic screen with holes of 2x2 cm and polypropylene curtain of the height of the wall up to 2.5 m (height of lining). From 2.5 m to the ridge were masonry with cladding and painted white. The pillars were made of reinforced concrete with a section of 15x15 cm spaced every 3 m.

The lateral closure consisted of a plastic screen with 2 x 2 cm holes and a blue polypropylene curtain. The shed had blue polypropylene lining on the underside and silver on the upper face. The structure of the roof was composed of timber. The roof was composed of 5 mm thickness asbestos-cement tiles (2.40 x 0.50 m). In the initial management of broilers, the cocoon was used, which serves to decrease the area to be heated and to have a better temperature control. In this shed was made of 12 x 30 m (360 m^2), with a polypropylene curtain as a closure on the four sides of the cocoon, without the use of a double curtain.

Shed 2 had a width of 12 m, a length of 110 m and a height of 3 m, the floor was cemented, the walls were made of masonry with a 0.20 m height. The owls were made of masonry, coated with cementon the west face and uncoated on the east side, both of which had 1.8 x 1.5 m openings for air circulation. The pillars were made of reinforced concrete of section 12 x 12 cm every 3.1 m.

The lateral closure was composed of plastic screen with holes of 0.02 x 0.02 m and curtain of blue polypropylene. The shed had no lining. The structure of the roof was made of wood composed of tassels, rafters and slats. The roof was composed of ceramic tiles (50 cm long, smaller base with 11.5 cm and larger base with 15 cm). In this shed was made a closure of 12 by 15 m (180 m^2), with polypropylene curtain, on the four sides of the cocoon, without the use of double curtains.

Heating system

The indirect air heating furnace to be used in the experiment was 2.2 m long, 1.2 m high and 1.8 m wide, with a volume of 5.76 m^3, providing an air flow of 5,950 m^3 h^{-1}, capable of generating 188,781 kcal h^{-1} of energy. The furnace was installed outside the shed where it was fed with firewood. It was provided with piping made of 50 m galvanized steel with perforations where steel cones were inserted alternately, mounted in the middle of the aviary in both directions distributing the air.

Radiation heating drums had a volume of 200 L. One of its ends had an opening for placing firewood, and the opposite end was provided with a chimney for venting unwanted gases. The heating of the environment occurred due to the dissipation of the radiant energy coming from heating the surface of the drum caused by the firewood combustion inside.

The heating systems were arranged according to the usual property management, being a furnace of indirect heating of the air by shed, and four heating drums for a shed. Both were regulated in order to maintain the internal temperature in the bands suitable for thermal comfort. At the beginning of the heating phase the birds were confined in an area corresponding to 360 m^2 in shed 1 and 180 m^2 in shed 2, delimited by polyurethane curtains, allowing a density of 58.8 birds m^{-2}. There was successive expansion of this area as the chicks grew, usually increasing 36 m^2 of the area of the cocoon, until they occupied the whole area of the aviary. At the end of the heating phase, all sheds were also managed in order to ensure that possible differentiations in bird performance indices were attributed to the different heating systems used in the initial phase of their life.

Environmental variables assessed

The following environmental variables were obtained continuously at the geometric center of the cocoons at the level of the birds (from 10 to 30 cm, accompanying the growth of the animals): dry bulb temperature and relative humidity. Measurements were performed using continuous reading data loggers at 15 min intervals throughout the experimental period, which was a complete productive cycle for males. The used data loggers had a resolution of 0.1°C (temperature) and 1% (humidity), and an accuracy of ± 0.5°C (temperature) and ± 1 % (Humidity). These data were used to calculate the Temperature and Humidity Index (THI), determined by equation:

$$\mathrm{THI} = \mathrm{Tdb} + 0.36\mathrm{Tdp}$$

where:
THI = Temperature and humidity Index
Tdb = Dry bulb temperature
Tdp = Dew point temperature

Animal performance

The most common performance indexes were used to evaluate the weekly performance of the animals: Weight gain (WG), which is the difference between the final weight and the initial weight of the birds, being weighed every seven days; Feed consumption (FC), which is the amount of feed consumed during the productive period, value obtained by weighing; Feed Conversion (FC), which is the relationship between the amount of feed consumed and the corresponding weight gain.

Experimental design and statistical analysis

The experiment was set up in a randomized block design (RBD), with a plot of plots scheme subdivided in time, with the following treatments: furnace of indirect heating of the air and heating drums, and in the subplots the days, with repetitions in the breeding lots and at times. The collected data were submitted to variance analysis (ANOVA) and covariance (ANCOVA) through the software Xlstat (Addinsoft, 2017).

Results

According to the daily mean values observed for Tdb (Table 1), although there is no statistical difference among all treatments, it is possible to infer that the system of heating furnace was more efficient in preventing the birds from suffering thermal stress. This can be affirmed due to the system composed by the heating drums having undergone an overheating on the second day, with average temperature above the recommended value, which according to Abreu et al. (2011), is at most 35°C for the first week of housing. As a consequence, there was a decrease in feed conversion, indicating physiological responses to thermal stress.

Table 1. Mean daily Tdb values of two heating systems compared to the environment for broiler chickens.

	Tdb (°C)		
Days	Furnace	Drums	Environment
1	33.03^{b*}	31.11^{b}	25.45^{a}
2	32.71^{b}	36.95^{b}	25.62^{a}
3	31.94^{b}	33.57^{b}	26.20^{a}
4	31.33^{b}	31.59^{b}	25.40^{a}
5	31.04^{b}	30.57^{b}	24.63^{a}
6	30.80^{b}	29.74^{a}	24.38^{a}
7	30.72^{b}	29.33^{b}	25.32^{a}
8	30.26^{b}	28.90^{a}	25.12^{a}
9	29.96^{b}	28.59^{a}	25.87^{a}
VC		8.66	

*Averages followed by the same letter do not differ by Tukey's test ($p \leq 0.05$). Averages obtained from 96 daily observations.

The furnace heating system provided temperatures closer to 32°C in the first two days, 31°C from the third to the fifth day and 30°C from the seventh to the eighth day. The heating system composed of drums provided temperatures above the ideal for the age of the birds in the adopted management having an average of 36.95°C on the second day of heating, a value above that recommended for the first week of the birds. However, until the 5th day, the birds experienced temperatures in the recommended range, suffering a fall from the sixth day, with values statistically different by the Tukey test ($p \leq 0.05$).

It was detected more difficult temperature control in drums system compared to the furnace system. One solution would be to modify the cocoon adopted management. The usual practice is to increase the cocoon area 36m^2 daily, decreasing the density and consequently increasing the area to be heated. Another suggestion is to control the opening for the air intake of the drums, thereby controlling the combustion inside them and the dissipation of heat.

The furnace system did not provide this kind of uncontrolled. Firstly, because the combustion chamber is located outside the shed, and also only be activated when necessary, because it has a sensor located inside the cocoon.

Regarding relative air humidity, there was no statistical difference for eight of the nine days of evaluation among the heating systems (Table 2). In both sheds, values below the recommended range were found, which would be 60-70%, but are close to the comfort range. According to Baião and Cançado (1998) values of relative humidity of the air well below the recommended one can cause chicks mucosa dehydration in the first weeks of life and increase the risk of cardiac and pulmonary diseases, being therefore recommended to adapt the heating for the purpose of improve relative humidity levels as well as the handling of curtains.

Table 2. Daily mean values of relative humidity (RH%) in two heating systems for broiler chickens.

	RH (%)		
Days	Furnace	Drums	Environment
1	47.38^{a*}	51.84^{a}	63.37^{c}
2	49.43^{a}	37.50^{b}	62.94^{c}
3	57.29^{b}	47.97^{b}	66.39^{c}
4	58.31^{b}	50.35^{b}	65.52^{c}
5	58.37^{b}	52.23^{b}	67.02^{c}
6	58.60^{b}	55.86^{b}	68.84^{c}
7	58.86^{b}	56.20^{b}	65.25^{c}
8	59.95^{b}	53.98^{b}	62.73^{c}
9	59.95^{b}	57.15^{b}	62.99^{c}
VC		10.85	

*Averages followed by the same letter do not differ by Tukey's test ($p \leq 0.05$). Averages obtained from 96 daily observations.

For the THI variable, in the first days, the values found were above the recommended range, ranging from 72.4 to 80 for the first week of life of the birds and from 68.4 to 76 for the second week, according to Abreu & Abreu (2011). This shows that heating systems provided more energy than was necessary for birds. In the first three days, the values found were higher than those recommended for birds in both heating systems, and from the third to the seventh day if there was stabilization, where both systems remained within the ideal range, with statistical differentiation only in the last two days for the drum system (Table 3). However, in the second week of life in the Furnace system there was overheating, whereas for the drum system the calculated values were in the ideal range, showing that only the temperature alone may not be a good parameter for evaluating comfort for broilers.

Table 3. Daily mean values obtained for the THI variable in two heating systems for broilers.

	THI		
Days	Furnace	Drums	Environment
1	81.62b*	79.41^{b}	73.07^{a}
2	81.43^{b}	85.36^{b}	73.23^{a}
3	81.35^{b}	82.45^{b}	74.48^{a}
4	80.64^{b}	80.06^{b}	73.31^{a}
5	80.23^{b}	78.95^{b}	72.36^{a}
6	80.03^{b}	78.27^{b}	72.25^{a}
7	79.91^{b}	77.65^{b}	73.07^{a}
8	79.10^{b}	76.81^{ab}	72.52^{a}
9	78.84^{b}	76.69^{ab}	73.54^{a}
VC		3.66	

*Averages followed by the same letter do not differ by Tukey's test ($p \leq 0.05$). Averages obtained from 96 daily observations.

In relation to the animal's performance, differences between the birds submitted to the two heating systems were detected (Table 4). The feed intake of the poultry from shed 2 (Drum Heating) was higher than that of shed 1 (Furnace), as well as average weight gain. However, the feed conversion of poultry from shed 1 was better. This fact is probably due to the energy expenditure of birds in the maintenance of homeothermia in the face of the thermos environmental challenges to which they were submitted as evidenced in some indexes used.

Table 4. Animal's performance of poultry due to the thermal comfort provided by two heating systems.

Animal's performance		
	Furnace	Drums
Feed intake Kg lot^{-1}	7.890	4.530
weight gain $bird^{-1}$	0.247	0.256
Shed weight gain Kg lot^{-1}	5261.1	2713.3
feed conversion	1.50	1.67
Thermal comfort		
Tdb	31.315^a	31.154^a
RH	56.466^b	51.458^a
THI	80.355^b	79.521^a

*Averages followed by the same letter do not differ statistically from each other by the Bonferroni test ($p \leq 0.0001$).

In the area of thermal neutrality, the fraction of metabolizable energy used to balance the body temperature is minimal and the net energy of production is maximum. Regarding environmental variables and comfort index, the data were submitted to covariance analysis, and a significant difference ($p \leq 0.0001$) was detected by the Bonferonni test, showing higher heating to the drum system, which gave higher gain values of weight.

As the thermo-environmental conditions provided by the heating system of Shed 1 were closer to the comfort range, birds used less energy to maintain body temperature, positively reflecting flock performance. However, at the end of the evaluation period, the weight gain of poultry from Shed 2 was higher, despite the lower efficiency in converting ration to meat detected in Shed 1. Flock mortality of poultry heated with the drum system was higher than in the furnace system, corroborating the improved performance of the furnace system.

Conclusion

Depending on the variables dry bulb temperature and relative humidity of the air, the furnace heating system provided a closer environment to the comfort zone for birds.

The two heating systems evaluated in this study provided a thermal comfort, here evaluated through the THI that increased the animal's performance. However, the furnace system was more able to provide a distribution of heat which promoted a homogeneous heating in the cocoon.

In relation to the performance indexes of the birds, the animals heated by the drum system presented greater weight gain and higher final weight. On the other hand they consumed more feed individually, and worse feed conversion.

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