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Use of alternative tiles in the free-range broilers rearing: thermal environment, productive performance and physiological responses

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Abstract The physiological parameters and the productive performance of free-range broilers submitted to installations with different materials of tile composition were evaluated. 320 male broilers of the Vermelho Pesadão lineage were used, with an initial age of 35 days, distributed among the following treatments: 1) Fiber cement tile painted white on the outside; 2) Cardboard tile coated with double-sided canvas - black for the interior and white for the exterior; 3) Tetra Pak® box tile; 4) Tile of Tetra Pak® boxes covered with PET bottles. A completely randomized design was used, with 4 replicates per treatment and 20 broilers per experimental unit. The climatic environment was evaluated daily at 8, 10, 12, 14 and 16 hours. The productive and physiological parameters were evaluated every 7 days, the last ones being collected at 9 and 15 hours. In the afternoon, the highest values of air temperature and black globe temperature index and humidity were recorded, regardless of the materials evaluated. Fiber cement tiles and cardboard tiles coated with double-sided canvas showed the lowest values of climatic variables. There was no difference between the types of tile for the variables of productive performance and physiological parameters. It was concluded that the fiber-cement tiles painted white on the outside, and the cardboard coated with light canvas on the outside provided a better thermal environment inside the aviaries, which can be indicated for use in shelters for the creation of free-range broilers.

Keywords ambience, alternative poultry farming, productive performance, physiological parameters

1. Introduction

Industrial poultry in Brazil has been growing every year, keeping the country among the main producers and as the largest chicken meat exporter in the world (ABPA 2020). Parallel to this market, there is the alternative production of birds, which has been conquering its space, becoming a relevant activity for small and medium producers, from different regions of the country, both for subsistence and for commercial production. Despite the high power of production and commercialization of industrial broiler meat, there is still a portion of the population that identifies itself better with a diet coming from productions understood as more natural, where the growth of birds is much less intense, the welfare of birds it is more respected and the use of growth stimulants is not practiced (Cavalcanti 2019).

In the free-range breeding, own lines of slow growth are used, adapted to semi-intensive management. However, in tropical and subtropical climates, as is the case in Brazil, high temperatures and relative humidity are among the main factors that can interfere negatively in the creation, significantly altering the productivity of these birds. Their exposure to heat stress conditions causes decreased food consumption, impairing growth, carcass yield and meat quality, in addition to promoting production energy expenditure for heat loss, increasing respiratory rate and cloacal temperature (Amaral et al 2011; Cassuce et al 2013).

Once proven that the ability of birds in thermal exchange with the environment is strongly affected by the facilities (Abreu e Abreu 2011; Nascimento et al 2014), producers have been looking for alternatives that aim to improve the thermal conditions of the environment in which the animal is in order to reduce the negative effects of these environmental factors on production. From a bioclimatic point of view, roofs are one of the main factors that significantly influence the thermal environment of the installation, mainly due to the materials used in their manufacture (Silva and Sevegnani 2001).

Various types of tiles are available on the market, made from materials ranging from the most common, such as clay and fiber cement, to innovative ones, such as ecological tiles, each with its specific characteristics. However, due to the cost of these tiles, some research has been carried out with alternative materials such as vegetable tile, Tetra Pak® packaging, waste from toothpaste tubes and others (Fiorelli et al 2010; Cardoso et al 2011; Silva et al 2015

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). Another alternative would be the use of polyethylene terephthalate (PET) based packaging, which, in addition to helping to reduce the costs of installations, prevents these packaging from being mistakenly disposed of, contributing to the reduction of environmental pollution.

In this sense, seeking information regarding the efficiency of alternative materials in making roofing tiles for poultry houses can bring great benefits to the creation of free-range broilers, minimizing production losses due to thermal stress and providing the producer with an alternative that reduces the cost of installations, in addition to benefiting the environment, since the materials used in making the tiles are commonly released into nature causing pollution.

Given the above, the objective of this research was to evaluate the physiological parameters and the productive performance of free-range broilers submitted to installations with different materials of tile composition.

2. Materials and Methods

Animal care and handling procedures followed the guidelines of the Ethics Committee on the Use of Animals in Experiments of the Universidade Estadual de Montes Claros (Process N° 091/2015). The experiment was carried out at the experimental farm of the Universidade Estadual de Montes Claros (UNIMONTES), located in the city of Janaúba, Minas Gerais, with a duration of 50 days. The experimental area was composed of 16 paddocks of 60 m² each, equipped with a screened wooden aviary on its sides, with measures of 1.8 m in height x 1.50 m in depth x 1.50 m in width, positioned in the east / west direction. Each aviary was equipped with a tubular feeder and a pressure type (manual) waterer. Outside the aviary, in a covered area, a pendant water cooler was installed. The paddocks area was separated by screens and fence posts and covered on its surface by Tifton grass, and on its sides, there are rows of *Azadirachta indica* (Nim) trees for shading the area.

320 male free-range broilers of the Caipira Pesadão strain, 35 days old and average initial weight of 700g ± 0.68g, were distributed in a completely randomized design with 4 treatments and 4 repetitions, totaling 16 plots of 20 birds each.

For the climatic variables, a completely randomized design was adopted with 4 treatments (types of tiles) x 5 collection times, with 4 repetitions.

The densities used were 1 bird every 3 m^2 in the paddock and 10 birds in 1 m^2 in the aviary. The broilers received commercial rations, with the feeding program divided into 2 stages: 35 to 60 days (growth ration with 18% crude protein and 3150 Kcal/Kg of metabolizable energy) and 61 to 85 days (termination ration with 17 % of crude protein and 3200 Kcal/Kg of metabolizable energy). The water was made available at will and the ration was provided once a day. During the night, animals were collected from aviaries to prevent attacks by predators.

The treatments consisted of four types of tiles made with alternative materials (Figure 1) with measures of 2 m wide x 2.80 m long, being: TF = fiber cement tile (fiber cement tiles painted on the outside with paint white); TPL = cardboard tile + double-sided canvas (cardboard covered by double-sided plastic canvas, with the white part facing the outside area and the black part facing the inside); TTP = tile of Tetra Pak® boxes (Tetra Pak® type boxes, previously opened and washed, installed with the laminated part facing outwards); and TTPP = tile of Tetra Pak® boxes + PET bottles (Tetra Pak® type boxes, previously opened and washed, installed with the laminated part facing outwards, covered with tiles made with PET bottles, in color green).

Figure 1 Roofing materials used for making the tiles: A- Fiber cement; B- Cardboard covered with double-sided canvas; C- Tetrapak® boxes and D- Tetrapak® boxes covered with PET bottles.

To characterize the thermal environment, the dry bulb (Tbs) and wet bulb (Tbu) temperatures were collected during the period with a thermo-hygrometer and the black globe temperature (Tgn) with a mercury thermometer placed inside a black globe. The devices were installed at the height of the birds and the data collected manually, every two hours, starting at 8 am and ending at 4 pm. With data on climatic variables, the Black Globe Humidity Index (BGHI) was calculated using the following formula proposed by Buffington et al (1981):

$$BGHI = tgn + 0{,}36\,x\,Tpo + 41{,}5$$

where: Tpo is the dew point temperature (°C) and Tgn is the temperature of the black globe (°C).

The physiological parameters were evaluated every 7 days at 9:00 am and 3:00 pm by randomly selecting three birds per plot. Rectal temperature measurements were performed, using a digital clinical thermometer and the respiratory rate, by counting, with a stopwatch, the number of abdominal movements performed by the bird during 15 seconds (later being multiplied by 4 to obtain the value in minutes).

The performance evaluation of the birds was made through feed consumption, body weight gain and feed conversion. Feed consumption was determined at the end of each week by the difference in the weight of the feed supplied and the remaining feed in the feeders. The birds were weighed weekly and the number of dead birds was recorded to calculate the percentage of mortality. Feed conversion was expressed in terms of kilogram of feed consumed per kilogram of weight gain.

Climatic variables, physiological parameters and performance were subjected to analysis of variance through the computer program SISVAR® (Ferreira 2011). The differences between the means related to the performance variables were evaluated by the Tukey test and those related to the climatic variables were subjected to regression analysis, both at 5% probability.

3. Results and Discussion

There was an effect of the times on the studied variables, presenting quadratic behavior ($P < 0.05$). The highest values of air temperature were observed at 2 pm, with a maximum value of 33.7 °C. The relative humidity values were higher in the morning, with a marked reduction throughout the day. As the air temperature increased and the relative humidity decreased, consequently, the UTI values increased. Medeiros et al (2005) found that broilers raised in BGHI conditions between 69 and 77 have higher productivity and better production parameters. Therefore, the values observed in this experiment, after 10 am, were above what is recommended as ideal to provide thermal comfort for broilers.

There was a significant effect ($P < 0.05$) of the different types of tiles on air temperature and BGHI (Table 1). Regardless of the type of tile used, there was an effect of the times on all variables where the regression analysis showed a quadratic effect ($P < 0.05$). There was no significant interaction for the relative humidity of the air and ($P > 0.05$) between the types of tiles and times (Table 1).

The air temperature obtained inside the aviary with white painted fiber cement tile on the outside provided a better result than the Tetra Pak® box tile, not differing from the others. Tinôco (2001) states that the painting of the tiles with the white color is able to reduce the heat penetration inside the installations due to the increased reflection of solar radiation, since the white paint reduces the absorbance coefficient of the tile, reducing the temperature gradient and, consequently, the thermal flow into the installation. Tetra Pak® packages, also known as “long life”, are formed by several layers of different materials such as paper, low density polyethylene and aluminum (Pedroso and Zwicker 2007). This constitution makes it possible to absorb moisture by changing the thermal conductivity of the material.

For BGHI, fiber cement tiles painted white on the outside (TF) and cardboard + double-sided canvas (TPL) provided better results than the others. Matos Júnior (2012), working with mobile aviaries with different types of coverage, also obtained better results with TPL from 10 am to 2 pm with averages 75.03 and 77.42, respectively. According to Baêta and Souza (2010) painting a light colored surface, especially white, is a good way to increase reflectivity. Changing the radiation absorption coefficient by painting is a very simple and economical procedure, in addition to being an efficient way to mitigate the negative effects of radiation on a building, especially in hot seasons. The fact that the canvas has the clear part positioned to the outside also contributed to the reflectivity of the sun's rays, thus making it possible, with the fiber cement covering, to lower the UTI values.

Regardless of the type of tile used, the physiological variables of the broilers did not differ (Table 2).

Dias et al (2016), in a research on the evaluation of free-range chicken lines in the northern region of Minas Gerais reared in aviaries with fiber cement tiles, found higher rectal temperature values, but close to those of this study, with an average of 41.5 °C. According to the researched literature (Dionello et al 2002; Silva et al 2003; Nazareno et al 2011), the rectal temperature averages that characterize a comfort condition for broilers vary between 41 to 42 °C, values close to found in that work. This shows that, despite the adverse climatic conditions, the birds managed to maintain their internal temperature, showing that the strain used was shown to be adapted to the environment.

The results of the variables final weight, feed intake, weight gain, and feed conversion did not differ between treatments (Table 3). Madeira et al (2010) in a study with birds of the Caipira Pesadão strain found values of weight gain and feed consumption different from those of this work being 3.21 kg and 10.76 kg, respectively, similarly to Castilho et al (2013) who obtained an average weight gain of 2.69 kg. However, Dias et al (2016) found values closer to that of this

work for feed consumption (5.14 kg) and lower for feed conversion with an average of 2.94.

Comparing the performance results recommended by the Colonial Line Management Manual (Globoaves 2011) with those found in the present research, the birds obtained inferior performance. This may have occurred due to the handling, since for the composition of the aforementioned manual the birds receive feed at will and in the present work they were fed only once a day. The unique feeding forces the birds to make more use of the paddocks in search of other foods, resulting in a greater expenditure of energy and, consequently, a lower performance of them. However, this type of management is recommended for free-range birds, as it does not make them excessively fat, they present a firmer meat texture and better skin color. In addition, it avoids accumulation of fat in the carcass, with fat being an undesirable characteristic for the consumer (Mikulski et al 2011; Veloso et al 2014).

Table 1 Average values of temperature, relative humidity and BGHI, observed throughout the day inside poultry houses used for free-range broilers covered with different types of tiles.

Roof tile/ Climate variable	Schedules					Average	Prob
	8	10	12	14	16		
			Air temperature (°C)				
TF	24.65	27.71	31.17	32.42	30.81	29.35^{B}	0.049
TPL	24.90	28.23	31.92	32.79	30.79	29.73^{B}	
TTP	25.21	29.50	32.08	33.79	31.42	30.40^{A}	
TTPP	24.83	29.13	31.60	33.50	31.00	30.01^{A}	
Average*	24.90	28.64	31.69	33.13	31.01		
Prob			0.000				
CV (%)			4.00				
			Relative humidity (%)				
TF	70.34	56.35	43.68	41.89	48.09	52.06	0.062
TPL	66.17	54.74	43.58	39.71	42.38	49.31	
TTP	65.24	52.11	43.37	42.43	41.61	48.94	
TTPP	67.33	49.91	45.35	39.03	40.48	48.42	
Média**	67.27	53.28	43.99	40.76	43.14		
Prob			0.000				
CV (%)			9.13				
			BGHI				
TF	73.80	76.88	80.23	81.59	79.92	78.4^{B}	0.000
TPL	73.53	77.80	80.55	81.45	77.34	78.1^{B}	
TTP	78.28	82.68	85.43	89.05	83.83	83.8^{A}	
TTPP	78.32	82.19	85.93	86.87	83.23	83.3^{A}	
Média***	75.98	79.89	83.08	84.74	81.08		
Prob			0.000				
CV (%)			2.32				

TF: Fiber cement tile; TPL: Cardboard tile + double-sided canvas; TTP: Tetra Pak® box tile; TTPP: Tetra Pak® box tile + pet bottle; means followed by different letters in the same column differ by the Tukey test ($P < 0.05$); quadratic effect (*$\hat{Y}$= -12.565857-6.555607-0.238348x², R^2= 0.97; **$\hat{Y}$= 180.365375-19.664406x+ 0.692734x², R^2= 0.99; *** $\hat{Y}$=31.653321+7.85767x -0.296049x², R^2= 0.94).

Table 2 Average values of rectal temperature (RT) and respiratory frequency (RF) of free-range broilers raised in poultry houses with different types of tiles.

Variable	Tile type				CV (%)	Prob
	TF	TPL	TTP	TTPP		
TR (°C)	40.65	40.68	40.64	40.70	0.50	0.9739
FR	54.35	54.51	56.84	53.33	7.22	0.6487

TF: Fiber cement tile; TPL: Cardboard tile + double-sided canvas; TTP: Tetra Pak® box tile; TTPP: Tetra Pak® box tile + pet bottle.

Sarmento et al (2005), evaluating the influence of the external painting of the tiles with white paint on the productive performance of broilers, in sheds covered with fiber cement tile, observed that the white color of the external surface of the tiles was efficient in reducing the temperature of the internal surface of the roof and in providing thermal comfort indexes within the thermoneutrality zone as well as the productive indexes that were shown within the ranges considered ideal by the poultry industry in Brazil.

Melo et al (2012), in a research with female birds of the Label Rouge lineage raised in mobile aviaries with cardboard tiles coated with double-sided canvas, observed final weight and satisfactory weight gain. However, these were accompanied by high feed consumption and worsening of feed conversion, due to the fact that birds have free feed at their disposal throughout the day.

Table 3 Average values of final weight (PF); feed consumption (CR); weight gain (GP); and feed conversion (CA) of free-range broilers raised in aviaries with different types of tiles.

Variable	Tile type				CV (%)	Prob
	TF	TPL	TTP	TTPP		
PF (Kg)	1.88	1.90	1.94	1.91	3.58	0.715
CR (Kg)	5.69	5.69	5.71	5.71	0.39	0.377
GP (Kg)	1.39	1.41	1.41	1.44	4.75	0.769
CA	4.12	4.04	3.95	4.03	4.90	0.713

TF: Fiber cement tile; TPL: Cardboard tile + double-sided canvas; TTP: Tetra Pak® box tile; TTPP: Tetra Pak® box tile + pet bottle.

4. Conclusions

Although the different types of materials evaluated for making the tiles do not influence the physiological and productive responses of the broilers, it can be inferred that the fiber cement tiles painted white on the outside, and the cardboard coated with light canvas on the outside provided a better thermal environment inside the aviaries, which can be indicated for use in shelters for the creation of free-range birds.

Conflict of Interest

The authors declare that they have no conflict of interest.

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