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RESEARCH ARTICLE

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EFFECT OF COVERAGE AND WRAPPING ON ELECTRIC POWER CONSUMPTION IN POULTRY HOUSES IN THE WESTERN REGION OF THE STATE OF PARANÁ

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ABSTRACT

This work presents a literature review in order to assess the influence of different coverage and insulation on electric power consumption in two poultry houses, dark house model, located in the western region of the State of Paraná, Brazil. Designated as poultry house A1 and poultry house A2, installation A1 is characterized with trapezoidal aluzinc cover on the upper side interspersed with a layer of polyurethane and aluminized film on the lower side, while installation A2 presents aluzinc cover with black tarpaulin. The data related to electric energy consumption were obtained employing a magnitudes analyzer, and the values of temperature and internal and external relative air humidity were obtained through a thermohygrometer. Thus, it was possible to observe and compare the existing differences in the consumption of electrical energy in the two facilities. Finally, it can be noted that the A1 poultry house, with thermal insulation in the roof, showed lower consumption of electrical energy recorded in a period of seven days during the housing of the birds, and also values for internal average temperature and internal average relative humidity closer to those considered as ideal by the literature.

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INTRODUCTION

Poultry production worldwide presented high rates in 2015, reaching a production of 88,010 million tons of chicken meat. The highlight of world production was the United States of America, followed by Brazil and China. In addition to the high production performance, Brazil stands out as the main exporter of chicken meat. The 2015 records show that the country was responsible for the export of 4,304 million tons, with the State of Paraná as the one with the best performance (ABPA, 2016a). Given this scenario, knowledge of the factors that influence this activity is essential to ensure a satisfactory production and reduced costs (Ponciano *et al*., 2011). The great challenge of the poultry sector is related to animal welfare, especially the thermal issues of poultry since the birds usually consume the energy provided by the food to compensate for the thermal variations they suffer concerning the environment.

The animal submitted to a stressful environment begins to have changes in internal functions and may present reduced growth, loss of nutrients, low resistance to diseases, and changes in respiratory rate (Baêta & Souza, 2010). Therefore, when not reaching their thermoneutral zones, the birds require from their metabolism the maintenance of body temperature to sustain or eliminate heat and thus require climatization and cooling systems, which directly reflect the consumption of electrical energy of the facilities (Belusso & Hespanhol, 2010; Nazareno *et al*., 2009). According to Belusso & Hespanhol (2010), temperature control in buildings is seen as the most significant management difficulty in the breeding of broiler chickens, due to the variations that should occur in the environment as the birds develop. Furlan & Macari (2008) point out that, for one-day-old chicks, the thermoneutral zone in buildings should be 33ºC to 35ºC. As for ten to fifteen days of life, the temperature belonging to the thermal comfort zone is reduced to 24ºC to 33ºC and, finally, after the sixth week, to 21ºC to 22ºC. Bridi (2007) highlights that the state of thermal comfort is related to environmental characteristics such as climate, ventilation, radiation, and humidity, in addition to aspects such as age, weight, feeding level, physiological and genetic state. Even though the technological advances provide the creation of environments with artificial climatization, it is still frequent the event of broiler mortality due to high temperatures. This is due to the insufficiency of climatization systems that require a constant power supply (Belusso & Hespanhol, 2010). Given the effects of climate change, along with socio-environmental issues, there is a need to consider renewable energy sources associated with bioclimatic principles (Schutte, 2014).

According to Bueno & Rossi (2006), the researches with emphasis on the rational use of electric energy are growing. Results demonstrate competence regarding the energy efficiency associated with the thermal comfort of broilers, which affect the higher density of animals, and as a result, raise productivity. Amid this search for the reduction of environmental impacts and for new technologies that minimize the use of fossil fuel energies (Silva, 2012 apud Santos & Siqueira, 2012), it also emerges the need to explore management options to reduce the thermal stress (The Poultry Site, 2008). In this sense, the choice of a suitable construction system has a strong potential in terms of heat control and ventilation in poultry facilities. According to Tinoco (2001), a shed elaborated from the local characteristics emerges from the architectural concept that aims to use the natural resources of the area, such as the use of natural ventilation, adjacent landscaping, water availability, solar availability and types of construction materials. Above all, regarding the cover elements, since the roofs represent one of the factors with greater influence on the thermal load in the poultry houses, due to the area range that receives solar radiation (Silva & Sevegnani, 2001). However, it is worth mentioning that such measures do not inhibit secondary modifications regarding the management of the internal environment, starting from the use of equipment that provides ventilation, heating, and artificial cooling (Curtis, 1983 apud Tinoco, 2001).

Poultry facilities are characterized by the variability of technologies and operating systems adopted in poultry houses. They can be classified into conventional, semi-climatized, or automated, climatized, dark house and blue house systems (Garcia & Ferreira Filho, 2005; Abreu & Abreu, 2010 apud Abreu & Abreu, 2011). The dark house type poultry adopts the use of controllers that perform functions in all internal sectors; thus, the use of the generator in this system is indispensable.

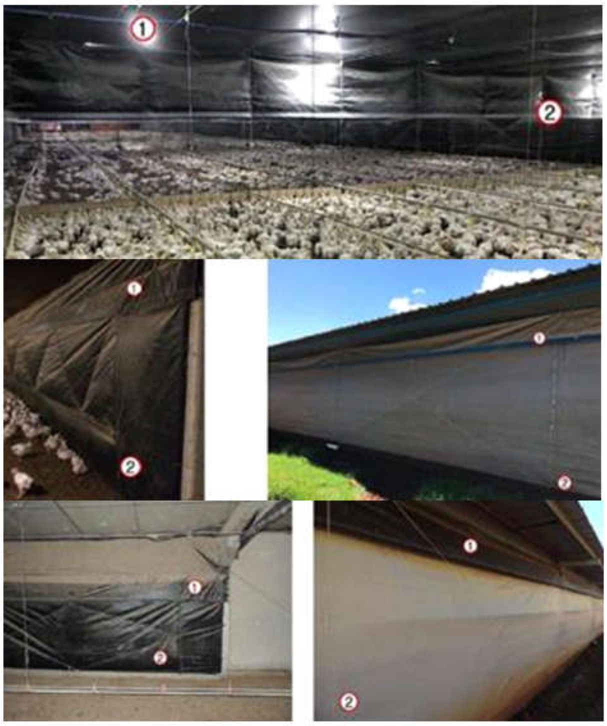
The feeders are automatic, and the drinkers are nipple system. As for cooling, nebulization, or pad colling associated with negative pressure exhaust fans can be used. The use of deflectors may or may not occur. The lighting system is performed by the use of dimmers, and the curtains, black polyethylene on one side and silver on the other, are completely sealed, not allowing light and air to enter (Abreu & Abreu, 2011). According to Glatz & Pym (2007), poultry production in controlled facilities generally provides superior performance when compared to birds produced in naturally ventilated environments, and this is because the optimal thermal comfort conditions of birds can be maintained.

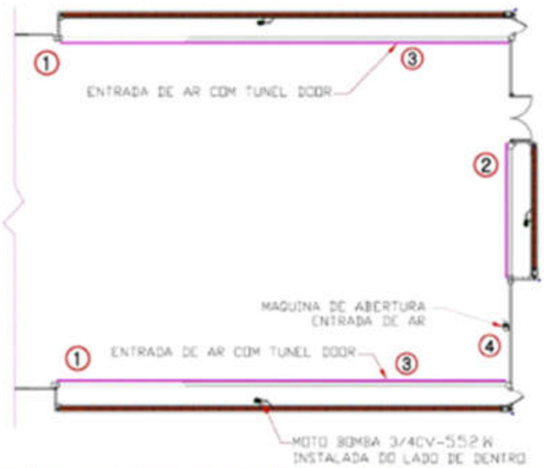
Therefore, this research aims to assess the electric energy consumption of two poultry houses of the dark house system, one with aluzinc coverage and tarpaulin lining and the other with thermoacoustic roofing tiles, and then consolidate the data serving as a contribution for producers, poultry project managers and other professionals in the sector.

MATERIAL AND METHODS

Location of experiments: Located in the city of Missal, in the western region of the State of Paraná, the broiler poultry houses are of the dark house system and belong to the same integrator. The poultry house named A1 is located in the geographic coordinates identified by latitude 25º3'15" to the South and longitude 54º15'40" to the West. While the poultry named A2 is located in the geographical coordinates described by latitude 25º4'48" to the south and longitude 54º11'32" to the West. The climate of the municipality, according to the Koppen and Geiger classification, is warm and temperate of the type Cfa. Rainfall rates are significant throughout the year, where the annual average is 1734 millimeters, and the average temperature is 20.2ºC (Climate Data Org, 2017).

Constructive characteristics of the poultry houses: By visiting on-site, it can be noted that the constructive characteristics of the poultry houses demonstrate similarity. Both the A1 poultry house (Figure 01) and the A2 poultry house (Figure 02) have 16x150 meters in size, totaling 2,400 square meters of area appropriate for the development of birds. The two poultry houses shelter animals with mixed-sex of the Cobb Slow lineage, but the A1 poultry house accommodates 31,500 birds while the A2 poultry houses 33,600 birds. The facilities start from the use of a precast concrete structure, formed by pillars arranged in 30 spans with a 5-meter distance, sealing in the masonry of ceramic tiles and a beaten earth floor with an overlapping bed of wood shavings (maravalha). Figure 1. West-east elevation of poultry house A1. Detail of the front facade. (1) Pad cooling. (2) Slaughterhouse maintenance door (3) Pad cooling access door (4) Precast concrete structure. Figure 2. East-west elevation of the A2 poultry house. Detail of the front facade. (1) Pad cooling. (2) Entrance door. The insulation system that accompanies the sealing of the poultry houses is composed of a black curtain on the inner face and silver on the outer face with a Y-type band (Figure 03). However, the A2 poultry house, in addition to the black curtain with a Y-type band, also has a black and silver eaves on the inner and outer face, respectively (Figure 04). Figure 3. A1 poultry house side sealing. Detail of the side sealing. (1) Black Y-type band (2) Curtain black-silver (internal face-external face). Figure 4. A2 poultry house side sealing. Detail of the side sealing. (1) Y-type band with black and silver eaves (internal face-external face) (2) Curtain black-silver (internal face-external face). Regarding the coverage system, the poultry house A1 presents thermoacoustic roofing tile of trapezoidal aluzinc TRP 35, on the upper side, interspersed with a layer of polyurethane with a density of 36 to 42 kg/m3 and aluminized film on the lower side (Figure 05). On the other hand, the A2 poultry house has trapezoidal aluzinc TRP 40 tile with black tarpaulin lining (Figure 06). Finally, the poultry house A1 has air reflectors in a triangular shape in black tarpaulin, which accompanies the slope of the roof, keeping the free ceiling height with 2.85 meters.





Furthermore, the A2 poultry house has air reflectors in a rectangular shape with 1.10 meters in black tarpaulin with a free ceiling height of 2.80 meters. Adjacent to the facilities are the support environments such as the control room, home of the heating and cooling system, and storerooms of equipment used for maintenance. Figure 5. Coverage system of poultry house A1 - thermoacoustic tile. (1) Lower layer of thermoacoustic tile-aluminized film (2) Air reflector in a triangular shape (accompanies the slope of the roof) in black tarpaulin. Figure 6. Coverage system of the A2 poultry house - aluzinc tile with tarpaulin lining. (1) Black tarpaulin lining (2) Rectangular black tarpaulin air reflector.

Technical characteristics of poultry houses

Poultry house A1: The building control system is based on an Inobram SMAAI 4 controller panel, which defines the ideal temperature and humidity according to the bird's lifetime. The controller is connected to the probes, the alarm, the heating, cooling,\ventilation, nebulizers, the nutrition system and operates at consumption of 0.2 hp. The heating system is based on the Agrobona AB 38-00 wood-fired oven, which is powered by two 4 hp engines. The cooling system consists of Big Dutchman nebulizers driven by a 2 hp engine. In addition to the nebulizers, the poultry house has a pad colling system, also of the Big Dutchman brand, with evaporative cellulose panel arranged on three sides of the installation, but only two are in use (Figure 7 and 8). Moreover, they are equipped with a motor pump with the power of 3/4 hp. Figure 7. Cooling system-Pad cooling. Distribution sketch. (1) Active evaporative pad cooling panels, (2) Disabled evaporative pad cooling panel (3) Tunnel door ventilation system (4) Tunnel door opening machine for air intake.

Figure 8. Cooling system-Pad cooling. Cellulose evaporative panel side view. (1) Cellulose plates (2) Hydraulic net of the pad cooling system, (3) 1-meter eaves in trapezoidal aluzinc tile TRP 35. There is also the air intake opening machine, responsible for the tunnel door ventilation system, which is moved by a 3/4 hp motor and automatically activated when the controller identifies the temperature variation. The equipment works in conjunction with the exhaust fans, which are arranged on both sides of the installation (Figure 9). Each side has five Big Dutchman exhaust fans, model 50" 70th with cone. Each device is handled by a 1.5 hp motor (Figure 10).).

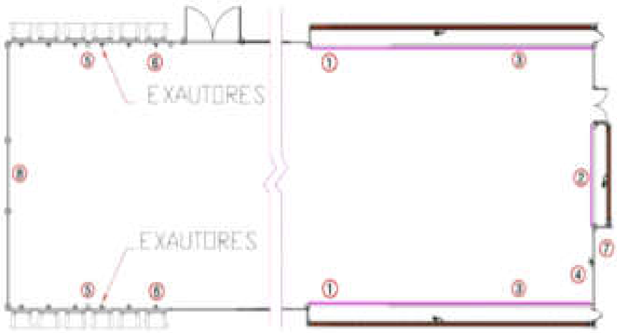


Figure 9. Ventilation system-Exhaust fans. Distribution sketch. (1) Active evaporative pad colling panels (2) Disabled evaporative pad colling panel (3) Tunnel door ventilation system (4) Tunnel door opening machine for air intake (5) Exhaust fans (6) Possible expansion exhaust fans (7) Main facade (8) Back facade

Figure 10. Ventilation system - Exhaust fans. Face 1 - External view. (1) Side access door (2) Space for the possible implementation of a new exhaust fan (3) Exhaust fans in operation.

The lighting system is composed of American LED dimmable lamps, with 8 Watts of power each. The distribution occurs with four lamps arranged in 30 lines, totaling 120 lamps. The Inobram I-8000 dimmer, installed to control and adjust the internal temperature, is connected to the controller and has a 220 Vca 50/60 Hz power supply, with a consumption of 5 Watts. Distributed in four lines, the HI-LO automatic feeders are Big Dutchman, Unigrow 360 model, and total 1,000 dishes. The primary distribution line has a traction/engine set moved by a 1 hp engine, and each line has a set operated by a 1 hp engine, having a total of 5 hp. There are also in the nutrition system, the Big Dutchman drinkers, model 4078, which are arranged in five lines totaling 3,250 nipples. The water supply in the installation comes from the artesian well. A 5 hp engine pumps the water to the polyethylene tank with a capacity of 20,000 liters. Finally, the poultry house has a synchronous generator system of the Nova brand three-phase NEW BEI line, which assists in the maintenance of the poultry house in case of power grid failure (Figure 11). The activation is manual and requires an agricultural tractor as the driving force.

Figure 11. Nova brand three-phase New Bei line synchronous generator system

Poultry house A2: Similar to the A1 poultry house, the installation control is performed through a control panel of the brand Inobram SMAAI 4, connected to the other systems, and which works at consumption of 0.2 hp. The heating system takes place through a wood-fired oven, model Agrobona AB 2614, powered by two 4 hp engines. As in the A1 poultry house, the cooling system is formed by Big Dutchman nebulizers that control the internal temperature and humidity and are operated by a 2 hp engine. There is also the pad colling system, also of the Big Dutchman brand, with evaporative cellulose panel and distributed on three sides of the building, which have a motor pump with 3/4 hp power for operation (Figure 12).

Figure 12. Cooling system - Pad cooling - Face 3

The pad cooling system is integrated into the manual activation of the curtains that assist the air intake (Figure 13). The A2 poultry house also has five exhaust fans arranged on each side of the installation. The equipment is of the brand Big Dutchman, model 50" 70th with cone, and each one is moved by an engine of 1.5 hp (Figure 14). Like the A1 poultry house, the A2 poultry house lighting system is made up of American LED dimmable lamps, with 8 Watts of power each. The distribution occurs with four lamps arranged in 30 lines, totaling 120 lamps.

Figure 13. Cooling system - Pad cooling with air control performed with manual activation of the curtains

To control and adjust the internal temperature, the Inobram A-15000 dimmer is interconnected to the control system, and its power supply is 127 to 254 VAC 60Hz, with a consumption of 5 Watts. The nutrition system is based on the distribution of four lines of Avioeste automatic feeders, model Corti Sintese, totaling 778 dishes. The primary distribution line has a traction/motor set moved by a 1 hp engine, and each line has a set operated by a 1 hp engine, totaling 4 hp. The drinkers are Avioeste, model 4006H, and are distributed in five lines totaling 2,807 nipples. As with the A1 poultry house, the water supply in the installation comes from the artesian well, and a 5 hp engine pumps the water to the polyethylene tank with a capacity of 20,000 liters. The poultry facility has a Stemac generator system that assists in the maintenance of the facility in case of power grid failure. The control unit follows the DS 7320 model, and its activation is automatic and makes use of diesel oil (Figure 15).

Figure 14. Ventilation system - Exhaust fans. Face 3 - Internal view. (1) Exhaust fans in operation, but not active

Characterization of the electric energy measurement system of the poultry houses: The A1 and A2 poultry houses have a power supply system through the Copel concessionaire and fall within the rural B2 subgroup. The two poultry houses present a three-phase energy standard with a Landis Gyr meter (Figure 16).

Figure 15. Stemac generator system

Figure 16. (1) Poultry house A1. Electronic energy meter Landis Gyr model Saga 1500 (2) Poultry house A2. Landis Gyr model E34A polyphase electronic meter

Technical specifications of the energy analyzer used to collect electrical energy consumption data from poultry houses: The analyzer of electrical quantities used to determine the consumption of electrical energy in poultry houses was the Embrasul RE7080 (Figure 17). The electrical characteristics and the measurement parameters are presented in tables 1 and 2, respectively.

Figure 17. Embrasul RE7080 Power Consumption Analyzer. Source: EMBRASUL, 2015

Technical specifications of the thermohygrometer used to measure temperature and relative humidity inside the poultry houses: We used an Istrutherm THDL - 400 Environment Meter thermohygrometer to measure the internal temperature and relative humidity inside the facility. The relative humidity measurement sensor allows values in the range of 25% to 95% to be measured. The temperature sensor provides values in the range of 20º C to 750º C (Figure 18).

Figure 18. Istrutherm THDL - 400 Environment Meter thermohygrometer

Method of measuring the internal and external temperature and relative humidity of the environment: Along the 150 meters of extension of the A1 and A2 poultry houses, 16 points were demarcated, every 10 meters, in order to collect the data regarding the temperature and internal and external relative humidity of the air. For the collection of the temperature and relative humidity of the facilities, two operators were arranged, one inside and the other outside, simultaneously equipped with a THDL - 400 thermohygrometer, to record the values, in triplicate, at the 16 points and 1-meter height from the floor level. Based on the measurements, it is possible to trace an average temperature per point and, subsequently, an average temperature per day of data collection. In table 3 it is possible to verify the information pertinent to the dates and age of the birds during data collection.

Method of measuring electrical energy in poultry houses; The electrical energy consumption data were determined using the electric energy analyzer RE7080 of Embrasul brand, which was installed in the poultry houses for a period of seven days during the housing of the birds in December and January, since they are the months with the most significant impact in terms of electric energy required for the maintenance of the systems inside the facilities (Figure 19).

Figure 19. Electrical energy analyzer properly installed in poultry houses (1) A1 and (2) A2 respectively

For the measurement of the electrical quantities, the energy analyzer was installed in the two phases (R and S) of the control panel. The inserted equipment obeys the correct order of the power transducers (TP's) and current transducers (CT's) connected in their respective phases. In the A1 poultry house, information regarding energy consumption was collected between 12/13/2017, from 11:35 AM until 12/20/2017 at 09:02 AM, characterizing the first week of the bird's life. In the A2 poultry house, the data were obtained between 20/12/2017 from 10:56 AM until 27/12/2017 to 12:09 AM, representing the third week of the bird's life. Based on the survey data and the number of birds housed in each poultry house, the consumption of electricity per bird was calculated. The values obtained were compared between the facilities in order to determine which poultry house had the lowest specific energy consumption.

Data analysis: The present research sought to assess the effects of the types of coverage and wraps on the electrical energy consumption of the A1 and A2 poultry houses. From the information collected regarding the energy consumption per housed chicken, it can be analyzed how the behavior of the specific electrical energy consumption occurred in each building. We used the Excell software for the organization of data in spreadsheets and preparation of graphs and analysis of the coverage and wrapping effect in the consumption of electrical energy in the poultry houses. On the other hand, the information gathered regarding the internal and external temperature and relative humidity in the facilities was submitted to the analysis of the coefficient of variation.

RESULTS AND DISCUSSION

The average values of temperatures (ºC), and relative humidity (%), internal and external, obtained for the poultry house A1 and A2, through the thermo-hygrometer, can be observed in table 4. Table 4: Temperature and average internal and external relative humidity in the A1 and A2 poultry houses during the first three weeks of housing the birds. When considering the interaction of data between the two poultry houses, it can be observed that the behavior of the average

Table 1. Measuring parameters of the electric energy consumption analyzer - electrical characteristics

Electrical Characteristics	
Auxiliary power supply or by voltage measurement	
Vac Range:	70 s 300Vac (Phase/Neutral)
Vdc Range:	100 to 300Vdc
Consumption:	5VA
Voltage input	
Number of entries:	3 (VA, VC, VC) or 4 (VA, VB, VC, VN)
Consistency range:	50 a 300Vac (Phase/Neutral) 519V (F/F)
Resolution:	0,01V
Precision:	0,2%
Voltage overload:	+ 10% maximum value for 1 second
Band impedance:	2MΩ
Bandwidth:	1500Hz
Current inputs	
Number of entries:	3 (IA, IB, IC) or 4 (IA, IB, IC, IN)
Type:	Flexible sensor or rigid pliers
Measuring range:	With flexible sensor: 5A to 3000A With AL100 rigid pliers: 0.05A to 100th With AL1000 rigid pliers: 5A to 1000A
Resolution:	0,01A
Precision:	0,2% + precisão do sensor de corrente
Bandwidth:	1500Hz
Nominal frequency	
Frequency:	45 to 70Hz
Resolution:	0,01Hz
Precision:	+/- 0,01Hz
Wiring Combinations	
Single-phase:	2F
Biphasic:	2F, 3F
Three-phase:	3F, 4F e 5F

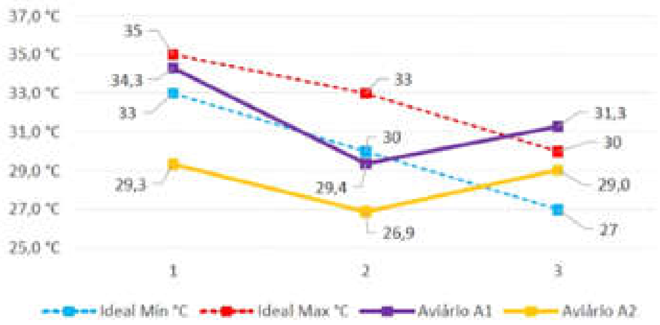
Table 2. Measuring parameters of the electric energy consumption analyzer - Measured parameters

MEASURED PARAMETERS	
Voltages:	By phase and three-phase
Current:	By phase and three-phase
Imbalances:	Percentages of imbalances between voltage phases (NEMA and IEC)
Powers:	Active, reactive and apparent by phase and totals
Power accuracy:	+/- 0.5% + current sensor accuracy
Power factor:	Inductive and capacitive
FP Range:	0.001 to 1 inductive and 0.001 to capacitive
FP Precision:	+/- 0,5%
Displacement factor:	Inductive and capacitive
FP Range:	0.001 to 1 inductive and 0.001 to capacitive
FP Precision:	+/- 0,5%
Distortions:	DHTi, DHTv, TDD, DHT GLOBAL

Table 3. Dates and age of the birds during the period of data collection of temperature and relative humidity inside and outside the poultry houses A1 and A2

		WEEK		
		1	2	3
Poultry A1	Accommodation date 13/12/2017	16/12/17	20/12/17	04/01/18
	Age of Birds (Days)	4	8	23
Poultry A2	Accommodation date 15/12/2017	23/12/17	27/12/17	04/01/18
	Age of Birds (Days)	9	13	21

external temperatures recorded 37 ºC for the A1 poultry house and 28 ºC for the A2 poultry house, representing the first week of information collection, while the average internal temperatures were 34.3 ºC for the first week of the birds' life, in A1 poultry house, and 29.3 ºC for the second week of the birds' life in A2 poultry house. Based on the principle that the poultry house that favors the development of the chick in the room temperature of thermal neutrality according to age has better thermal performance, it is possible to note that the A1 poultry house had an average internal temperature, for the first week of data collection, closer to those considered ideal when related to the parameter of 33 °C to 35 °C. In contrast, the A2 poultry house presented values slightly below the recommended values of 30 °C to 33 °C (Macari; Furlan, 2001 apud Bedin, 2015). For the second week of collection, the average external temperatures presented 27.5 ºC and 26.3 ºC for the A1 and A2 poultry houses, respectively. On the other hand, the internal average temperatures were 29.4 ºC for the A1 and 26.9 ºC for the A2 poultry, both for the second week of the bird's life. Following the parameters of 30 ºC to 33 ºC (Macari, Furlan, 2001 apud Bedin, 2015), it was found that the two poultry houses had values below the recommended conditions for the development of the bird.



However, it can be observed that the average internal temperature collected in the A1 poultry house has more proximity to the minimum ideal value. In the third week of data collection, the behavior of the average external temperatures showed 33.8 ºC for the A1 poultry house and 31.1 ºC for the A2 poultry house. As for the internal average temperatures, the data obtained in the third week of the bird's life, in the A1 poultry house was 31.1 ºC and for the A2 poultry house was 29.0 ºC. Thus, observing the concepts of 27 ºC to 30 ºC (Macari, Furlan, 2001 apud Bedin, 2015), it was found that the A2 poultry house met the desirable values for the development of the bird in accordance with the age. Finally, analyzing the variation of the average internal temperature recorded in the poultry houses (Figure 20), during the three weeks of collection, with the comparison of the recommended values according to Macari and Furlan (2001 apud Bedin, 2015), it can be noted that the A1 poultry house has demonstrated an internal average temperature closer to those considered as ideal.

Figure 20. Variation of the average internal temperature recorded in poultry houses A1 and A2, over the three weeks of data collection, with a comparison of the values considered as ideal When considering the interaction of the data regarding the average relative humidity collected in the poultry houses, it can be observed that the A1 poultry house registered 64.4%, 78.8%, and 63.3%, and the A2 poultry house registered 78.7%, 82.3% and 68.4% in the first, second and third week of survey, respectively. According to Abreu & Abreu (2011), the values for the relative humidity of the internal air considered as ideal during the seven-week life cycle of the bird are from 60% to 70%. Thus, the A1 poultry house presented a value closer to the recommended conditions when compared to the A2 poultry house, in the first week of data collection. In the second week the poultry houses showed higher values than those pointed out in the literature and ultimately, in the third week both fell within the suggested parameters, being that the value collected from poultry house A1, 63.6%, was closer to the average considered as ideal, while that of poultry house A2 indicated a value closer to the maximum recommended relative humidity of 68.4 ºC. According to Nascimento (*et al*., 2012), the birds dissipate heat through evaporation, which in turn depends on the relative humidity of the air. Thus, when the relative humidity of the environment is high, the bird starts to change the maintenance process of homeothermy by dissipating the air through the airways, thus causing a higher respiratory rate, which may compromise its performance. Therefore, it can be concluded that the A1 poultry house showed a relative internal humidity average closer to those considered as ideal. In figure 21, the variation of the internal relative humidity registered during the three weeks in the poultry houses can be visualized together with the comparison of the values considered as ideal, according to Abreu and Abreu (2011).

Table 4. Temperature and average internal and external relative humidity in the A1 and A2 poultry houses during the first three weeks of housing the birds

	External				Internal			
	Temperature (ºC)		Relative humidity (%)		Temperature (ºC)		Relative humidity (%)	
Week	A1	A2	A1	A2	A1	A2	A1	A2
1	37.0	28.0	33.0	84.7	34.3	29.3	64.6	78.7
2	27.5	26.3	83.9	84.6	29.4	26.9	78.8	82.3
3	33.8	31.1	41.1	46.0	31.3	29.0	63.6	68.4
Average	32.8	28.5	52.7	71.7	31.7	28.4	69.0	76.4
Standard deviation	4.8	2.5	27.4	22.3	2.5	1.3	8.5	7.2
C.V. (5)	14.7	8.6	52.0	31.1	7.9	4.7	12.4	9.4

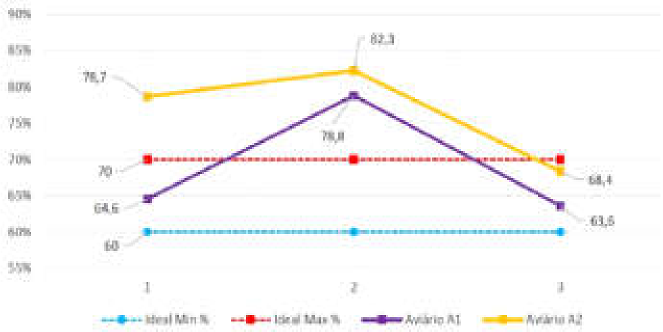


Figure 21. Variation of the average internal relative humidity recorded in the A1 and A2 poultry houses, over the three weeks of data collection, with a comparison of the values considered as ideal. Regarding electricity consumption, the data obtained for poultry houses A1 and A2 recorded through the electricity consumption analyzer in seven days, presented values of 377.074 KWh and 438.398 KWh, respectively. Thus, it can be concluded that the A1 poultry house, which has thermal insulation in the roof, presented lower energy consumption than the A2 poultry house, without thermal insulation. When the electric energy consumption data is related together with the number of birds housed in the facilities, being 31,500 birds for the A1 poultry house and 33,600 birds for the A2 poultry house, the values of 0.0120 kWh/bird and 0.0130 kWh/bird were observed, respectively. Even though the outdoor climate in the A1 poultry house has higher temperatures than the A2 poultry house, its electricity consumption was lower. As described by Rovaris (2015), when comparing the consumption of electricity between two poultry facilities, both of them in the dark house system, one with 1,800 square meters with fiber cement roofing tiles without thermal insulation, called scenario 1, and the other with 2.100 square meters with aluzinc roofing tiles with thermal lining and walls with polystyrene thermal insulation, called scenario 2, the consumption data were 4510.94 kWh of electric energy and 0.2078 kWh/housed bird, and 3756 kWh of electric energy and 0.134 kWh/housed bird for scenario 1 and 2 respectively. Thus, it can be noted that scenario 2, being the poultry house with thermal insulation on the roof, presented lower consumption of electrical energy.

CONCLUSION

According to the data obtained, under the conditions in which the experiment was performed, the following conclusions can be determined: the A1 poultry house, with thermal insulation in the roof, presented internal average temperature closer to those considered ideal by the literature, presenting the values of 34.3 °C, 29.4 °C and 31.3 °C for the first, second and third week of data collection, respectively, while the A2 poultry house, without thermal insulation in the roof, presented the values of 29.3 °C, 26.9 °C and 29.0 °C. In addition, it was the A1 poultry house that also presented the best conditions regarding internal relative humidity with recordings of 64,.4 %, 78.8 % and 63.6%, while the A2 poultry house showed values of 78.7 %, 82.3 % and 68.4 % for the first, second and third week of data collection, respectively. As for the lower consumption of electrical energy recorded for seven days during accommodation, the A1 poultry house also showed higher viability with consumption of 377.074 KWh, being 0.0120 kWh/bird housed, as the A2 poultry house presented a consumption of 438.398 KWh, being 0.0130 kEh/bird housed.

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