IMPACT OF DIFFERENT LIGHT SOURCES ON BROILER REARING ENVIRONMENT

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ABSTRACT: Broiler production is highly dependent on the use of artificial light. The light source may affect the effectiveness of housing conditions due to increasing ambient temperature and concentration of noxious gases. This research aimed to evaluate the effects of different bulb types on the thermal, aerial, and acoustic environment of broiler aviaries. The experiment was carried out at a commercial broiler farm in Dourados, Mato Grosso do Sul State, Brazil. Three aviaries were used, and two flocks of male broilers from Cobb® genetic strain were reared from the first day to slaughter. Each aviary was equipped with a different light source, comprising the adopted treatments (A1 - incandescent light bulb, control; A2 - sodium vapor light bulb; A3 - fluorescent light bulb). The aviaries were divided into nine quadrants, and the environmental data (ambient dry bulb temperature and relative humidity), litter surface temperature, CO_2 and NH_3 concentrations, and bird sound pressure behavior were recorded in each quadrant. The aviary with incandescent light presented higher air and litter temperatures, and concentration of gases than the other tested alternatives. It also presented higher level of sound pressure in the second week of the growing period; however, from this period up to slaughter, there was no effect of the light source on the results of broiler sound pressure level.

KEYWORDS: poultry industry, gas concentration, lighting, temperature.

IMPACTO DA FONTE DE ILUMINAÇÃO NA AMBIÊNCIA DE AVIÁRIOS PARA FRANGO DE CORTE

RESUMO: A produção de frangos de corte é altamente dependente do uso de luz artificial. A fonte de luz pode influenciar a eficiência do ambiente de alojamento, devido ao aumento da temperatura ambiente e da concentração de gases nocivos. A pesquisa teve como objetivo avaliar os efeitos do uso de diferentes tipos de lâmpadas em aviários de frangos de corte, sobre o ambiente térmico, aéreo e acústico. O experimento foi realizado em uma fazenda comercial no Município de Dourados, MS, Brasil. Três aviários foram utilizados e dois lotes de frangos machos da linhagem Cobb® foram criados a partir do primeiro dia até o abate. Os aviários foram equipados com uma fonte de luz diferente, sendo cada um deles um tratamento adotado (A1 - lâmpada incandescente, controle; A2 - lâmpada de vapor de sódio misturado; A3 - lâmpada fluorescente). Os aviários foram divididos em nove quadrantes e os dados ambientais (temperatura ambiente de bulbo seco e umidade relativa), a temperatura da superfície da cama, as concentrações de CO_2 e NH_3 e o comportamento da pressão sonora de aves foram registrados dentro dos quadrantes. O aviário usando lâmpada incandescente apresentou maior temperatura do ar e da cama, bem como o aumento da concentração de gases, do que as alternativas testadas. Este também apresentou maior nível de pressão sonora na segunda semana do período de crescimento dos frangos, no entanto, desta idade até o peso de abate, não foi encontrada nenhuma influência da fonte de luz sobre os resultados do nível de pressão sonora das aves.

PALAVRAS-CHAVE: avicultura, concentração de gases, iluminação, temperatura.

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INTRODUCTION

Several schemes using different light intensities have been proposed for broiler rearing with the aim to provide adequate environmental conditions, thus improvement in weight gain, feed conversion, superior carcass quality, and lack of metabolic alterations (OWADA et al., 2007). In broiler housing, the photoperiod is related to the number of lighting hours (natural and/or artificial), while the luminous intensity is associated with the sensitivity of light perception by birds, usually measured in lux (MENDES et al., 2010).

The poor rearing environment is one of the factors that may lead to the development of respiratory disease in birds (CURTIS, 1983). Variations in temperature and humidity during broiler rearing, associated with excessive dust and ammonia, inadequate ventilation, high stocking density, and, generally, negligent cleaning and disinfection of sheds, are mentioned in the literature as factors that affect the pathogenesis of these diseases (CASTRO, 1999).

Although there is available information in the literature related to the use of lighting programs for broiler chickens (MORAES et al., 2008; LEWIS, 2010), little is known about the effect of the light source on the thermal conditions and air quality in broiler housing. As the thermal environment influences the ammonia concentration inside poultry houses, it is necessary to know more about the light source effect on this aspect of the air environment and broiler performance. The ammonia gas irritates mucous membranes of the eyes and respiratory tract, and later, when it falls into the bloodstream, has a harmful effect on the physiological metabolism, negatively impacting bird welfare (CURTIS, 1983; COUFAL et al., 2006).

This research aimed to evaluate the impact of different light sources on the thermal, aerial, and acoustic environment of broiler aviaries.

MATERIAL AND METHODS

The experiment was carried out from May 2011 to September 2012 at a commercial broiler farm, located in Dourados, Mato Grosso do Sul State, Brazil (21°34' S, 54°55' W, and 532 m altitude). Three aviaries with the same dimensions were adapted for broiler growing under three treatments (A1, A2 and A3) (Table 1); two consecutive flocks were studied. The aviaries were 12 m wide, 100 m long, and 2.7 m high. The open sides had a 0.35 m wall, with a polypropylene curtain, which could close the sides, allowing the management of natural ventilation. The aviaries had nipple drinkers and automated feeders. There were 18 fans (0.5 HP, 60 Hz engine, three blades, 1.00 m diameter) in each aviary, distributed every 15 m along the house in three parallel lines, which were manually turned on and off, with mean flow of 1.2072 m^3/h. Fogging was performed by two pipelines along the houses, with 28 nozzles per line. The roof was made of fiber cement tiles on a metallic structure, with polypropylene ceiling.

The flocks consisted of Cobb 500® male broilers reared on reused litter of 5 cm thickness and rice hulls as bedding material. Litter was reused from the sixth (first flock) to seventh (second flock) production cycles. The birds were housed from one day of age up to market weight at 42 days of growth. They had access to isonutritive fodder, according to the growing period, and water *ad libitum*.

The treatments comprised the use of different light sources. Number of bulbs for each aviary was calculated using the lumen number for aviary control, which was the incandescent light one. This allowed the use of the same light regime recommended by the genetic strain guidelines (COBB-VANTRESS, 2008).

TABLE 1. Description of the artificial light sources used for each treatment.

	Treatment		
	A1	A2	A3
Type of light source	Incandescent	Sodium vapor	Fluorescent
Number of bulbs (potency)	22 (100W)	6 (250W)	10 (48W)
Luminous flux (lumens)	1,320	5,000	2,970
Illuminance (lx)	24.2	25	24.7

The illuminance applied in the aviaries was lower than 25 lx, measured at broiler height, with the aim to stimulate the early weight gain; then it was gradually reduced to 5-10 lx up to the end of the production cycle (COBB-VANTRESS, 2008). After installation of the light bulbs, aviaries were divided into equidistant quadrants and, at each geometric center, the following environmental data were recorded: ambient dry bulb temperature (DBT, °C), litter surface temperature (LST, °C), ambient relative humidity (RH, %), illuminance (lx), sound pressure (dB), and NH_3 and CO_2 concentrations.

Data of DBT and RH were recorded for each quadrant of all tested aviaries using thermo-hygrometers. The LST was assessed using a Testo® infrared thermal camera. Images were taken daily at 7 am, and then processed by IRSoft® software. Concentration of gases (NH_3 and CO_2) was recorded at 25 cm height from the floor using a Dragger® manual pump and color meter detection tubes.

The sound pressure level was assessed in each aviary for determination of the light source influence on the sound produced by the broilers, using a decibel meter.

Data analysis was performed using ANOVA, and results were compared by the Tukey test at 5% probability. The software SIGMAPLOT (2011) was used for data processing.

RESULTS AND DISCUSSION

Dry bulb temperatures (DBT) and litter surface temperatures (LST) were higher in treatment A1 (Table 2), indicating that the use of incandescent light increased the ambient temperature, probably because it generates an excess of sensible heat. This result differs from those described by JÁCOME (2009), who did not find any effect of different light bulbs (23 W PL, 70 W sodium, 125 W mercury, and incandescent) on the ambient temperature.

TABLE 2. Means of dry bulb temperature (TBS, °C) and litter surface temperature (LST, °C) for treatments A1, A2, and A3.

	Age (days)				
	14	21	28	35	42
Treatment	Dry bulb temperature (°C)				
A1 (control)	21.62	28.52c	21.42c	21.72b	25.43b
A2	22.45	26.24b	20.32b	22.14b	25.15a
A3	22.25	25.52a	19.51a	21.11a	25.05a
	Litter surface temperature (°C)				
A1 (control)	23.7b	27.8b	23.6c	26.5a	27.3c
A2	23.8b	26.4a	23.0b	27.5c	26.8b
A3	23.0a	26.7a	21.5a	27.0b	26.5a

Means followed by different letters in the column differ from each other by the Tukey test ($p<0.05$); otherwise means that no difference was found. A1 - incandescent light bulb; A2 - sodium vapor light bulb; A3 - fluorescent light bulb.

The ambient DBT varied according to the production phase, what was expected and recommended in the production manual (COBB-VANTRESS, 2008); however, DBT values were lower than the recommended temperature during the brooding phase, and higher than thermal comfort at slaughter age (CURTIS, 1983). The difference among temperature values was only found in the third and sixth weeks of growth ($p < 0.05$). Aviary A3, with fluorescent light, presented a high variation in the ambient temperature, probably due to failure in the heating equipment or, yet, lack of perfect sealing of the heated area, what allowed heat loss to the outside environment (VIGODERIS et al., 2010).

Heat loss during heating may affect broiler performance (ALMEIDA, 2010). Although rearing temperatures did not differ in the first five weeks ($p<0.05$), in the sixth week, values were higher than the recommended (Table 2), indicating a possible failure in the management of fans.

Values of relative humidity (RH) did not differ at 14 days of growth ($p = 0.18$). At the 21st day, there was no difference between A1 and A2 results; however, both treatments differed from A3 ($p<0.010$). At 28, 35, and 42 days of growth, RH values did not differ among the aviaries ($p = 0.13$; $p = 0.30$; and $p = 0.16$, respectively). This RH behavior was expected in the aviaries, that is, low during the brooding phase, and increasing towards the end of the rearing period, at 42 days (Table 3). During the first weeks of growth, associated with low RH values, we found great values of suspended dust, what affects the air quality inside the houses (CORDEIRO et al., 2010). High temperatures, associated with low relative humidity, are reported to affect the physiological mechanisms of broilers (BAÊTA & SOUZA, 2010).

TABLE 3. Means of relative humidity (RH, %) for treatments A1, A2, and A3.

	Age (days)				
	14	21	28	35	42
Treatment	Relative humidity (%)				
A1 (control)	64.98	85.05b	61.63	38.88	88.15
A2	61.78	81.61b	57.36	38.04	88.13
A3	61.96	54.64a	61.63	38.29	87.33

Means followed by different letters in the column differ from each other by the Tukey test ($p<0.05$); otherwise means that no difference was found. A1 - incandescent light bulb; A2 - sodium vapor light bulb; A3 - fluorescent light bulb.

Another factor possibly responsible for the increased rate of air humidity in the last weeks is the use of fogging to reduce ambient temperatures. LIMA et al. (2009), when comparing ammonia concentration and emission from sheds with different ventilation systems, associated the difference of humidity in sheds to the poor condition of foggers; in most cases, these devices are not properly calibrated or maintained. It is recommended in the literature, for adult broilers, that threshold of ambient temperature and relative humidity should remain 22 ^{o}C and 50%, respectively; also, that the entire air exchange process should last 1.3 min, approximately (CARVALHO et al., 2011). The values found in this study were higher than the suggested threshold.

Ammonia concentration in the studied first days presented low mean values, regardless the treatment (Table 4). However, the mean values were lower than the thresholds recommended by COBB -VANTRESS (2008). Treatment with fluorescent light (A3), presented the lowest ammonia concentration mean ($p<0.05$). We found a relationship between light source and ammonia concentration, despite the fact that current literature reports both as independent variables (OWADA et al., 2007; CARVALHO et al., 2011).

Ammonia concentration varied throughout the days, but it did not present the noticeable increase mentioned in the current literature (HERNANDÉZ, 2012; GATES et al., 2008). This gas profile was expected since ammonia is formed by microbial decomposition of the uric acid excreted by the broilers, tending to increase as they grow. High flock densities also lead to increasing ammonia concentration (MANNO et al., 2011). Decomposition of uric acid is also easier in an alkaline medium (pH > 7), as the urease enzyme, which is responsible for the acid transformation, has its maximum activity at pH 9 (BLAKE & HESS, 2001). The ammonia threshold for broiler rearing environments was determined by WATHES et al. (1998) and ranges from 5 to 30 ppm.

TABLE 4. Means of ammonia (NH_3, ppm) and carbon dioxide (CO_2, ppm) concentrations for treatments A1, A2, and A3.

	Age (days)					
	14	21	28	35	42	
Treatment	NH_3 concentration (ppm)					Mean
A1 (control)	7	12	9	10	3	9.6a
A2	7	12	8	10	7	9.4a
A3	6	6	7	6	2	6.4b
	CO_2 concentration (ppm)					Mean
A1 (control)	320.5	380.5	460	560	580	460.3a
A2	200	219	220	220	220	215.8b
A3	162	162	202	200	201	185.4b

Means followed by different letters in the column differ from each other by the Tukey test ($p<0.05$); otherwise means that no difference was found. A1 - incandescent light bulb; A2 - sodium vapor light bulb; A3 - fluorescent light bulb.

Carbon dioxide concentration increased throughout the growing period, and is consistent with bird metabolic heat and weight (PEDERSEN & THOMSEN, 2000). We observed a steady increase of the gas concentration mean values in A1 throughout the broiler growing period (Table 3), what was probably related to the increasing ambient and litter temperatures, as the gas concentration is directly proportional to the fermentation of litter biomass (COUFAL et al., 2006). GAO et al. (2010) mention that, although CO_2 is a byproduct of the cell metabolism of living creatures, the basal CO_2 level in the environment is relatively low (0.038%); on the other hand, it may substantially vary in the atmosphere due to human industrial activities.

Acoustic pressure is the local pressure deviation from the ambient pressure, caused by a sound wave. Sound pressure is a logarithmic measure of the actual sound pressure of a sound in relation to a reference value. It is measured in decibels (dB) above a standard reference level. The analysis of the noise generated in the tested houses indicated a lower value inside A3, at 14 days ($p=0.02$), when compared with A1 or A2 (Table 5). At 21 days of growth, no differences were found among treatments regarding the noise level in the aviaries ($p>0.05$). At the 35th day, the sound level in A1 was different from that found in A2 ($p=0.026$); however, A1 and A2 were similar to A3 ($p>0.05$). At 42 days, no differences were found among treatments ($p=0.12$). According to CHLOUPEK et al. (2009), broilers exposed to noise stimuli of both 80 and 100 dB intensities for 10 min presented a significant elevation in plasma corticosterone levels. In this study, all values were lower than 80 dB, what may indicate that, even during brooding, birds were not stressed and emitted low vocalization, as also reported by MOURA et al. (2008).

TABLE 5. Means of sound pressure (dB) during the growing period of broilers.

	Age (days)				
Treatment	14	21	28	35	42
	Noise level (dB)				
A1 (control)	60.27b	60.62	57.24	69.05a	69.27
A2	57.33b	58.54	58.68	74.23b	72.91
A3	55.74a	60.36	57.86	71.83ab	68.35

Means followed by different letters in the column differ from each other by the Tukey test ($p<0.05$); otherwise means that no difference was found. A1 - incandescent light bulb; A2 - sodium vapor light bulb; A3 - fluorescent light bulb.

CONCLUSIONS

The aviary with incandescent light presented higher ambient and litter temperatures than the others with different light sources. Concentration of gases was also higher in the house with incandescent light, as well as the sound pressure level at the second week of the growing period.

However, from that week up to slaughter weight, there was no impact of the light source on the results of broiler sound pressure level.

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