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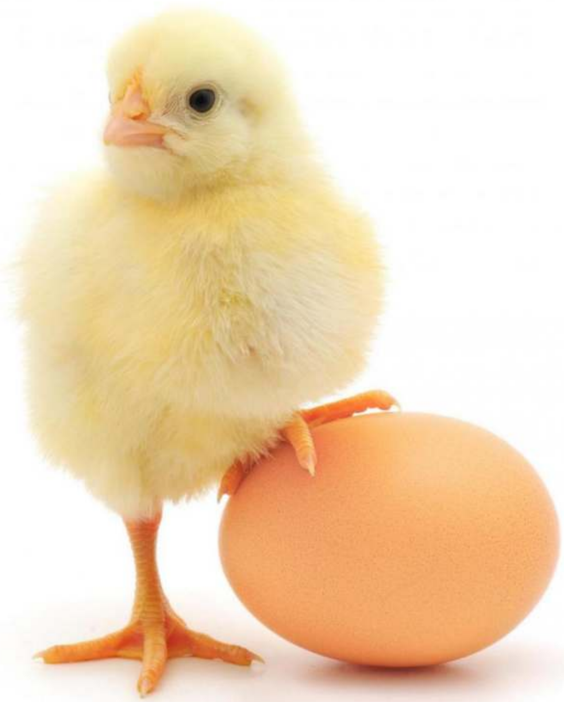

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Behavior of Broilers Reared under Monochromatic and Fluorescent Light Sources

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Abstract: The study aimed to evaluate the behavior of broiler chickens reared in the blue and red light emitting diode (LED), using a fluorescent light as a control. The bird behaviors were recorded at 28, 35 and 42 d of grow-out using video clips. Broilers were randomly distributed in a factorial arrangement of 2 x 3 (two sex and three light sources) using six treatments and four replications. Blue and red LED light source and fluorescent light were tested from the 10th day until the 42nd day of grow-out. Behavioral data were analyzed using ANOVA and Kruskal-Wallis test was applied. An association was found between bird age, sex and source of light in the eating, drinking, preening and foraging behavior. Broilers were more active when exposed to fluorescent light and red LED than the birds exposed to the blue LED light source.

Key words: Broiler welfare, color lighting, light-emitting diode, poultry production

INTRODUCTION

Commercial broilers are reared for high productivity under the artificial environment (lighting, ventilation and limited housing space). The primary role of artificial light is to improve feed consumption (Bayraktar *et al*., 2012; Blatchford *et al*., 2012). Studies on poultry rearing conditions regarding the animal welfare concerns demand answers for producers and consumers. The lighting program, light intensity and color of the light source are amongst the rearing variables that need to be handled properly to allow normal circadian rhythm (Huber-Eicher *et al*., 2013; Rozenboim *et al*., 2013). Although the effects of different light source on broiler performance have been previously studied (Halevy *et al*., 1998; Cao *et al*., 2012, Borille *et al*., 2013; Mendes *et al*., 2013); information sill lack on the consequence of the different color of monochromatic light source on broiler behavior and welfare (Er *et al*., 2007).

The light environment may affect domestic fowl through interactions between physiological and behavioral responses. Broilers have shown different time-budget across light sources and intensities (Kristensen *et al*., 2007) and both age and time-of-day affected most behaviors studied. Increased light intensity resulted in more pronounced behavioral rhythms (Blatchford *et al*., 2009); while broilers showed more foraging behavior under dim light than bright light intensities (Newberry *et al*., 1988; Kristensen *et al*., 2007). Keeping broilers in constant low-intensity light is a common practice in commercial houses for controlling the bird activity and reducing the fearful behavior, being detrimental to the welfare (Martrenchar, 1999; Blatchford *et al*., 2009). Bright light may also be stressful indicating that light intensity plays a significant role in broiler behavior (Morgan and Tromborg, 2007). Broiler welfare assessment is typically done by analyzing their physiological characteristics (weight gain, surface temperature) associated with the behavioral repertoire (Bizeray *et al*., 2002; Borille *et al*., 2013). These previous studies provide valuable evidence on the effect of light on broiler behavior. However, the impact of different colors of LED in broilers behavior has not been further considered.

This research intended to evaluate the behavior of broiler chickens reared under blue and red LED light source colors, using a fluorescent light source as a control.

MATERIALS AND METHODS

The present study was carried out from May to July in the experimental broiler house at the Federal University of Grande Dourados, Brazil. The region has latitude 22°13'18" S, longitude 54°48'23" W and altitude of 430 m. The regional climatic characteristic is a humid and hot weather during the summer and dry winter.

The experiment was approved by the university ethics committee CEUA (010/2013).

Birds, husbandry and experimental design: A total of 1,296 broilers (male and females) from Cobb® 500 genetic strain were reared in pens measuring 4.5 m^2, with a final grow-out (42 days) flock density of 12

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birds/m^2. Rearing ambient data (dry bulb temperature = 24.0±2.0°C and relative humidity = 65.0±5.0%) were adopted as recommended by the genetic strain manual (Cobb-Vantress Manual, 2013). The litter substrate was rice hulls (5 cm thick). Broilers were reared for 42 days with water and feed ration *ad libitum*. The commercial feed ration was balanced providing appropriate nutrition about the four production phases (pre-initial, initial, growth and final) throughout the experiment. The pens were isolated using a black polypropylene curtain to avoiding the interference between treatments. Heating during brooding was done using infrared lamps (250 W, E-27). During the first ten days of growth, all chicklings were reared under a 23L:1D regimen (provided by fluorescent lights) with intensities of 15 and 1 lx during the photophase and scotophase, respectively. The exposure of blue and red LED started on the 10th day of grow-out when the present experiment started. The fluorescent light source was used as the control. The light schedule used was continuous with 23L:1D regimen during the grow-out period (Win-bin *et al.*, 2010). The number of light bulbs was used to make available the proper amount of light intensity (20-10 lx, Cobb-Vantress Manual, 2013). Light intensity was assessed using a light meter in five places of the pen at a height of approximately 1 m.

Broilers were randomly distributed in a factorial scheme of 2 x 3, being two sex and three light sources, using six treatments and four replications. A total of 54 birds were used in each experimental unit. Blue (light spectrum of 480 nm), red (light spectrum of 660 nm) LED light source (20 lx) and fluorescent light (light spectrum of 450-650 nm, 6500 K, 15 lx; control) were tested starting on the 10th day until the 42nd day of grow-out.

Broiler behavior assessment: Broiler behavior was analyzed by indirect monitoring using pictures and video footage, as previously done by Prayitno *et al.* (1997), Bizeray *et al.* (2002) and Kristensen *et al.* (2007). One portable digital video camera (Sony DCR-TRV330, 16530 Via Esprillo, San Diego, USA) was used focused on the center of the pen providing a full view of the experimental area and the broilers. Four video clips of 5 min each was taken in each pen at 28, 35 and 42 days of the grow-out period, in a total of 72 videos being 20 min for each treatment.

The videos were recorded starting at 18 h: 00 min. In a second stage, while watching each recorded video, five broilers from the flock were randomly chosen to be observed within each treatment (Altmann, 1974; Bizeray *et al.*, 2002). The broilers behavioral repertoire (Table 1) was recorded considering the number of times each bird performed the described behavior.

Statistical analysis: The effect of different sources of light and colors between the studied variables were investigated. Due to the non-normality and unequal variance between the groups, the number of each behavior found in each treatment was counted and analyzed using a non-parametric test. A confidence level of 0.95 was adopted. The calculations were done using the statistical software Assistat (ASSISTAT 7.6 beta, 1st edn).

RESULTS

No interaction was found ($p>0.05$) between broilers age, sex, light source and some studied behaviors (lying down, pecking, standing and stretching; Table 2). Males spent more time lying down ($p<0.05$). Light sources did not influence ($p>0.05$) some data of the studied behavior (lying down, non-aggressive pecking, aggressive pecking, pecking objects, stopping and stretching; Table 3). Possibly the change in these behaviors would be related to the light intensity and not the wavelength (color of light).

An interaction was identified ($p<0.05$) between the age of bird and the light source regarding the eating behavior, drinking, preening and feather pecking (Table 3). The males were particularly more active in foraging than the females. The profiles of the drinking and eating behaviors at 28, 35 and 42 days of grow-out are shown in Fig. 1 and 2, respectively. Broilers 35-days-old reared under red LED drank water more often than the others age-groups. There was a higher frequency of eating in the flock of broilers exposed to the fluorescent lamp (Fig. 3) than the other studied groups. Broilers time-budget preening differed only at 42-days-old (Fig. 4). Birds exposed to lighting with fluorescent bulb had a higher frequency of prenning behavior ($p<0.05$; Fig. 5) than other studied behaviors. Ambient with red LED broilers showed an unusual drinking behavior (35-days-old; Fig. 1) and foraging (Fig. 6) at 28-days-old (Fig. 7).

Birds reared in an environment with fluorescent lamp had a higher frequency of eating (35 d-growth phase; Fig. 2) when comparing the power factor and light.

DISCUSSION

Males remained longer time seated and resting and this result might be related to the higher body weight of males than females. Prescott and Wathes (2002) found that hens eat more in a lighter environment (200 lx). The results indicate that bright lighting is likely to stimulate the appetitive component of feeding behavior. Since the light intensity of the current study was low (15-20 lx) the dim rearing environment probably led the broilers to rest. The present results are not conclusive in the interference of the considered light sources on the broiler performance.

Results indicate that birds at 28 days of growth showed a slightly higher rate of aggressive non-pecking behavior than the other age-groups. The results of the change in the aggressive behavior are related to age and not to the

Table 1: Description of the observed behavioral repertoire in broiler chickens during the present study

Behavior		Description
Lying down	LD	The bird sits or lies down on the litter
Eating	ET	Birds are consuming feed ration on the feeder
Drinking	DR	Birds are standing in front of the drinker and drinking water
Preening	PR	The bird cleans its feathers with the beak, inducing the uropygial gland
Non-aggressive pecking	NP	Bird is slightly pecking another in a non-aggressive way
Aggressive pecking	AP	Bird beaks aggressively another bird provoking a defensive reaction including feathers pecking
Pecking objects	BO	Bird pecks objects such as feeder, drinker or other parts of the pen
Stretching	SC	The bird pulls one wing and one leg of the same body side and ruffle feathers
Foraging	FO	Movement of scratching the litter with its feet, searching for food in the litter
Standing	ST	The bird stands still, not moving

Adapted from Altmann (1974), Bizeray *et al.* (2002), Meluzzi and Sirri (2009) and Villagra *et al.* (2014)

Table 2: Mean values of behavioral time budget of broilers exposed to blue and red LED and fluorescent light source

	Behavior					
	LD	NP	AP	PO	S	SC
Sex						
Male (n = 75)	2.03±0.50^{a}	0.10±0.05	0.01±0.50	0.03±0.00^{b}	0.61±0.01	0.85±0.01
Female (n = 75)	1.70±0.40^{b}	0.04±0.02	0.03±0.40	0.12±0.00^{a}	0.55±0.01	0.80±0.01
Age (day)						
28 (n = 150)	1.46±0.30^{b}	0.14±0.02^{a}	0.06±0.00	0.13±0.01	0.47±0.00	0.65±0.00^{b}
35 (n = 150)	2.33±0.02^{a}	0.03±0.03^{b}	0.00±0.00	0.03±0.03	0.57±0.01	1.11±0.00^{a}
42 (n = 150)	1.81±0.02^{b}	0.04±0.02^{ab}	0.00±0.00	0.07±0.03	0.71±0.00	0.71±0.00^{ab}
Light source						
Blue LED (n = 150)	1.71±0.02	0.13±0.02	0.03±0.00	0.03±0.00	0.42±0.01	0.76±0.00
Red LED (n = 150)	1.85±0.02	0.06±0.03	0.01±0.00	0.06±0.00	0.74±0.01	0.71±0.01
Fluorescent (n = 150)	2.04±0.02	0.03±0.01	0.01±0.00	0.14±0.01	0.60±0.01	1.00±0.01

Mean±standard error, LD: Lying down, NP: Non-aggressive pecking, AP: Aggressive pecking, PO: Pecking an object, S: Standing and SC: Stretching, mean values followed by a different letter in the column are significantly different (p<0.05) from one another by the Kruskal-Wallis test

Table 3: Mean values of the behavior time-budget interaction between age and light source in broiler chickens exposed to blue and red LED and fluorescent light source

Age (day)	Treatment	ET	DR	PR	FO
	Blue LED	0.67	0.63	0.25	0.08^{b}
28	Red LED	0.42	0.42^{Y}	0.46	0.54^{aX}
	Fluorescent	0.71^{Y}	0.33	0.46	0.29^{abX}
	Blue LED	0.50^{b}	0.71^{b}	0.58	0.00
35	Red LED	0.04^{b}	2.00^{aX}	0.21	0.00^{Y}
	Fluorescent	1.67^{aX}	0.25^{b}	0.33	0.00^{Y}
	Blue LED	0.38	0.21	0.29^{b}	0.08
42	Red LED	0.38	0.42^{Y}	0.42^{b}	0.04^{Y}
	Fluorescent	0.63^{Y}	0.42	0.83^{a}	0.08^{XY}

ET: Eating, DR: Drinking, PR: Preening and FO: Foraging, mean values followed by different letters in column (lowercase within the particular age (a, b) and uppercase letters between the studied ages (X, Y)) differ by the Kruskal-Wallis test (p<0.05)

studied light source. When establishing the social hierarchy birds begin pecking within the second week of age (Blatchford *et al.*, 2012) and this particular behavior becomes more frequent after the seventh week in males and after the ninth week, in females. The current study intended to simulate Brazilian broiler production cycle (birds are slaughtered around the sixth or seventh week-far from the development of social dominance hierarchy). Therefore, the aggressive behavior should not be credited to sexual maturity. High frequency of pecking behavior in birds exposed to red light was observed by Jang Ho and Velmurugu (2009), differing from the results of the present study. The result of the current study agrees with the findings described by Solangi *et al.* (2004) who established that the aggressive behavior of broilers under white light color was lower than that of birds exposed to red and blue light source. Other studies evaluating light intensity indicate that low intensity decreases activities of birds (Prayitno *et al.*, 1997; Blatchford *et al.*, 2009; Blatchford *et al.*, 2012). The effect of natural light on the management of side curtains is reported in the literature (Vercellino *et al.*, 2013) indicating that broilers remained lying longer time when exposed to less light.

Foraging is characterized as a natural behavior of birds and it is defined primarily as an exploratory behavior (Mendes *et al.*, 2013). In the current study, a greater frequency of foraging behavior was observed in 28-days-old broilers exposed to red light LED (p>0.05). Previous study results also demonstrated that the light color

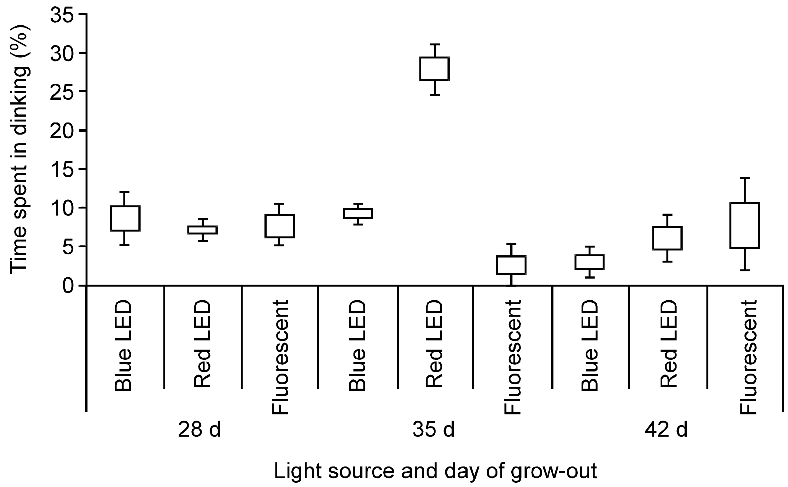

Fig. 1: Boxplot of broilers time-budget spent in drinking (%) under the blue and red Light Emitting Diode and fluorescent light sources at 28, 35 and 42 days of grow-out (n = 150; max error-bar = max value-the value of the third quartile; min error-bar = value of the first quartile-min value)

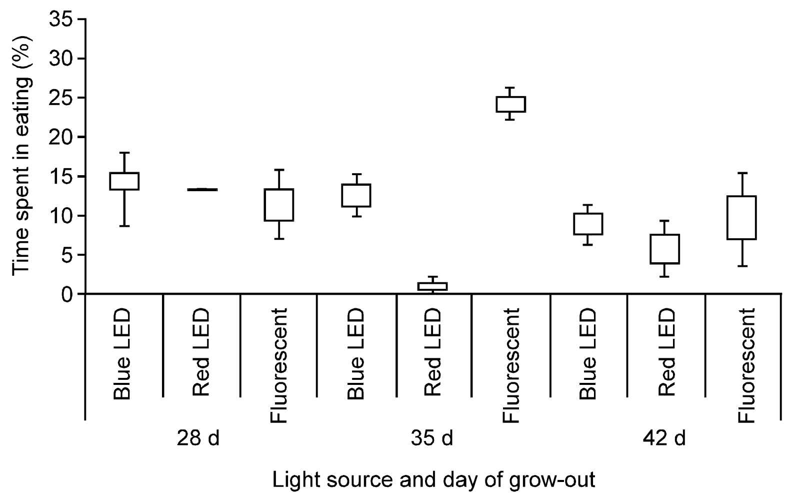

Fig. 2: Boxplot of broilers time-budget spent in eating (%) under the blue and red Light Emitting Diode and fluorescent light sources at 28, 35 and 42 days of grow-out (n = 150; max error-bar = max value-the value of the third quartile; min error-bar = value of the first quartile-min value)

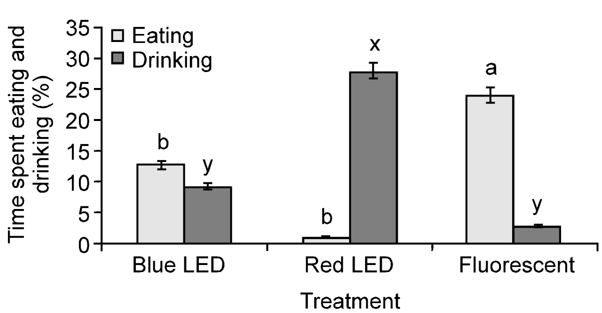

Fig. 3: Average percentage of time-budget spent in eating and drinking behavior of broilers 35-days-old exposed to blue and red Light Emitting Diode and fluorescent light sources (n = 150; error-bars in error, %)

might impact broiler performance and behavior (Jang Ho and Velmurugu, 2009) that was confirmed in the current study in the foraging behavior. Th behavior of standing and walking was perceived mostly in broilers reared under red light conditions from 4 to 18 days of grow-out compared with the remaining growing period.

Light intensity plays a vital role in the behavior of broilers. Birds might not detect accurately short wavelengths lights (blue and green), hence the observed reduction in eating time (Mobarkey *et al.*, 2010; Mahmood and Abbas, 2014). Red light makes birds more active (Prayitno *et al.*, 1997), which may cause distress and consequently a reduction in food consumption. Broilers under slightly intense light laid more and decreased behaviors of foraging, preening, dust-bathing, stretching and wing

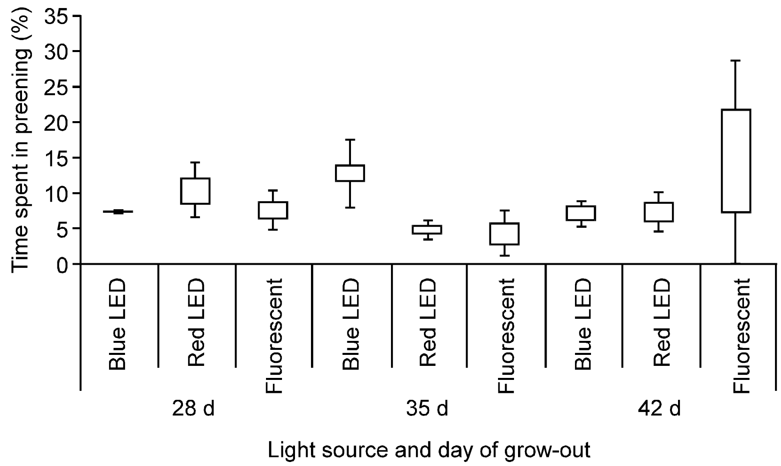

Fig. 4: Boxplot of broilers time spending in preening (%) under the blue and red Light Emitting Diode and fluorescent light source at 28, 35 and 42 days of grow-out (n = 150; max error-bar = max value-the value of the third quartile; min error-bar = value of the first quartile-min value)

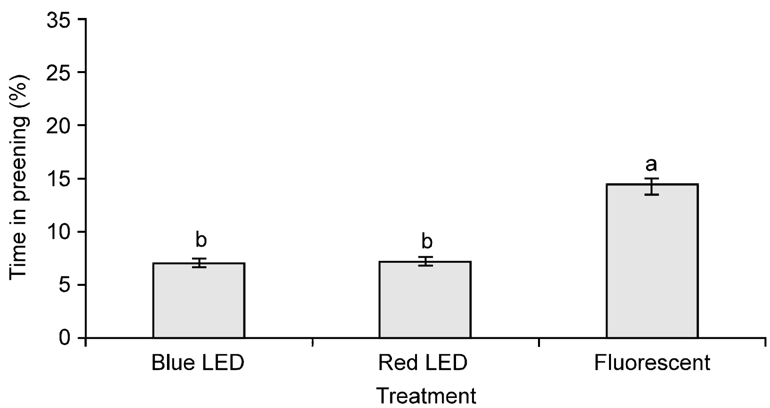

Fig. 5: Average percentage of time-budget spent in preening behavior of 42-days-old broiler chickens exposed to blue and red Light Emitting Diode and fluorescent light sources (n = 150; error-bars in error, %)

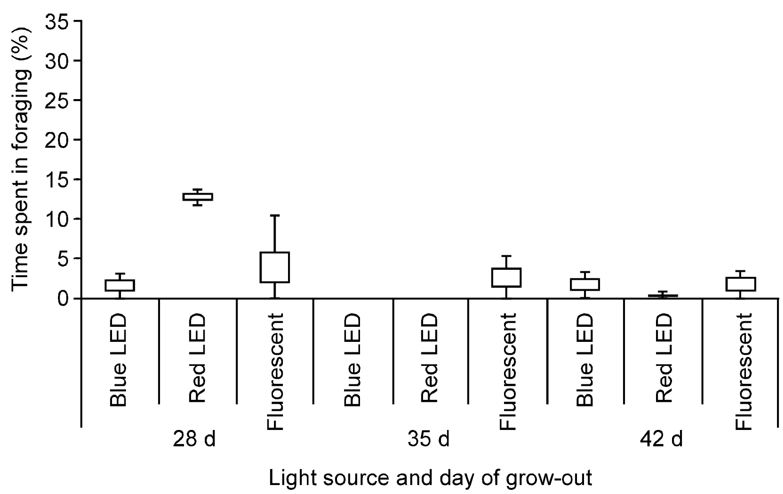

Fig. 6: Boxplot of broilers time-budget spent in foraging (%) under the blue and red Light Emitting Diode and fluorescent light sources at 28, 35 and 42 days of grow-out (n = 150; max error-bar = max value-the value of the third quartile; min error-bar = value of the first quartile-min value)

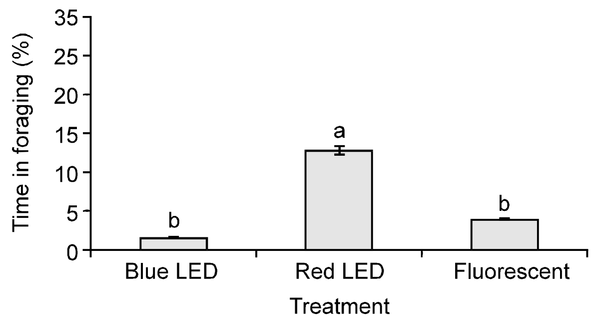

Fig. 7: Average percentage of time-budget spent in foraging behavior of 28-days-old broiler chickens exposed to blue and red Light Emitting Diode and fluorescent light sources (n = 150; error-bars in error, %)

flapping in high light intensity (Deep *et al.*, 2010). Broiler preening is referred as a comfort behavior (Mahmood and Abbas, 2014). However, when the aerial rearing environment is dusty and ammonia concentration is high broilers tend to increase preening. Prayitno *et al.* (1997) found preening an indication of a problematic behavior that might indicate poor welfare condition. The presence of dirt on the bird feathers might lead to a greater need to explore and clean them (Barehan, 1976). The increased foraging and preening seen at high light intensities could also be related to better visual acuity due to the brightness in the ambient (Alvino *et al.*, 2009). Considering that the excess of activity might induce thermal stress as a consequence (Jang Ho and Velmurugu, 2009), the increase in water intake might have been a natural result. There was a rise in the ambient temperature in the days before data recording that might have exposed the bird to some heat stress, leading to thirsty.

According to Senaratna *et al.* (2012), the effect of light colors is related to the age of broilers and to the time of the day. In the present study, the effect of the sex and age was only seen on the 28th day or grow-out.

Conclusions: Broilers are more active (eating, drinking, preening and foraging) when exposed to red LED and fluorescent light sources than those reared under blue LED light source. Blue and red LED light source can be used in broiler production as the use did not induce unsafe behaviors.

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