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Artículos

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Desempeño de pollos de engorde sometidos a diferentes intensidades y duraciones de estrés

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Abstract: The performance of broilers submitted to thermal discomfort in the first weeks of life may be impaired, since the thermoregulatory system of the bird is not fully developed. The objective of this study was to analyze the effects of different thermal challenges on the performance of broilers. Two hundred and forty broilers were submitted to different desired dry-bulb temperatures (t_{db}: 24, 27, 30 and 33°C) and stress duration (SD: 1, 2, 3 and 4 days) in the second week of life. Feed intake (FI), weight gain (WG) and feed conversion (FC) were evaluated at 21 days of age. Although differences were verified for FI ($p < 0.05$), none were observed for WG ($p > 0.05$). Reductions of FC for the 24, 27 and 33°C t_{db} were 14.8, 8.6 and 10.1%, respectively. The smallest FC was observed at 30°C, indicating comfort condition.

Keywords: animal environment, poultry farming, productive responses, thermal comfort.

Resumen: El desempeño de pollos de engorde sometidos a estrés térmico en las primeras semanas de vida puede ser perjudicado, una vez que el sistema termorregulador del ave no está completamente desarrollado. El objetivo de este trabajo fue analizar los efectos de diferentes desafíos térmicos sobre el desempeño de pollos de engorde. Doscientos cuarenta pollos de engorde fueron sometidos a diferentes temperaturas de bulbo seco del aire deseada (t_{bs}: 24, 27, 30 y 33°C) y a duraciones de estrés (DE: 1, 2, 3 y 4 días) en la segunda semana de vida. El consumo de ración (CR), ganancias de peso (GP) y conversión alimenticia (CA) fueron evaluadas a los 21 días de edad de las aves. A pesar de que las diferencias fueron verificadas para CR ($p<0,05$), ninguna diferencia fue observada para GP ($p>0,05$). Reducciones de CA para las t_{bs} de 24, 27 y 33°C fueron de 14,8, 8,6, y 10,1%, respectivamente. El CA más pequeño se observó a 30°C, lo cual se caracterizó como condición de confort.

Palabras clave: ambiente animal, avicultura, respuestas productivas, confort térmico.

1. Introduction

To obtain maximum productivity, broilers need to be reared in an appropriate thermal environment, with adequate control of air dry-bulb temperature (t_{db}), relative humidity (RH), air speed and radiation [1,2]. Thus, it is possible to maintain the productivity as well as attend to new policies and exigences of the market related to animal well-being.

Therefore, aiming to provide ideal conditions throughout production phases, the thermal control in the breeding environment is necessary [3,4], mainly in the first days of life [5], once the bird's thermoregulation system is not completely developed and there is some limitation to the bird produces heat.

When subjected to unfavorable thermal conditions, the birds are subjected to thermal stress [6], thus modifying their feeding behavior, decreasing or increasing feed intake (FI) [7]. This modification in eating behavior helps in physiological changes to adapt to stress [8]. However, the energy expenditure that should be used to provide adequate weight gain (WG) will be allocated to the process of body thermoregulation [9,10], harming productive performance [11].

The evaluation of the broilers productive responses according to the thermal conditions of the facilities is performed through the analysis of zootechnical parameters, such as FI, WG and feed conversion (FC) [12].

Several studies have shown that the productive responses of broilers are closely related to the thermal conditions of the facilities [13-15]. However, most researches only vary the intensity of the thermal stress, not varying the its duration [15-18].

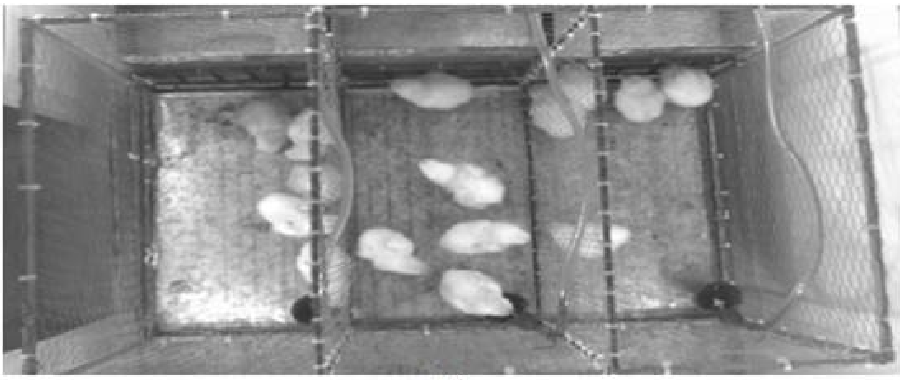
Given the importance of the thermal environment and its influence on broilers productive responses in the initial stages, the objective of this study was to evaluate the performance of broilers submitted to different intensities and duration of thermal stress in the second week of life.

2. Material and methods

The research was carried out in air-conditioned wind tunnels, and the procedures performed during the experiment were approved by the Ethics Committee for Animal Use (Comissão de Ética para Uso de Animais - CEUA) of the Universidade Federal de Lavras - (UFLA), Minas Gerais, protocol No. 008/12.

Four air-conditioned wind tunnels (0.8 x 5.0 m) were used, which were built in steel sheets and PVC pipes (Fig. 1a), each tunnel being equipped with two electric heaters and two humidifiers, in two stages of operation with capacity of 600 W and 300 mL_{water} h^{-1} per stage, respectively.

a)



b)

Figure 1

a) Overview of air-conditioned wind tunnels. b) Top view of the cages placed inside the tunnels.

Source: The Authors.

The ventilation inside each tunnel was performed by means of an exhaust fan, 40 cm in diameter, and the speed adjusted by potentiometer. Inside the tunnels, cages of 0.24 m^2 (0.40 x 0.60 m) were allocated, in which they were divided into three equal parts and equipped with independent feeders and drinkers in each division, thus characterizing three replicates (Fig. 1b). To condition the temperature inside the room, two air conditioning systems with 5,272.2 W (18,000 BTUs) of power were used.

The control of the thermal environment within the wind tunnels was performed through a datalogger (CR1000, Campbell Scientific), a relay controller (SDM-CD16AC, Campbell Scientific), a channel multiplexer (AM16/32B, Campbell Scientific), and t_{db} and RH sensors (HMP45c, Vaisala, accuracy of ± 0.3°C for t_{db} and ± 2 % for RH).

During the experimental period, 240 chicks of the Cobb 500® males and females were used. The chicks were from the same hatchery and vaccinated against Marek, Gumboro and Bouba aviary diseases. The birds arrived at the experiment shortly after birth and remained until they were twenty-two days old. During this period, water and feed *ad libitum* were supplied to the birds to meet their nutritional requirements according to [19]. The feed used was the same for all the chicks throughout the experimental period, with no variation of their formulation. The broiler chicks received a corn and soybean meal mash diet, formulated according to the nutritional recommendations described by [19], for chickens from 1 to 21 days old, containing 3000 kcal of metabolizable energy per kg of diet, 21.4% crude protein, 0.90% Ca, 0.43% P disponible, 0.21% Na, 1.20% lysine digestible, 0.89% methionine + cystine digestible, 0.80% threonine digestible and 0.21% tryptophan digestible.

The RH was maintained at 60 ± 1% and the air velocity at 0.2 ± 0.1 m s^{-1}, characterized as comfort for the broilers [20]. The luminosity was adjusted via a luxmeter (LDR-380, accuracy of ± 3%), with intensities of 25 and 10 lux for the first and second week of life, respectively [21].

The experiment was carried out in four stages of 21 days each (Table 1), using sixty birds in each stage.

Table 1

Desired air dry-bulb temperature (t_{db}) and thermal stress duration (in bold) applied to broilers from 1 to 21 days of age during the second week of life.

		Air dry-bulb temperature (°C)						
		Week 1	Week 2					Week 3
Days of life		1-7	8	9	10	11	12-14	15-21
Stage	Tunnel							
1	A	33	**33**	30	30	30	30	27
	B		**33**	**33**	30	30	30	
	C		**33**	**33**	**33**	30	30	
	D		**33**	**33**	**33**	**33**	30	
2	A	33	**27**	30	30	30	30	27
	B		**27**	**27**	30	30	30	
	C		**27**	**27**	**27**	30	30	
	D		**27**	**27**	**27**	**27**	30	
3	A	33	**24**	30	30	30	30	27
	B		**24**	**24**	30	30	30	
	C		**24**	**24**	**24**	30	30	
	D		**24**	**24**	**24**	**24**	30	
4	A, B, C and D	33	30					27

Source: The Authors.

In each division of the cage were allocated five birds, characterizing fifteen birds per air-conditioned wind tunnel in the first week of life. In order to maintain optimal comfort density, in the second and third week of life, four and three birds, respectively, were maintained in each replicate, according to recommendations of the lineage guide [21]. The cleaning of the breeding environment was carried out daily to avoid the formation of gases and to provide an adequate environment for the development of the broilers. The time that handling opening of each air-conditioned wind tunnel was maintained opened was very short to avoid changes in the thermal environment desired.

The birds were submitted to thermal challenge only in the second week of life, from the 8th day of life. During the first and third weeks of life, the t_{db} were maintained in the thermoneutral zone, i.e. 33°C and 27°C, respectively [22]. In the second week, the differences between the treatments were established between the intensities and duration of the thermal challenge, and the stress intensities were 24, 27 and 33°C for each stage, in addition to t_{db} of 30°C, considered as of comfort for the second week of life [22]. These desired t_{db} values were maintained throughout each treatment.

In Table 1, it can be observed that the thermal stress was applied in four duration (1, 2, 3 and 4 days) in the first four days that compose the second week (8th, 9th, 10th and 11th days of life). Soon after this period the t_{db} returned to the recommended value as characteristic of the thermal comfort zone (30°C) [5,23].

The experimental stage submitted to t_{db} of 30°C is considered as control (comfort), and the others were maintained in order to provide thermal stresses both by low (24 and 27°C) and high (33°C) temperatures [22,24].

The values of FI, WG and FC accumulated in 21 days were analyzed, adopting the completely randomized design (DIC) in split plots in time scheme. The plots were set according to the 4x4 factorial arrangement, that is, four t_{db} in the second week of the birds' life (33°C, 30°C, 27°C and 24°C) and four stress duration (1, 2, 3 and 4 days), according to the model specified in eq. (1). The variables were analyzed by the statistical program SISVAR 5.3 [25] submitted to analysis of variance, and the means were compared using the Scott-Knott test and regression at the 5% probability level.

$$y_{ijkl} = \mu + \alpha_i + \beta_j + \alpha\beta_{ij} + \epsilon_{ijk} + \tau_l + \alpha\tau_{il} + \beta\tau_{jl} + \alpha\beta\tau_{ijl} + e_{ijkl} \qquad (1)$$

in which, Y_{ijkl} is the observed value of the replicate k of the i-th temperature by j-th duration at time l; μ is a constant; α_i is the effect of i-th temperature; β_j is the effect of the j-th duration of the thermal stress; $\alpha\beta_{ij}$ is the interaction between i-th temperature and j-th duration; $\#_{ijk}$ is the whole-plot error; τ_l is the effect of the time; $\alpha\tau_{il}$ is the interaction between i-th temperature and l-th time; $\beta\tau_{jl}$ is the interaction between j-th duration and l-th time; $\alpha\beta\tau_{ijl}$ is the interaction between i-th temperature, j-th duration and l-th time, and e_{ijkl} is the subplot error.

3. Results and discussion

The thermal environments inside of the air-conditioned wind tunnels were monitored during the experimental period to verify the t_{db} and RH values to which the birds were subjected. The averages and standard deviations (in parentheses) of the observed values are listed in Table 2.

Table 2

Air dry-bulb temperature values desired (t_{db}, desired, °C), observed means ($t_{db,obs}$ (°C) and RH_{obs} (%)) and standard deviations (in brackets) inside the air-conditioned wind tunnels.

Stage	Thermal Variables	Week1	Week 2				Week 3
			1 day	2 days	3 days	4 days	
1	$t_{db,desired}$	33.0	24.0				27.0
	$t_{db,obs}$	33.1(0.3)	24.3 (0.3)	24.3 (0.3)	24.3 (0.3)	24.3 (0.3)	27.2(0.3)
	RH_{obs}	60.3(0.6)	60.4 (0.7)	60.4 (0.8)	59.9 (1.0)	60.8 (0.6)	60.4(1.2)
2	$t_{db,desired}$	33.0	27.0				27.0
	$t_{db,obs}$	33.1(0.3)	27.2 (0.3)	27.2 (0.2)	27.1 (0.2)	27.2 (0.3)	27.2(0.3)
	RH_{obs}	60.3(0.9)	60.0 (1.6)	60.3 (1.0)	60.0 (0.9)	60.4 (0.9)	59.9(1.4)
3	$t_{db,desired}$	33.0	33.0				27.0
	$t_{db,obs}$	33.1(0.3)	33.0 (0.3)	33.0 (0.3)	33.0 (0.3)	33.0 (0.3)	27.2(0.3)
	RH_{obs}	60.2(1.4)	60.0 (1.7)	60.1 (1.3)	59.9 (1.4)	60.5 (1.3)	60.3(0.8)
4	$t_{db,desired}$	33.0	30.0				27.0
	$t_{db,obs}$	33.2 (0.3)	30.2(0.2)				27.2 (0.2)
	RH_{obs}	60.1 (1.1)	60.3(0.7)				60.3 (0.8)

Source: The Authors.
tdb, desired =Desired air dry-bulb temperature; tdb,obs = Observed air dry-bulb temperature; RHobs = Observed air relative humidity.

In the first week of life the t_{db} and RH desired were 33°C and 60%, respectively, and the observed value (Table 2) was very close at all stages, with the highest standard deviations for t_{db} and RH were ± 0.3°C and ± 1.4%, respectively. During the second week of life, period which the birds were submitted to different intensities of t_{db}, the highest standard deviations found were ± 0.3°C for t_{db} and ± 1.7% for RH. To the t_{db} of third week of life, in which the birds were submitted to t_{db} of 27°C, considered of comfort [22], it is observed that the averages of $t_{db,obs}$ are close to desired. The small variations demonstrate the efficiency of the air-conditioned wind tunnels for the maintenance of the desired thermal variables, corroborating with [26].

The interaction between t_{db} and thermal stress duration was significant ($p<0.05$, F test) for the FI variable (Table 3). When analyzing the t_{db} within each stress duration (Table 3), it was generally observed that the highest FI averages occurred at t_{db} of 24°C ($p<0.05$, Scott-Knott test), except for the duration of 4 days that no significant difference was verified ($p>0.05$, Scott-Knott test). The increased in FI in low temperature stress conditions is due to the bird's need to obtain more energy from its diet [27].

Table 3
Average values and standard deviation (in brackets) of the mean accumulated feed intake (FI, g) of broilers at 21 days of age, submitted to different intensities and thermal stress duration.

Air dry-bulb temperature (°C)	Thermal stress duration (days)			
	1	2	3	4
24	941.33 (80.89) c A	901.93 (47.78) b A	902.00 (75.49) b A	867.86 (75.98) a A
27	824.43 (31.30) b A	811.36 (59.47) a A	888.53 (68.68) b A	830.03 (36.55) a A
30	717.86 (37.45) a A	758.96 (16.04) a A	776.26 (28.09) a A	797.63 (50.27) a A
33	911.86 (28.16) c A	826.83 (46.76) a B	783.70 (36.34) a B	808.00 (26.17) a B
CV (%)	6.05			

Source: The Authors.
Averages with different letters (uppercase in the row and lowercase in the column) indicate statistical differences ($p < 0.05$) by the Scott-Knott test.
CV = Coefficient of variation.

On the other hand, the lowest FI for the different stress duration studied was verified for t_{db} of 30°C ($p<0.05$, Scott-Knott test), except for the stress duration of 4 days, in which there was no statistical difference between the various t_{db} evaluated ($p<0.05$, Scott-Knott test).

For t_{db} of 33°C, as the duration of thermal stress increases, it was verified the reduction in the effect of t_{db} in FI at 21 days of the birds' age, indicating the occurrence of adaptation of the broilers to the stress environment. It is also verified that t_{db} of 33°C applied to thermal stress duration of 2, 3 and 4 days, does not yet represent a condition of significant discomfort ($p>0.05$, Scott-Knott test) for broilers when compared to the condition recommended in the literature as of comfort (t_{db} = 30°C) [5,23].

However, considering the stress duration of 1 day, there was statistical difference between the t_{db} of 33°C and 30°C. In conditions of high t_{db}, the reduction of FI is expected to decrease the metabolic increment [28], thus facilitating the homeothermic control [29]. In this study, it was verified that FI on the first day of stress was also higher at 33°C, this probably occurred due to this t_{db} not fully characterize discomfort by high temperature. In Fig. 2, the exploratory analysis is illustrated in bar format, the days of thermal stress (1, 2, 3 and 4 days) for the FI associated with each t_{db}.

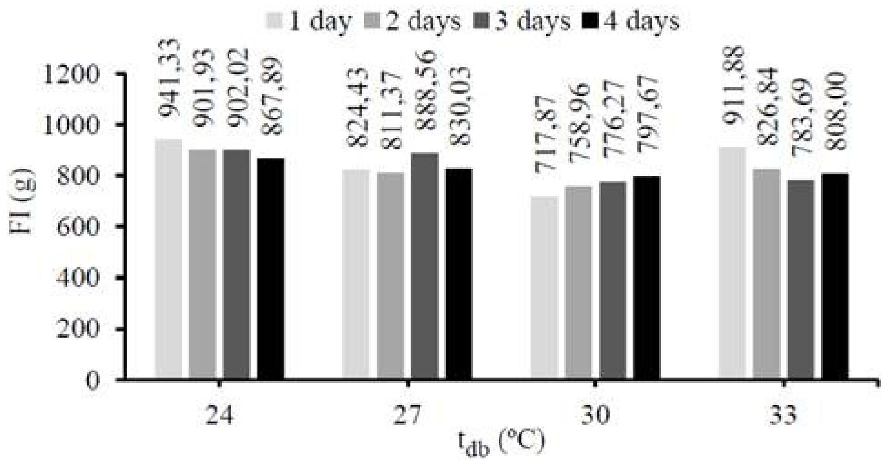


Figure 2

Analysis of feed intake (FI, g) as a function of air dry-bulb temperatures (t_{db}) and thermal stress duration evaluated.

Source: The Authors.

The interaction of t_{db} and the thermal stress duration was not significant (p>0.05, F test) for WG. Analyzing the separate effect of the different t_{db} and thermal stress duration (Table 4), there was no significant difference (p>0.05, F test). Thus, it is verified that even with the variation of FI, WG was the same in all treatments tested, thus characterizing as compensatory gain reported in several studies [30-32]. This occurs when broilers are housed in a breeding system in which t_{db} is outside the comfort zone, since the birds need to redirect the energy destined for production to the thermoregulatory process [9,10]. Thus, the birds possibly used the energy supplied by the feed to maintain body temperature [33].

Table 4

Mean weight gain (WG) and standard deviation (in brackets) accumulated in the broilers' third week of life submitted to different intensities and duration of thermal stress.

Air dry-bulb temperature (°C)	Weight gain (g)	Thermal stress duration (days)	Weight gain (g)
24	613.77 (19.74) a	1	605.33 (28.80) a
27	599.22 (21.08) a	2	598.88 (11.41) a
30	592.68 (21.29) a	3	612.73 (41.25) a
33	590.13 (44.33) a	4	578.87 (13.92) a
CV (%)		5.96	

Source: The Authors.

Means followed by different letters differ from one another by the Scott Knott test (p <0.05).

CV = Coefficient of variation.

According to the analyzes presented, the highest FI values are associated with the thermal stress of (24 and 33°C), the average being 926.60g and for thermal comfort the average was 717.86g, demonstrating that the birds consumed an average of 208.73g more to obtain the same

WG at 21 days. As the feed represents about 60% of the total costs for broiler breeding [34], any extra consumption represents financial risks for the segment, increasing the production cost, thus reducing the profit margin. In modern poultry farming, in order to keep the activity even more attractive and competitive on the world scenario, lower production costs should be obtained [35], thus, it is important to control the thermal variables inside the facilities.

The interaction ($p>0.05$, F test) between the factors assessed (t_{db} and thermal stress duration) for the FC (Table 5) was not observed. The best (1.28) and worst (1.47) FC values were observed for t_{db} of 30°C and 24°C, respectively, which are statically different ($p<0.05$, Scott-Knott test). On the other hand, the t_{db} of 27°C and 33°C presented intermediate FC values, and similar ($p>0.05$, Scott-Knott test).

Table 5
Mean and standard deviation (in brackets) of the accumulated feed conversion (FC) in the broilers' third week submitted to different intensities and duration of thermal stress.

Air dry-bulb temperature (°C)	Feed conversion ($g\ g^{-1}$)	Length of stress (days)	Feed conversion ($g\ g^{-1}$)
24	1.47 (0.01) c	1	1.38 (0.08) a
27	1.39 (0.03) b	2	1.37 (0.10) a
30	1.28 (0.06) a	3	1.38 (0.08) a
33	1.41 (0.02) b	4	1.42 (0.04) a
CV (%)		5.16	

Source: The Authors.
Means followed by different letters differ from one another by the Scott-Knott test ($p <0.05$).
CV = Coefficient of variation.

The lowest FC value associated with t_{db} of 30°C is in agreement with literature, given that this temperature is considered as thermal comfort for broilers in the second week of life [5,23].

On the other hand, the poor performance of the broilers is associated with the stress of low temperatures (24°C), because when subjected to cold stress, the growing birds modify their behavior, in which affects their physiological and metabolic functions, decreasing their productivity [10]. For t_{db} of 33°C, the FC rise in relation to the thermal comfort condition (30°C) was verified in the first day of stress duration. It was due to the use of energy intake from the feed for helping the biophysical and chemical adjustments of broilers to dissipate body heat. There was no significant difference ($p>0.05$, F test) between FC values for the various durations of thermal stress. In Fig. 3, a bar chart showing the FC as a function of t_{db}, comparing them with the performance of broilers, raised in comfort conditions, in the second week of life, according to the breed's Guide [36], with the reference value of 1.32 $g\ g^{-1}$.

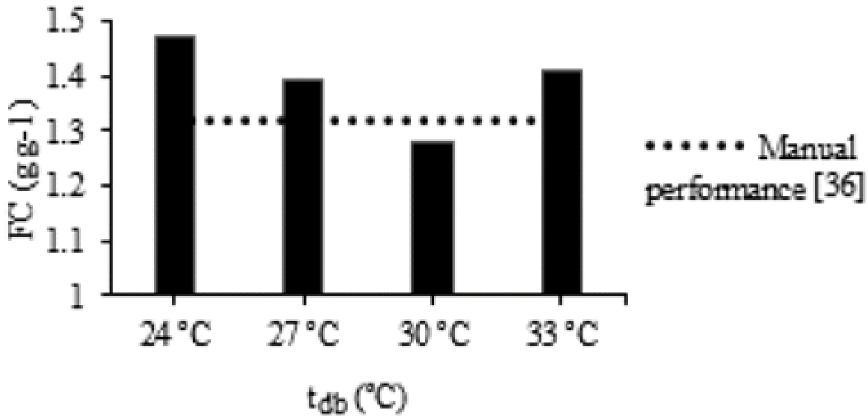


Figure 3

Feed conversion (FC, g g^{-1}) of broilers subjected to different air dry-bulb temperatures (t_{db}), compared to the performance of broilers kept in thermal comfort according to the lineage manual.

Source: The Authors.

When submitted to t_{db} 24, 27 and 33°C, the birds' performance was worse in 14.8, 8.6 and 10.1%, respectively, when compared with the comfort t_{db} (30°C). [29] observed a reduction of this variable in 9.4 and 5.7% when subjected to stress by low (24°C) and high temperatures (33°C), respectively, in the second week of life. Therefore, the results found in this study, as that obtained by [29], indicating that broilers respond in different ways when subject to low or high temperatures. Theses results corroborate with [37] that reported the deleterious effect of thermal stress in promote a fall in the final performance of the lot, damaging the productivity and profitability of the activity.

4. Conclusions

The performance of the broilers was affected as a function of the thermal stress intensities, and the best performance based on FC variable was observed for t_{db} of 30ºC, confirmed as thermal comfort for the birds' second week of life. The reduction of feed conversion to the t_{db} of 24, 27 and 33°C were 14.8, 8.6 and 10.1%, respectively.

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