Periods of heat stress during the growing affects negatively the performance and carcass yield of broilers

Mello, J.L.M.[1@]; Boiago, M.M.[2]; Giampietro-Ganeco, A.[1]; Berton, M.P.[1]; Vieira, L.D.C.[1]; Souza, R.A.[1]; Ferrari, F.B.[1] and Borba, H.[1]

[1]Department of Technology. São Paulo State University. UNESP. Jaboticabal. SP. Brazil.
[2]Department of Animal Science. University of State of Santa Catarina. UDESC. Chapecó. SC. Brazil.

Additional keywords

Environment.
Feed conversion.
Thermoregulation.

SUMMARY

The aim of this study was to evaluate the possible effect of exposure of broilers for up to 72 hours of acute heat stress, in different phases of growing, on the performance and carcass yield. Five hundred Cobb male broilers were reared in two climatic chambers equipped with heating and cooling systems. Two hundred and fifty birds were submitted to heat stress (32°C±0.5°C), for up to 72 hours, starting at 21 and 35 day old. The remaining 250 birds were kept in thermal comfort throughout the experiment. The environmental heat influenced negatively the body weight (1.595 kg) and feed conversion (1.81) of broilers submitted to heat stress from 21-days-old. After two periods of heat stress, broilers showed lower ($p<0.05$) feed intake (3.914 kg) and, consequently, body weight (1.958 kg) when compared to control group (4.182 kg and 2.097 kg, respectively). Birds subjected to heat stress at 21 day old showed decrease ($p<0.05$) of breast yield. The slaughter body weight for broilers from heat stress group decreased after the first and the second expositions to heat. Broilers submitted to periods of acute heat stress after 35 days old shows poor than broilers reared in thermal comfort. There is no influence of heat stress on the commercial cuts yield.

Períodos de estresse térmico durante o crescimento afetam negativamente o desempenho e o rendimento de carcaça de frango de corte

Palavras chave adicionais

Ambiente.
Conversão alimentar.
Termoregulação.

RESUMO

O objetivo deste estudo foi avaliar o efeito da exposição de frangos de corte por até 72 horas a estresse térmico agudo, em diferentes fases do crescimento, sobre o desempenho e rendimento de carcaça. Quinhentos frangos de corte Cobb machos foram criados por até 42 dias em duas câmaras climáticas equipadas com sistemas de aquecimento e refrigeração. Duzentas e cinquenta aves foram submetidas ao estresse térmico (32°C±0,5°C), com duração de até 72 horas, com início aos 21 e 35 dias de idade. As demais 250 aves foram mantidas em conforto térmico durante todo o experimento. O calor do ambiente influenciou negativamente o peso corporal (1,595 kg) e a conversão alimentar (1,81) de frangos de corte submetidos ao estresse por calor a partir dos 21 dias de idade. Após dois períodos de estresse térmico, os frangos apresentaram menor consumo de ração (3,914 kg) e, consequentemente, menor peso (1,958 kg), quando comparados ao grupo controle (4,182 kg e 2,097 kg, respectivamente). Aves submetidas ao estresse térmico aos 21 dias de idade apresentaram redução do rendimento de peito. O peso ao abate de frangos de corte submetidos ao estresse térmico diminuiu após duas exposições ao calor. Frangos de corte submetidos ao estresse térmico agudo após 35 dias de idade apresentam pior desempenho do que frangos de corte criados em conforto térmico. Não há influência do estresse térmico sobre o rendimento de cortes comerciais da carcaça.

Información

Cronología del artículo.
Recibido/Received: 10.5.2015
Aceptado/Accepted: 1.9.2015
On-line: 10.12.2015
Correspondencia a los autores/Contact e-mail:
julianalolli@zootecnista.com.br

INTRODUCTION

Brazil, since 2004, is the third world's producer of chicken meat and occupies the first place in exports (ABPA, 2015). According to the United States Department of Agriculture (USDA, 2015), in 2014, the Brazilian production of broilers reached about 12.7 million tons of produced meat and according the Brazilian Association of Animal Protein (ABPA, 2015) the Brazilian intake of chicken meat was approximately 42.8 kg/capita/year, 2.2% higher than 2013.

The national poultry production has developed into a complex economic sector, whose objective is the maximum meat production at the lowest cost. The productive performance of birds has improved with technological, genetic and nutritional advances, resulting in animals with accelerated metabolism, in general, with moderate capacity to protect themselves from intense heat, affecting body temperature maintenance.

Environmental temperature is the physical factor that mostly influences birds' organism. Birds are homeothermic animals that keep their body temperature through adaptive behavioral and mechanical reactions of thermoregulation, which is responsible for the maintenance and control of homeothermy by exchanging heat with the environment (Furlan and Macari, 2002).

When the environmental temperature is higher than the thermal comfort zone, the animal is submitted to a stress condition that makes its body react in an attempt to increase heat dissipation and keep the body thermal balance (Furlan and Macari, 2002). In heat stress situations, the main forms of heat loss used by the animal are radiation, convection and evaporation (Brossi *et al.*, 2009). Usually the bird spreads its wings away from the body to increase the surface in contact with the air and its feathers are raised to allow body cooling (Santos, 2007).

In Brazil, the thermal comfort conditions are difficult to achieve due to climatic changes and temperature variations caused by heat waves that directly affect livestock, especially the poultry sector. According Brossi *et al.* (2009), this is due mainly to decreased intake of food and water, the worst feed conversion and, consequently, increased mortality. High temperature and humidity, characteristics of the tropical regions, limit optimal productivity and interfere in the quality of broilers' rearing, and lineages with high growth rates are more sensitive to environmental heat than others.

The increase respiratory rate involves great muscle effort, results in a greater use of energy, and generates more heat with consequent reduction of the bird's productive efficiency. In these cases, death by prostration may occur quickly, mainly in heavier birds (Santos, 2007). Furthermore, environmental temperature (30 °C) from 4-week-old up to slaughter age has been shown to reduce growth performance as a result of decreased feed intake, growth rate and feed utilization of broilers (Cooper and Washbrun, 1998). Moreover, exposure of chickens to high temperature (32 °C) tends to reduce nutrient digestion as a result of decreasing blood flow to the digestive system (Yalcin *et al*., 2001).

The aim of this study was to evaluate the possible effect of exposure of broilers for up to 72 hours of acute heat stress, in different phases of growing, on the performance and carcass yield.

MATERIAL AND METHODS

This experiment was conducted in the poultry sector of the Faculty of Agricultural and Veterinary Sciences (Faculdade de Ciências Agrárias e Veterinárias – FCAV/UNESP), Jaboticabal, São Paulo, Brazil.

Five hundred one-day-old Cobb male broilers were used in this study. The experiment were reviewed and approved by the Ethics Committee for the Use of Animals from São Paulo State University (Jaboticabal, São Paulo, Brazil) by protocol number 4207/2010.

The following treatments were evaluated: control group, controlled environment characterized by thermal comfort using temperature and relative humidity ideal for every age, according Cobb Breeder Management Guide (Cobb, 2008); heat stress group, submitted to heat stress (32 °C±0.5 °C) for up to 72 hours, at 4th and 6th weeks of age; each group with two hundred and fifty animals.

Birds were distributed in two climatic chambers being one equipped with heaters and coolers (to provide heat during the heat stress period and comfort temperature between the heat stress periods) and other one with coolers (to provide thermal comfort temperature throughout the experiment). Birds were reared for up to 42 days.

Table I. Composition and calculated nutrient content of diets (Composição percentual e calculada das rações experimentais).

Ingredient (%)	Starter (1 to 21 day old)	Growing (22 to 35 day old)	Finisher (36 to 42 day old)
Corn grain	57.20	63.89	65.04
Soybean meal	36.94	30.26	27.86
Soybean oil	1.81	2.47	3.87
Dicalcium phosphate	1.83	1.63	1.38
Calcitic limestone	1.30	0.85	0.95
Salt	0.30	0.30	0.30
Vitamin and mineral mix *	0.50	0.50	0.50
DL- methionine (98%)	0.12	0.10	0.10
Calculated nutrient composition			
Crude protein (%)	21.5	19.00	18.00
ME (kcal/kg)	3000	3121	3225
Available phosphorus (%)	0.45	0.40	0.35
Calcium (%)	0.95	0.84	0.80
Total M+C (%)	0.85	0.78	0.75
Total methionine (%)	0.50	0.46	0.45
Total lysine (%)	1.20	1.06	1.00

ME= Metabolizable energy; M+C= methionine + cysteine; *Product composition (per kg) – Starter: A vitamin: 176.000 UI, D3 vitamin: 40.000 UI, E vitamin: 500 mg, K vitamin: 120 mg, B2 vitamin: 200 mg, B6 vitamin: 70 mg, B12 vitamin: 700 mcg, B3 vitamin: 750 mg, biotin: 3 mg, pantothenic acid: 600 mg, folic acid: 30 mg, C vitamin: 20 mg, Fe: 1.100 mg, Cu: 300 mg, I: 24 mg, methionine: 32 mg, Ca: 180 mg, P: 66 mg, Na: 23 mg, Cl: 36 mg, growth promoter: 2 mg, coccidiostatic: 10g, BHT: 1 mg, Mg: 5 g, S: 4 g, inert vehicle: 1.000 g. Growing: A vitamin: 150.000 UI, D3 vitamin: 35.000 UI, E vitamin: 480 mg, K vitamin: 110 mg, B2 vitamin: 170 mg, B6 vitamin: 70 mg, B12 vitamin: 650 mcg, B3 vitamin: 700 mg, biotin: 3 mg, pantothenic acid: 500 mg, folic acid: 25 mg, C vitamin: 12 mg, Fe: 1.100 mg, Cu: 300 mg, I: 24 mg, methionine: 20 mg, Ca: 176 mg, P: 60 mg, Na: 23 mg, Cl: 36 mg, growth promoter: 2 mg, coccidiostatic: 10g, BHT: 1 mg, Mg: 5 g, S: 4 g, inert vehicle: 1.000 g. Finisher: A vitamin: 150.000 UI, D3 vitamin: 35.000 UI, E vitamin: 450 mg, K vitamin: 100 mg, B2 vitamin: 160 mg, B6 vitamin: 70 mg, B12 vitamin: 650 mcg, B3 vitamin: 700 mg, biotin: 3 mg, pantothenic acid: 500 mg, folic acid: 25 mg, C vitamin: 12 mg, Fe: 1.100 mg, Cu: 300 mg, I: 24 mg, methionine: 18 mg, Ca: 176 mg, P: 58 mg, Na: 23 mg, Cl: 36 mg, BHT: 1 mg, Mg: 5 g, S: 4 g, inert vehicle: 1.000 g.

During the experiment, the animals were fed with different diets according to the age (starting, growing and finishing diets as described in **table I**) and formulated according to the recommendations of Rostagno *et al.* (2005) in order to meet the nutritional requirements of each phase. Water and feed were offered ad libitum throughout the experimental period using pressure drinkers and tray feeders during the first week, and then gradually replacing them by tube feeders and bell drinkers.

The rearing density was 10 birds/m², and the floor was covered with wood-shavings poultry litter (layer thickness of 10 cm). The used light program was con-

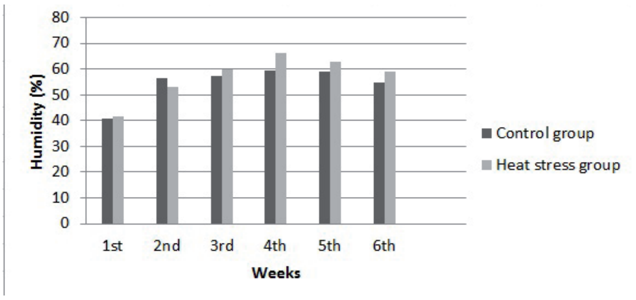

Figure 1. Average relative humidity inside the chambers throughout the experiment (Umidade relativa do ar média no interior das câmaras climáticas durante a execução do experimento).

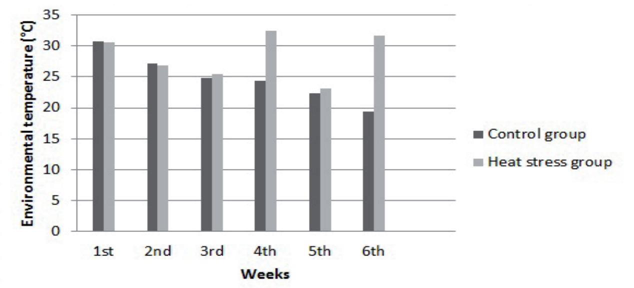

Figure 2. Average environmental temperature inside the chambers throughout the experiment (Temperatura ambiental média no interior das câmaras climáticas durante a execução do experimento).

tinuous light throughout the experiment, using incandescent 100-watt lamps.

In order to control the temperature inside the chambers, infrared lamps (250 W/127 V) were used as heaters, and the coolers were controlled by thermostats and digital thermometers so that thermo neutral temperature was achieved. Three thermo hygrometers were used to register the average temperatures and relative humidity inside of each chamber. The equipment's were placed at the extremities and at the middle of the sheds. The average relative humidity and temperature inside the chambers were recorded three times a day (morning, afternoon and night) and are shown in **figures 1** and **2**.

The group exposed to heat stress was submitted to two heat stress periods at two ages (started at 21 and 35 days; 4th and 6th weeks of age, respectively. After 72 hours, the heaters were turned off and the animals were kept again in thermo neutral conditions until the beginning of the next heat stress period, when the heaters were turned on again.

At the end of the starting phase (21 day old), growing phase (35 day old) and finishing phase (42 day old), the broilers and leftover feed were weighed to evaluate performance indices: body weight, feed intake and feed conversion. Average body weight was obtained by subtracting the final from the initial body weight. Feed conversion was calculated by dividing feed intake by body weight. Mortality was observed throughout the experiment.

Until 21 day old, birds of both groups were reared in the same environmental conditions and there were no differences related to performance, confirming that groups started the experiment in the same physical conditions.

At the beginning of each heat stress period (0 hours) and after 24, 48 and 72 hours of exposure to heat stress, during the two studied periods, 10 birds from each treatment were selected to slaughter after fasting and water diet for 8 hours. During the fasting, the birds remained under the same thermal conditions of the treatments that they were subjected. After each selection, the density was kept 10 birds/m² through the space reduction.

They were stunned in a controlled atmosphere system using carbon dioxide (CO_2) to induce and maintain the animals in a state of unconsciousness until the bleeding. The birds submitted to treatments and not selected to slaughter, remained under heat stress conditions by the end of period and waited for the beginning of the next one under a thermo neutral environment.

Before slaughter, the animals were individually weighed to obtain the slaughter body weight (SBW) and to calculate the cold carcass yield (CCY). Later, the broilers were conduced to experimental slaughterhouse in the Poultry Sector at Faculty of Agricultural and Veterinary Sciences (Faculdade de Ciências Agrárias e Veterinárias – FCAV/UNESP), Jaboticabal, São Paulo, Brazil.

To calculate the cold carcass yield was used CCY= (CCW*100)/SBW. The commercial cut yield (CY) was obtained from the weight of each cut (WC) (breast, legs and wings) and cold carcass weight (CCW) according to the formula CY= (WC*100)/CCW.

Performance data were analyzed using a completely randomized experimental design with two treatments (control and heat stress groups) done in ten replications for each group, considering the performance of each group from 1 to 35 day old and 1 to 42 day old.

Data about slaughter body weight, cold carcass yield and commercial cut yield data, collected during 4th week old and 6th-week-old, were analyzed using a completely randomized 2×4 factorial experimental design (two treatments × four heat stress periods) done in ten replications for each group. Data about the slaughter body weight, cold carcass yield and commercial cut yield at 42 day old also were analyzed using a completely randomized experimental design with two treatments and ten replications.

For performance data, each box containing 25 birds was considered one replication. For slaughter body weight, cold carcass yield and commercial cut yield each slaughtered bird was considered one replication. Data were submitted to analysis of variance and means were compared by the Tukey test at a level of significance of 5%, using the SAS (2002).

RESULTS

Table II shows the birds' performance indices, evaluated at 1 to 35 day old (with one heat stress period) and 1 to 42 day old (with two heat stress periods).

Table II. Feed intake, body weight, feed conversion and viability of broilers submitted or not submitted to heat stress, from 1 to 35 days old and 1 to 42 days old (Consumo de ração, peso corporal, conversão alimentar e viabilidade de frangos de corte submetidos ou não ao estresse térmico, de 1 a 35 dias de idade e de 1 a 42 dias de idade).

	Feed intake (kg)	Body weight (kg)	Feed conversion	Viability (%)
		1 to 35 d		
Heat stress	2.979	1.595^{B}	1.81^{A}	99.00
Control group	3.085	1.964^{A}	1.53^{B}	98.00
p-value	0.1699	<0.0001	<0.0001	0.3397
CV (%)	4.42	2.26	4.16	1.88
		1 to 42 d		
Heat stress	3.914^{B}	1.958^{B}	2.04	88.00^{B}
Control group	4.182^{A}	2.097^{A}	1.91	96.00^{A}
p-value	0.0236	0.0255	0.1964	0.0357
CV (%)	4.89	5.12	8.24	7.05

^{A,B}Means in the same column followed by different letters differ significantly by the Tukey test (5 %). CV= coefficient of variation.

Table III. Average slaughter body weight, cold carcass yield and commercial cut yield of broilers submitted to the first heat stress period, started at 21 days old (Peso médio ao abate, rendimento de carcaça fria e rendimento de cortes comerciais de frangos de corte submetidos ao primeiro período de estresse térmico, iniciado aos 21 dias de idade).

	SBW (kg)	CCY (%)	WY (%)	LY (%)	BY (%)
			Treatments (T)		
Heat stress group	0.904	81.89	10.53	25.76	28.69
Control group	0.893	80.60	10.43	25.57	29.15
			Stress duration (SD)		
Start	0.868^{B}	77.95^{A}	10.69	25.70	31.36^{A}
After 24 hours	0.833^{B}	80.68^{AB}	10.61	25.44	27.60^{BC}
After 48 hours	0.883^{B}	83.71^{A}	10.57	25.71	27.47^{C}
After 72 hours	1.012^{A}	82.63^{A}	10.04	25.81	29.26^{B}
			p – value		
Treatments	0.6780	0.1772	0.6311	0.6072	0.3200
Stress duration	<0.0001	0.0005	0.1588	0.8929	<0.0001
Int. TxSD	0.9265	0.7979	0.8700	0.2432	0.9507
CV (%)	9.85	3.99	7.22	4.67	5.52

^{A,B}Means in the same column followed by different letters differ significantly by the Tukey test (5%). SBW= slaughter body weight; CCY= cold carcass yield; WY= wings yield; LY= Legs yield; BY= breast yield; CV= coefficient of variation.

At 35 day old, after the first heat stress period, it was observed that the feed intake and viability were not influenced by heat (p>0.05), however, there were differences between evaluated groups in body weight and feed conversion, 18.8 % lower and 15.5 % higher for heat stress group, respectively. The variables have been negatively influenced by exposition to heat stress.

After the second heat stress periods (42 day old), the broilers showed a significant lower feed intake (p<0.05) and lower body weight (p<0.05) than the control group. There was no significant difference in feed conversion between the studied groups.

There was a significant increase in the percent of dead broilers after the exposure to the second heat stress period. Broilers were found dead with a normal appearance, in dorsal position and without macroscopic lesions. There was no necropsy to identify the cause of death.

During the first heat stress period, started at 21-day-old, it is observed that the average slaughter body weight, as well the cold carcass, wings, legs and breast yields, were not influenced by the environmental temperature. The birds submitted to heat stress and the control group showed, statistically, the same average results **(table III)**.

It is verified that the slaughter body weight and cold carcass yield were increased (p<0.05) with the time. The wings and legs yield were not influenced (p>0.05) by the heat stress duration. Although there has been an increase in slaughter body weight and cold carcass yield, heat stress caused reduction in breast yield, main commercial cut of chicken carcass.

The results of average slaughter body weight, cold carcass yield and commercial cut yield of broilers exposed to the second heat stress period are shown in **table IV**.

Table IV. **Average slaughter body weight, cold carcass yield and commercial cut yield of broilers submitted to the second heat stress period, started at 35 days old** (Peso médio ao abate, rendimento de carcaça fria e rendimento de cortes comerciais de frangos de corte submetidos ao segundo período de estresse térmico, iniciado aos 35 dias de idade).

	SBW (kg)	CCY (%)	WY (%)	LY (%)	BY (%)
			Treatments (T)		
Heat stress group	1.759^{B}	84.02	9.55	26.61	30.71
Control group	1.881^{A}	84.35	9.48	25.92	31.04
			Stress duration (SD)		
Start	1.700^{C}	82.59^{B}	9.42	26.08	30.97
After 24 hours	1.775^{BC}	84.42^{AB}	9.57	26.23	31.14
After 48 hours	1.858^{AB}	84.28^{A}	9.63	26.48	31.01
After 72 hours	1.948^{A}	85.44^{A}	9.42	26.27	30.37
			p - value		
Treatments	0.0039	0.5261	0.6324	0.0801	0.4768
Stress duration	0.0005	0.0037	0.6714	0.9006	0.6395
Interaction TxSD	0.6116	0.0654	0.6491	0.6057	0.7165
CV (%)	7.54	2.11	5.54	5.04	5.10

^{A,B}Means in the same column followed by different letters differ significantly by the Tukey test (5%). SBW= slaughter body weight; CCY= cold carcass yield; WY= wings yield; LY= Legs yield; BY= breast yield; CV= coefficient of variation.

Table V. **Average slaughter body weight, cold carcass yield and commercial cut yield of broilers with 42 days old, submitted to two heat stress periods** (Peso médio ao abate, rendimento de carcaça fria e rendimento de cortes comerciais de frangos de corte com 42 dias de idade, submetidos a dois períodos de estresse térmico).

	SBW (kg)	CCY (%)	WY (%)	LY (%)	BY (%)
			Treatments (T)		
Heat stress group	2.195^{B}	82.52	10.34	26.12	30.08
Control group	2.341^{A}	84.30	9.77	26.96	30.93
			p - value		
Treatments	0.0002	0.1339	0.0838	0.9094	0.0656
CV (%)	6.98	2.12	6.53	4.71	4.68

^{A,B}Means in the same column followed by different letters differ significantly by the Tukey test (5%). SBW= slaughter body weight; CCY= cold carcass yield; WY= wings yield; LY= Legs yield; BY= breast yield; CV= coefficient of variation.

During the second heat stress period (started at 35 day old), there were no effects of the environmental temperature on the cold carcass and cuts yields. There was difference ($p<0.01$) for slaughter body weight, being 6.5% lower for heat stress group.

During the heat stress, the slaughter body weight and cold carcass yield were increased ($p<0.05$), however this increase can't be attributed certainly to environmental heat. Probably this increase was due the natural growth of birds over time. During the second heat stress period, the percentage of cuts yield not was influenced ($p>0.05$) by the exposure to high temperature.

At 42 day old **(table V)**, after two expositions to heat stress, the absence of temperature effects on the cold carcass yield, wings, legs and breast yields was verified. The slaughter body weight was influenced ($p<0.05$) by the two heat stress periods and was higher in birds reared under thermal comfort throughout the experiment.

DISCUSSION

PERFORMANCE

The birds exposed to heat stress reduce the feed intake due the organism defensive mechanisms to decrease the endogenous heat production. Birds reared in thermo neutrality showed higher slaughter body weight than the birds exposed to heat stress because with the advance of age, the dissipation of body heat in birds becomes more difficult, and the decrease of feed intake, due to hyperthermia caused by the warm environment, affected the animals' performance.

At 35 day old, the body weight of broilers submitted to heat stress was approximately 18% lower ($p<0.05$) than the control group. It was a greater difference than the one found by Ribeiro *et al.* (2008) who, in a study about the effects of environmental temperature on immunity and performance of Ross broilers at 1 to 35 day old, observed a reduction of 7% body weight of broilers reared under heat stress (25°C to 32°C). These authors observed feed intake 5.5% lower than birds housed under thermo neutral environment and feed conversion statistically similar for both groups, unlike what was observed in this study.

Laganá *et al.* (2007) confirmed the effect of the high temperature on feed intake (14 % lower than control group) and body weight (10 % lower than control group) and not on feed conversion in an evaluation of performance, carcass yield and diet digestibility in broilers reared under different thermal environments. Pelicano *et al.* (2005) confirmed the effect of high temperature (33°C) on the body weight reduction in 21 day old Ross broilers, when compared to the gain of birds reared under thermo neutral temperature.

It is not known whether the prejudicial effect of heat stress on immune function of birds can be overcome by providing some nutrients in the diet. Some authors studied the vitamin supplementation during the heat stress and observed beneficial results (Ribeiro *et al.*, 2008). However, Pelicano *et al.* (2005) claim that hyperthermia caused by high environmental temperature leads to decrease of feed intake in an attempt to reduce metabolic heat production, consequently, affecting the performance. Thus, manipulation of diet ingredients as an attempt to combat the environmental heat and provide thermal comfort can be a viable alternative but still needs to be further investigated.

According to Faria Filho *et al.* (2006), the reduction of feed intake can reach 36 % in broilers reared at 32°C when compared to birds reared at 22°C. The decrease of body weight in birds from heat stress group is higher than the decrease of feed intake caused by the deviation of the metabolizable energy used to dissipate endogenous heat excess by evaporation, which harms the animal feed conversion.

Marchini *et al.* (2009), studying broilers with 42 day old submitted to cyclic high environmental temperature, observed a decrease of about 7 % in the body weight of birds reared in warm environment. These differences of weight gain, verified at the end of productive cycle under high temperature, can indicate a lower tolerance and more sensibility of older broilers to environment heat.

Carcass yield

During the first heat stress period (started at 21 day old) an 11.99 % decrease of the breast yield in birds exposed to 24 hours of high temperature was observed. Oliveira *et al.* (2006b) also noticed a negative effect of temperature on the breast yield (9.5 % lower). Studies have revealed that the reduction of breast yield is directly related to inadequate intake of nutrients and energy, reducing the synthesis and storage of glycogen, the main source of energy for the breast (Rosa *et al.*, 2007). Faria Filho *et al.* (2006) attributed the lower breast muscle development to the increased respiratory frequency due to heat stress. This increase in respiration provides a higher activity of the breast muscles, whose development is hampered by the limited reserves of glycogen in the animal body.

Other studies have shown that exposure to high environmental temperatures has resulted in higher leg yield and lower breast yield (Faria Filho *et al.*, 2006), and are associated to muscle metabolism, glycolytic to breast muscles and oxidative to legs muscles (Macari *et al.*, 2002).

Oliveira *et al.* (2006a) reported a possible influence of high environmental temperature on protein metabolism, so that the depositing of this nutrient in the leg muscle tissue has priority over breast muscle in broilers, and this differential muscle growth, attributed to high temperature, can be related to the muscle fiber characteristics, they are predominantly white with less blood supply in the breast, and predominantly red in the legs, and, therefore, more blood flow. These modifications in protein metabolism (synthesis and degradation) can explain the differences in the muscle protein gain and development of breast and leg muscles in birds reared under thermal stress conditions. However, further development of legs instead of the breast was not observed in this study at any age.

After the second heat stress period (started at 35 day old), the yield percentages of evaluated commercial cuts were not influenced by the exposure to the high temperature, differently from the results obtained by Faria Filho *et al.* (2006) who observed higher carcass yield in broilers submitted to heat stress; by Oliveira *et al.* (2006a) who found higher leg yield in birds maintained in warm environment; and by Rosa *et al.* (2007) who related decrease in breast muscle yield with different genetic potential broilers submitted to heat stress.

According to Fernandes *et al.* (2013), broilers need to keep the internal body temperature at relatively constant levels in environments where temperature conditions are variable, through physiological mechanisms represented by compensation. These adjustments are done at the expense of production from these animals that instead of employing the nutrients for the synthesis use them to generate or dissipate heat. In tropical countries as Brazil, high temperatures become a serious factor on rearing of broilers, because the thermal stress in the age next the slaughter affects directly and negatively influencing the meat quality.

CONCLUSIONS

Broilers submitted to periods of acute heat stress after 35 days old shows poor performance like lower feed intake, lower body weight, higher feed conversion, lower viability and lower slaughter body weight than broilers reared in thermal comfort. There is no influence of heat stress on the commercial cuts yield.

ACKNOWLEDGMENTS

This study was financially supported by Foundation for Research Support in the State of São Paulo (Fundação de Amparo à Pesquisa do Estado de São Paulo – FAPESP, 2009/53628-1) to whom the authors want to express their gratitude.

BIBLIOGRAPHY

ABPA. Associação Brasileira de Proteína Animal. 2015. Avicultura. Estatísticas do Mercado interno. Relatório Anual 2015. http://abpa-br.com.br/setores/avicultura/mercado-interno/frango (29/08/2015).

Brossi, C.; Contreras-Castillo, C.J.; Amazonas, E.A. and Menten, J.F.M. 2009. Heat stress during the pre-slaughter on broiler chicken. *Ciênc Rural*, 39: 1296-1305.

Cobb. 2008. Cobb Breeder Management Guide. http://cobb-vantress.com/docs/default-source/guides/cobb-broiler-management-guide--english.pdf (01/09/2015).

Cooper, M.A. and Washburn, K.W. 1998. The relationships of body temperature to weight gain, feed consumption, and feed utilization in broilers under heat stress. *Poultry Sci*, *77*: 237-242.

Faria Filho, D.E.; Rosa, P.S.; Figueiredo, D.F.; Dahlke, F.; Macari, M. and Furlan, R.L. 2006. Low-protein diets on broilers performance reared under different temperatures. *Pesqui Agropecu Bras,* 41: 101-106.

Fernandes, J.I.M.; Scapini, L.B.; Gottardo, E.T.; Burin Junior, A.M.; Marques, F.E.S. and Gruchouskei, L. 2013. Thermal conditioning during the first week on performance, heart morphology and carcass yield of broilers submitted to heat stress. *Acta Sci*, 35: 311-319.

Furlan, R.L. and Macari, M. 2002. Termorregulação. In: Macari, M.; Furlan, R.L. and Gonzales, E. Fisiologia aviária aplicada a frangos de corte. Funep-Unesp. Jaboticabal. Brazil. pp. 209-228.

Laganá, C.; Ribeiro, A.M.; Kessler, A.M.; Kratz, L.R. and Pinheiro, C.C. 2007. Effects of the reduction of dietary heat increment on the performance, carcass yield, and diet digestibility of broilers submitted to heat stress. *Braz J Poultry Sci,* 9: 45-51.

Macari, M.; Furlan, R.L. and Gonzales E. 2002. Fisiologia aviária aplicada a frangos de corte. Jaboticabal. Ed. Funep/Unesp. Brazil. 375 pp.

Marchini, C.F.P.; Silva, P.L.; Nascimento, M.R.B.N.; Beletti, M.E.; Guimarães, E.C. and Soares, H.L. 2009. Intestinal morphometry of the duodenal mucosa in broiler chickens underwent to high cyclic environment temperature. *Arq Bras Med Vet Zoo,* 61: 491-497.

Oliveira, G.A.; Oliveira, R.F.M.; Donzele, J.L.; Cecon, P.R.; Vaz, R.G.M.V. and Orlando, U.A.D. 2006b. Effect of environmental temperature on performance and carcass characteristics of broilers from 22 to 42 days old. *Rev Bras Zootecn,* 35: 1398-1405.

Oliveira, R.F.M.; Donzele, J.L.; Abreu, M.L.T.; Ferreira, R.A.; Vaz, R.G.M.V. and Cella, O.S. 2006a. Effects of temperature and relative humidity on performance and yield of noble cuts of broilers from 1 to 49 days old. *Rev Bras Zootecn*, 35: 797-803.

Pelicano, E.R.L.; Bernal, F.E.M.; Furlan, R.L.; Malheiros, E.B. and Macari, M. 2005. Effect of environmental temperature and protein or energy restriction on body weight gain and broiler chicken bone growth. *Arq Bras Med Vet Zoo*, *57*: 353-360.

Ribeiro, A.M.L.; Vogt, L.K.; Canal, C.W.; Laganá, C. and Streck, A.F. 2008. Vitamins and organic minerals supplementation and its effect upon the immunocompetence of broilers submitted to heat stress. *Braz J Poultry Sci*, 37:636-644.

Rosa, P.S.; Faria Filho, D.E.; Dahlke, F.; Vieira, B.S.; Macari, M. and Furlan, R.L. 2007. Performance and carcass characteristics of broiler chickens with different growth potential and submitted to heat stress. *Braz J Poultry Sci*, 9: 181-186.

Rostagno, H.S.; Albino, L.F.T.; Donzele, J.L.; Gomes, P.C.; Oliveira, R.F. and Lopes, D.C.; Ferreira, A. S.; Barreto, S. L.T. 2005. Tabelas brasileiras para aves e suínos: composição de alimentos e exigências nutricionais. 2nd ed. Editora UFV. Viçosa. MG. Brazil. 186 pp.

Santos, C.C. Mecanismos adaptativos em frangos submetidos a estresse térmico agudo pré-abate e suas implicações na funcionalidade proteica muscular. 2007. Dissertação (Mestrado em Agronomia). Universidade de São Paulo. Escola Superior de Agricultura Luiz de Queiroz. Piracicaba. Brazil. 58 pp.

SAS. User's Guide. 2002. Release 9.1. SAS Inst. Inc. Cary. NC.

USDA. United States Department of Agriculture. 2015. Brazil Poultry and Products Annual Report. http://gain.fas.usda.gov/Recent%20GAIN%20Publications/Poultry%20and%20Products%20Annual_Brasilia_Brazil_8-13-2015.pdf (29/08/2015).

Yalcin, S.; Ozkan, S.; Turkmul, L. and Siegel, P.B. 2001. Responses to heat stress in commercial and local broiler stocks. 1. Performance traits. *Brit Poultry Sci,* 42: 149-152.