



# How heat stress (continuous or cyclical) interferes with nutrient digestibility, energy and nitrogen balances and performance in broilers

Lilian Francisco Arantes de Souza, Livia Pegoraro Espinha, Eduardo Alves de Almeida, Raquel Lunedo\*, Renato Luís Furlan, Marcos Macari

Department of Animal Morphology and Physiology, College of Agriculture and Veterinary Sciences, São Paulo State University (UNESP), Via de Acesso Paulo Donato Castellane s/n, CEP: 14884-900 Jaboticabal, São Paulo, Brazil

## ARTICLE INFO

### Article history:

Received 23 November 2015

Received in revised form

30 August 2016

Accepted 31 August 2016

### Keywords:

Cyclical heat stress  
Continuous heat stress  
Nutrient digestibility  
Heat production  
Nitrogen efficiency  
Pair-feeding

## ABSTRACT

The effect of continuous and cyclical heat stress on broiler growth performance, nutrient digestibility, energy and nitrogen balances was investigated. Four hundred and fifty, 21-day-old, Cobb male broilers were raised in battery cages in five treatments: 22C/AL (continuous 22 °C, *ad libitum* feed consumption); 32C/AL (continuous 32 °C, *ad libitum* feed consumption); 22C/PF32C (continuous 22 °C, pair-fed on the daily feed intake of 32C/AL); CY/AL (cyclical – 32 °C for 8 h and 25 °C for 12 h, *ad libitum* feed consumption); 22C/PFCY (continuous 22 °C, pair-fed on the daily feed intake of CY/AL). Between 39 and 42 days of age, dry matter, crude protein, crude fat and AME<sub>n</sub> were analyzed in the diets and excreta to determine nutrient digestibility. Energy and nitrogen balances were evaluated through comparative slaughter (21 and 42 days of age). Growth performance was significantly lower in broilers exposed to either continuous or cyclical heat stress. However, the cyclical heat stress had a lower effect on feed intake and weight gain and no effect on the feed conversion rate. Nutrient digestibility was only influenced by continuous heat exposure, decreasing dry matter (3.9%) and protein digestibility (9.7%) in comparison to control birds. Broilers exposed to continuous heat stress increased metabolizable energy intake (20.3%) and heat production (35.5%), and decreased energy retention (20.9%) and energy efficiency (32.4%) in relation to control ones. Nitrogen intake and nitrogen retention were reduced by both forms of heat exposure, in comparison to control, but more strongly under continuous heat. Nitrogen retention was reduced by 50.4% and 20.4%, for continuous or cyclical heat stress, respectively. Nitrogen efficiency was reduced only by the continuous heat exposure (33.1%). These results revealed important differences between the effects of a continuous or a cyclical heat exposure in broiler chickens for digestibility, performance and energy and nitrogen balances.

© 2016 Published by Elsevier B.V.

## 1. Introduction

Heat stress causes great losses to the poultry industry, and especially, the broiler industry. In addition to the concerns regarding performance impairment, recently there has been increased research on the effects of heat stress due to the increased pressure of “global warming” (Gregory, 2010; Nardone et al., 2010).

Broilers under heat stress conditions show decreased feed intake. While this drop in feed consumption (Dale and Fuller, 1979; Abu-Dieyeh, 2006) affects weight gain and the feed conversion ratio, it does not fully explain the complete damage to growth performance. Hence, it is necessary to isolate the effects of high temperature *per se* from the effects of reduced feed intake in response to the heat stress.

Bonnet et al. (1997) concluded that some of the broiler performance loss caused by continuous heat exposure can be attributed to a decrease in nutrient digestibility. This effect could be due to peripheral vasodilation and reduced blood flow in the gut. However, the high temperature effect *per se* in metabolizable energy remains controversial, showing, depending upon the study, an increase (Keshavarz and Fuller, 1980), a decrease (Yamazaki and Zi-Yi, 1982) and no effect (Geraert et al., 1992; Faria Filho et al., 2007). Furthermore, continuous heat exposure directly affects carcass composition and energy metabolism, independently of feed consumption (Geraert et al., 1996). Protein metabolism is also affected through a decrease in nitrogen consumption and body retention (Temim et al., 1999). Finally, Temim et al. (2000) found decreases in muscle protein deposition in heat-stressed (32 °C) broiler chickens at 5–6 weeks of age, mainly by reducing protein synthesis, but also by an increase in proteolysis.

Gonzales-Esquerria and Leeson (2006) demonstrated the importance of distinguishing the type of heat exposure in broiler

\* Corresponding author.

E-mail address: [bln.raquel@yahoo.com.br](mailto:bln.raquel@yahoo.com.br) (R. Lunedo).

experiments. Continuous heat stress was most widely used in research that isolated the direct effect of heat from the feed intake reduction on the metabolism of birds (Geraert et al., 1996; Abu-Dieyeh, 2006). However, continuous heat stress does not normally occur in natural environments, and the effects described for continuous heat exposure cannot occur in cyclical heat conditions (Mashaly et al., 2004).

This study tested the hypothesis that growth performance, nutrient digestibility, and energy and nitrogen balances will respond differently in broiler chickens exposed to either a continuous or a cyclic heat stress between 21 and 42 days of age.

## 2. Materials and methods

### 2.1. Birds and Management

This study was conducted in accordance with the ethical principles for animal experimentation adopted by the Brazilian College of Experimentation (COBEA), and with approval of the local Committee for Ethical Animal Use (CEUA), Protocol 019508/09, São Paulo State University (UNESP), Jaboticabal, SP, Brazil.

The birds were raised in three climate-controlled chambers, measuring 6.0 m × 8.0 m, with concrete floors. The walls and ceilings consisted of insulating material with four exhaust fans. The chambers were equipped with cooling systems and infrared lamps, all thermostatically controlled. Ninety (90) battery cages 1 m wide, 0.60 m deep and 0.40 m high, with 5 birds/cage were used. The cages had wire flooring, trough feeders and cup waters.

Four hundred fifty (450), one-day-old male Cobb broiler chicks were first brooded in wood shaving bedding. All birds received the same diet (Table 1) until 21 days of age and were grown at the temperature recommended for Cobb 500™ broilers. At 21 days of age, the birds were weighed and experimental units were composed of chickens with the same average weight.

The birds were transferred to battery cages and distributed in a completely randomized design with five treatments: 22C/AL (continuous 22 °C, *ad libitum* feed consumption); 32C/AL (continuous 32 °C, *ad libitum* feed consumption); 22C/PF32C (continuous 22 °C, pair-fed on the daily feed intake of 32C/AL); CY/AL (cyclical – 32 °C for 8 h and 25 °C for 12 h, *ad libitum* feed consumption); 22C/PFCY (continuous 22 °C, pair-fed on the daily feed intake of CY/AL) (Table 2). There were five treatments with six replicates of 15 birds each (three cages of 5 birds/cage), totaling 30 experimental units. The birds were subjected to the experimental treatments from 21 to 42 days of age.

For the continuous heat treatments (treatments with the prefix “22C” and “32C”), the birds were subjected to a constant temperature of 22 and 32 °C, respectively. For the cyclical treatment (CY/AL), the birds were subjected to an oscillating temperature scheme of 8 h at 32 °C (9h00 to 17h00) and 25 °C for 12 h (19h00 to 7h00), with 2 h to elevate the temperature from 25 °C to 32 °C and 2 h to reduce the temperature from 32 °C to 25 °C. The climatic chambers had no humidity control, and the average relative humidity throughout the experiment was 66%, 60%, and 68% for the 22C, 32C, and CY chambers, respectively.

All birds received the same diet, formulated according to Ros-tagno et al. (2005) (Table 1). Birds reared in 22C/AL, 32C/AL, and CY/AL were fed *ad libitum*. For the 22C/PF32C and 22C/PFCY treatments, birds were allocated (in four portions) the same amount of feed consumed by the birds in the 32C/AL and CY/AL treatments on the previous day. The pair-feeding schedule was used to separate the effects of temperature from the effects of feed intake. The lighting regimen was 23:1 h light: dark. This program was used due to the melatonin effect of feed intake (Phetteplace and Nockels, 1985; Clark and Classen, 1995).

**Table 1**

Ingredient and nutrient composition of broiler diets.

Ingredients (%)	Starter (1–21 days)	Grower (22–42 days)
Corn	57.96	58.47
Soybean meal <sup>a</sup>	35.62	32.42
Soybean oil	2.57	5.47
Dicalcium phosphate <sup>b</sup>	1.82	1.68
Limestone	0.99	0.95
Salt	0.44	0.40
Choline chloride (60%)	0.10	0.10
DL-methionine (99%)	0.15	0.14
L-lysine HCl (78%)	0.16	0.18
Vitamin-mineral premix <sup>c</sup>	0.10	0.10
Antibiotic <sup>d</sup>	0.04	0.04
Coccidiostat <sup>e</sup>	0.05	0.05
<b>Calculated analysis</b>		
Metabolizable energy (MJ/kg)	12.55	13.39
Crude protein (%)	21.40	20.00
Calcium (%)	0.96	0.90
Available phosphorus (%)	0.45	0.42
Sodium (%)	0.22	0.20
Potassium (%)	0.83	0.77
Chlorine (%)	0.37	0.35
Choline (ppm)	1950	1868
Digestible lysine (%)	1.14	1.08
Digestible Methionine (%)	0.45	0.42

<sup>a</sup> Soybean meal contains 45% CP.

<sup>b</sup> Dicalcium phosphate contains 24.5% of calcium and 18.5% of available phosphorus.

<sup>c</sup> Composition of vitamin-mineral premix per kg of product: vitamin A 7,000,000 IU; vitamin D3 3,000,000 IU; vitamin E 25,000 mg; vitamin K 980 mg; vitamin B1 1780 mg; vitamin B2 9600 mg; vitamin B6 3465 mg; vitamin B12 10,000 mcg; nicotinic acid 34,650 mg; calcium pantothenate 9500 mg; biotin 1600 mg; copper 10,000 mg; iodine 1300 mg; manganese 76,260 mg; selenium 273.6 mg; zinc 91,250 mg; antioxidant (Butylated hydroxytoluene) 100 mg.

<sup>d</sup> Zinc bacitracin 15%.

<sup>e</sup> Salinomycin sodium 12%<sup>®</sup>.

**Table 2**

Treatments according to temperature/feeding (21–42 days of age).

Treatment	Temperature (°C)	Feeding
22C/AL	22 constant	<i>Ad libitum</i>
32C/AL	32 constant	<i>Ad libitum</i>
22C/PF32C	22 constant	<i>Pair-fed to 32C/AL<sup>a</sup></i>
CY/AL	32 cyclic	<i>Ad libitum</i>
22C/PFCY	22 constant	<i>Pair-fed to CY/AL<sup>a</sup></i>

<sup>a</sup> Continuous and cyclic heat exposed broilers' (32C/AL and CY/AL) feed intake was measured daily and allocated to 22C/PF32C and 22C/PFCY, respectively.

### 2.2. Measurements

Growth performance was evaluated from 21 to 42 days of age through feed intake (FI), body weight gain (BWG), feed conversion rate (FCR), and mortality (MORT). From 39 to 42 days of age, after an adaptation period of 3 days, total excreta was collected to measure the nutrient digestibility. Excreta was collected twice a day (7:00 a.m. – morning collection – and 6:00 p.m. – afternoon collection), pooled and frozen. Later, it was dried at 55 °C for 72 h and ground. The 22C/PF32C and 22C/PFCY groups were fed 8 times a day during the digestibility assay. Diets and excreta were analyzed in triplicate to determinate dry matter, crude protein and crude fat according to AOAC (1984). The apparent metabolizable energy was adjusted for nitrogen balance (AME<sub>N</sub>) according to the methodology of Hill and Anderson (1958) using a PARR 1281 adiabatic calorimeter. Dry matter (DMD), crude protein (CPD), and crude fat (CFD) digestibility were calculated from the differences between nutrient excretion (excreta) and ingestion (diet). The digestibility values were calculated as a percentage.

Download English Version:

<https://daneshyari.com/en/article/2446853>

Download Persian Version:

<https://daneshyari.com/article/2446853>

[Daneshyari.com](https://daneshyari.com)