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MELATONIN ENTRAINS CIRCADIAN RHYTHMICITY OF COLONIC TEMPERATURE IN LAYING HENS DURING THE HOT-DRY SEASON

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ABSTRACT

Experiments were conducted with the aim of evaluating effects of melatonin on fluctuations in colonic temperature (CT) of 26 Isa Brown layers during the hot-dry season. The CT of 14 melatonin-treated and 12 control laying hens were taken for 2 days, one week apart, at 06:00 h, 14:00 h, using standard digital thermometer, inserted through the cloaca into the rectum. Unlike the control birds that were given water only, the treated layers were individually administered at 18:00 h with melatonin orally at 1.5 mg/kg daily throughout the period of the experiment. The overall mean CT in experimental (n = 14) and control (n = 12) birds were 41.0 ± 0.05^{0}C and 40.9 ± 0.04^{0}C, respectively ($P < 0.05$). The recorded hourly CT of the melatonin-treated group was lowest at 06:00 h (40.9 ± 0.10^{0}C) and highest at 18:00h (41.2 ± 0.05^{0}C, $P < 0.05$). The hours of the day had an opposite effect on CT of melatonin-treated ($r = 0.4154$, $P < 0.01$) and control ($r = 0.2447$, $P > 0.05$) layers. The relative humidity was negatively correlated with the CT in both melatonin-treated ($r = -0.6495$, $P < 0.001$) and control ($r = -0.3294$, $P < 0.05$). The results indicated that only the CT of the melatonin-treated layers showed distinct diurnal fluctuations. The findings showed that layer birds administered with melatonin had higher CT values. This indicated the entrainment of CT circadian rhythm and considerable metabolic effect of melatonin administration on the treated layers. It is concluded that melatonin administration to layers sustained homeostasis and enhanced metabolic processes during the stressful period of the hot-dry season, and, thus, may enhance their productivity in the Northern Guinea Savannah Zone of Nigeria.

1. INTRODUCTION

Adaptation to the harsh weather conditions of the hot-dry season is stressful to birds (Ayo *et al*., 2005). Heat stress is caused by high environmental temperature and high relative humidity (RH). It reduces the performance of layer hens by interrupting egg production; an effect caused not only by a reduction in feed intake, but also by a decrease in responsiveness of granulosa cells to luteinizing hormone and disruption of hormones responsible for ovulation (Franco-Jimenez *et al*., 2007; Dai *et al*., 2011). Heat stress induces oxidative stress causing impairment in body functions and economic losses (Khan and Sardar, 2005). Several expensive and cumbersome methods are available for adoption by poultry farmers to alleviate the adverse effects of heat stress on the performance of laying hens (Ubosi and Gandu, 1995; Minka and Ayo, 2008). Therefore, supplementation of antioxidants to mitigate the oxidative stress has become a common practice in the poultry industry (Zhao et al., 2011). Melatonin was found to alleviate the harmful effects of heat stress on broiler chickens by maintaining their temperatures at relatively low values (Sinkalu et al., 2014). It is conceivable that administration of the antioxidant, melatonin (Maldonado *et al*., 2012) to layer hens during the hot-dry season, prevailing in the Northern Guinea Savannah zone of Nigeria may be beneficial.

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2. AIM OF THE STUDY

To determine the effects of melatonin on the fluctuations in colonic temperature of Isa Brown layers during the hot-dry season.

3. MATERIALS AND METHODS

3.1 SITE AND LOCATION OF THE EXPERIMENT

The experiment was performed in a standard poultry house at the Department of Physiology, Faculty of Veterinary Medicine, Ahmadu Bello University, Zaria (11^{o}4□N, 7^{o}42□E), located in the Northern Guinea Savannah zone of Nigeria.

3.2 METEOROLOGICAL DATA

The dry- and wet-bulb temperatures at the experimental site were measured using a dry- and wet-bulb thermometers (Brannan ®, England), at 06.00 h, 14.00 h and 18.00 h daily for 12 consecutive days. From the data, RH and temperature-humidity index (THI) of each hour of the measurement were calculated. The THI was calculated using the equation of Avendano-Reyes *et al.* (2006):

$$THI = (0.41 \times AT) + RH\ (AT – 14.4) + 23.2$$

Where AT = ambient temperature

The meteorological data of rainfall, evaporation, maximum AT, wind speed, minimum AT, RH, wind direction and sunshine duration during the study were collated from the Meteorological Unit, Institute for Agricultural Research, Ahmadu Bello University, Zaria, Nigeria, located at a distance of 1km from the experimental site.

3.3 EXPERIMENTAL PROCEDURE

The colonic temperature (CT) of 14 melatonin-treated and 12 control laying hens were measured for 2 days, 1 week apart, at 06:00 h, 14:00 h, and 18:00 h using a standard digital thermometer inserted into the cloaca. The control birds were given water only, while the treated layers were individually administered with melatonin orally at 1.5 mg/kg daily for 12 days at 18:00 h.

3.4 STATISTICAL ANALYSES

Data were analyzed using the Student's *t*-test to compare between melatonin-treated and control hens, while one-way analysis of variance was used to compare between diurnal fluctuations in CT of the birds at 06:00 h, 14:00 h and 18:00 h. Pearson's correlation analysis was used to establish relationships between CT and thermal environmental parameters, including dry-bulb temperature, RH and THI**.** Multiple means were compared by Tukey's *post-hoc* test. Data were expressed as mean ± SEM. Analyses were performed using Graphpad prism software package version 4.0 for windows, San Diego, California, USA (www.graphpad.com). Values of P < 0.05 were considered significant.

4. RESULTS

The overall mean value of CT for the melatonin-treated (n = 14) and control (n = 12) birds were 41.0 ± 0.05 °C and 40.9 ± 0.04 °C, respectively (P < 0.05). The hourly CT value of the melatonin-treated group was lowest at 06:00 h (40.9 ± 0.10 °C) and highest at 18:00 h (41.2 ± 0.05 °C, P < 0.05). In the control layers, the CT values recorded from 06:00 h to 14:00 h were not different (P > 0.05). The findings showed that the CT values were higher (P < 0.05) in layer birds administered with melatonin, compared to those of control laying hens. The hour of the day was significantly correlated with CT values of melatonin-treated layers (r = 0.4154, P < 0.01), but not with those of control layers (r = 0.2447, P > 0.05). The RH was negatively correlated with the CT in melatonin-treated (r = -0.6495, P < 0.001) and control (r = -0.3294, P < 0.05) laying hens. The result also indicated that the CT of the melatonin-treated layers showed diurnal fluctuations. The finding indicated circadian rhythm entrainment in the CT values, and considerable metabolic effect of melatonin administration on the laying hens.

Table 1: Proximate Analysis of the Ration fed to the Layer Hens during the Hot-dry Season

Ingredient, %	Values
Dry matter	94.58
Crude protein	16.19
Crude fibre	6.24
Oil	4.87
Ash	4.76
Nitrogen free extract	67.94

Proximate analysis of the feed was conducted at the biochemical laboratory of the Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria.

Table 2: Meteorological Data from the Study Period

Meteorological Parameters	Mean ± SEM
Maximum AT, ºC	33.2 ± 1.13
Minimum AT, ºC	21.4 ± 0.61
Range AT, ºC	11.8 ± 1.08
AT, ºC	30.99 ± 0.68
RH, %	71.2 ± 3.31
THI, ºC	44.98 ± 0.37
Sunshine duration, h/d	7.3 ± 0.72
Rainfall, mm	6.0 ± 2.69
Evaporation, mm/d	10.5 ± 0.84
Wind speed, m/s	2.7 ± 0.21
Wind direction	SW/NW

AT = Ambient temperature, RH = Relative humidity, THI = Temperature-humidity index, NW = North-West, SW = South-West

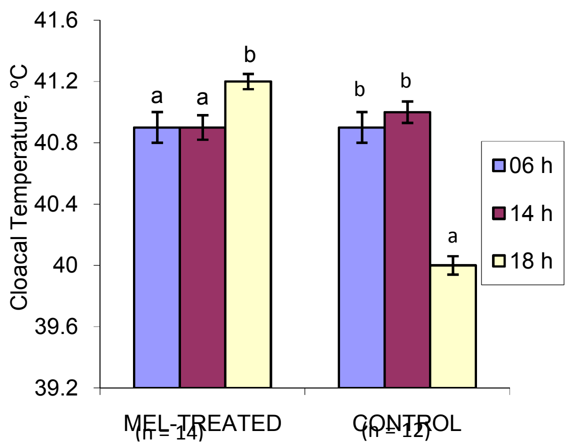

Fig.1: Fluctuations in circadian rhythm of colonic temperature in laying hens administered with melatonin (MEL) during the hot-dry season

Table 3: Relationship between dry-bulb temperature, relative humidity, temperature humidity-index, hour of day and colonic temperature during the hot-dry season

Correlated parameters	**MEL-treated, (n = 14)**	**Control, (n = 12)**
DBT and CT	0.6737***	0.2885^{NS}
RH and CT	-0.6495***	-0.3294*
THI and CT	0.4593**	0.1000^{NS}
Hour of day and CT	0.4154**	0.2447^{NS}

*** = P < 0.0001, ** = P < 0.01, NS = Non-significant difference, * = P < 0.05
CT = colonic temperature, DBT = dry-bulb temperature, RH = relative humidity,
THI = temperature-humidity index

5. DISCUSSION

The higher colonic temperature values recorded in melatonin-treated laying hens were attributed to higher laying performance, resulting from greater metabolic and production processes. The findings agree with the results of Osei *et al.* (1989), who reported that melatonin enhanced weight gain, feed conversion ratio and energy retention by an average of 19 % in male broiler chickens. Thus, high metabolic activity overruns high laying performance in hens, which is capable of increasing body temperature within physiological limits. Furthermore, melatonin circadian rhythmicity entrainment of colonic temperature observed in the present study is suggestive of its innate ability to enhance productive activities in laying hens during the day.

The significantly higher colonic temperature response obtained in the melatonin-treated group obtained at 18:00 h showed that the treated layer hens were engaged in higher metabolic or production processes at this time than the early hours of the day. The findings agree with the results of Weaver and Lockley (2009), who found that melatonin regulates circadian rhythmicity of various physiological parameters in vertebrates.

6. CONCLUSION

It is concluded that melatonin administration stabilises fluctuations in circadian rhythmicity and reduces CT responses of laying hens to heat stress in the Northern Guinea Savannah zone of Nigeria.

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