THE MODULATING EFFECT OF TAURINE ON CIRCADIAN RHYTHM OF SERUM CALCIUM IN MALE BROILER CHICKENS DURING HOT-DRY SEASON.

Harold Kuta Makeri[*], Joseph Olusegun Ayo[‡], Tagang Aluwong[‡] and Ndazo Salka Minka[*]

[*] Division of Agricultural Colleges, Department of Animal Health and Husbandry, College of Agriculture and Animal Science, Ahmadu Bello University, Mando-Kaduna, Nigeria
[‡] Faculty of Veterinary Medicine, Department of Physiology, Ahmadu Bello University, Zaria, Nigeria.
Corresponding author: Harold Kuta Makeri, +2349067831084, +2348089288150, kutamakeri@gmail.com, mhkuta@abu.edu.ng

ABSTRACT
An experiment was conducted to study the modulatory effect of supplemental taurine on rhythm of serum calcium in male broiler chickens of different ages during the hot-dry season. Twenty, 21-day old Arbor Acre male broiler chickens were assigned ten each to control (Cgp) and treatment (Tgp) groups in a completely randomized design. The broiler chickens in the Tgp were served drinking water which contained taurine at a dose rate of 0.1% and the Cgp, clean drinking water *ad libitum* along with their standard diet from day 21 to 42 of the study period. Two (2mL) millilitres of blood samples was collected from the wing vein from each broiler chicken in the respective groups on a four-hourly basis over a 24 h period on scheduled days 28, 35 and 42. Serum samples were harvested for determination of serum calcium concentration using flame emission photometric method. The collected data was fitted into the single cosinor application, results showed serum calcium exhibited clear circadian rhythmicity in both groups. Taurine significantly ($P < 0.05$) increased the mesors of serum calcium in all age groups. The acrophases in Cgp fluctuated between the early (3.2 h) to the late (15.6 h) photophase, however, in Tgp the acrophases were restricted to the early photophase (7.9 h, 6.4 h and 7.4 h, respectively). It was concluded taurine modulated the rhythms of serum calcium in all age groups. The finding may be beneficial in combating low calcium ionization during heat stress, thereby improving calcium levels, regulating body temperature and improving immunity during the hot-dry season.

Keywords: Broiler chickens, Circadian rhythm, Hot-dry season, Serum calcium, Taurine,

Introduction

Heat stress affects physiological potentials in birds (Ayo *et al.,* 2010). Behavioural changes; locomotion, Gular flutter, feed and social states are mechanisms of heat dissipation in birds with increased respiration/muscle activity resulting in excess heat generation, respiratory alkalosis (Abbas *et al.,* 2012) and loss of electrolytes (Borges *et al.,* 2004). Decreased feed intake also decreases intake of electrolytes in the diets (Scanes, 2015). Heat stress causes increased blood sodium and chloride concentrations (Abbass *et al.,* 2012) whereas the concentrations of potassium and phosphates are reduced (Yosi *et al.,* 2017). The study was aimed at determining the effect of taurine in modulating the changes in serum calcium during the hot-dry season.

Materials and Methods

The study was conducted in March to May, 2020, at the poultry experimental pen of College of Agriculture and Animal Science, Mando-Kaduna (11° 10/N, 07° 38/E), which is located in the Northern Guinea Savannah zone of Nigeria. Approval for the study protocol was obtained from the Institutional Animal Care and Use Committee of Ahmadu Bello University, Zaria (ABUCAUC) with approval number ABUCAUC/2021/122.

Twenty (20) 21-day-old clinically-healthy Arbor Acres hybrid male broiler chickens with similar weights, were preconditioned prior to commencement of experiment. The birds were kept on deep litter in two partitions (1,200 x 2,000 cm) of 10 birds each (Cgp and Tgp), they had access to water and standard diet (Chikun Feeds®, Olam Feeds and Flour Mills, Kaduna, Nigeria) *ad libitum* during the experimental phases. The Tgp received daily supplemental taurine (Nutricost®, 7 S 1550 W ♯ 200 Lindon, UT.84042. USA., purity 1000 mg. g^{-1}.) at a dose rate of 0.1% in drinking water *ad libitum*

(Belal *et al.*,2018) and the Cgp had access to only clean drinking water *ad libitum* for 21 days of the study period. Thermo-hygrometric readings and blood samples were recorded four-hourly from 09:00 h on day 1 to 09:00 h on day 2, on scheduled days of 28, days 35 and 42. The ambient temperature (AT) was measured using a dry and wet-bulb thermometer (DTH 1; Clarke International Ltd., Essex, UK), placed in the middle of the pen (Silanikove, 2000). The RH values were calculated using Osmon's hygrometric table (Narinda Scientific Industries® Haryana, India). The temperature-humidity index (THI) was calculated using the formula (Tao and Xin, 2003): THI= 0.85 (t_{db}) + 0.15 (*twb*); Where THI = temperature-humidity index for broiler chickens, t_{db} = dry-bulb temperature and t_{wb} = wet-bulb temperature. Two (2mL) millilitres of blood samples was collected from each broiler chicken in each group through the wing vein. Serum samples were harvested, frozen and stored at -20 °C for the determination of calcium ion concentrations using flame emission photometric method (Magoshes and Vallee,1956).

Data Analyses

The results were presented as mean ± SEM. Evaluation for rhythmicity by the cosinor procedure using Cosinor Online Software (Molcan, 2019). Three rhythmic parameters were characterised and determined: mesor (M) rhythm adjusted mean level, amplitude (A), acrophase (Φ) time at which peak of rhythm occurred. The trigonometric statistical model of each time series was analysed by repeated-measures analysis of variance (ANOVA model-3) (Graph-pad Prism Software version 8). The mean level of the rhythm was computed as the arithmetic mean of all values in the data set. The amplitude of the value rhythm was calculated as half the maximum – minimum range of the oscillation (which was computed as the difference between the peak and trough). The difference between control, treatment groups and times of measurement were tested by two-way ANOVA. The results are presented as tables and chronograms. Values of $P < 0.05$ were considered significant.

Results and Discussion

Serum calcium ion concentration in both Cgp and Tgp expressed circadian rhythmicity during the photophase and scotophase (Figure 1). The serum calcium concentrations on days 28, 35 and 42 of age for Cgp group were significantly ($P < 0.05$) lower; with a mesor of 2.32 ± 0.2, 2.83 ± 0.4 and 1.7 ± 0.2 mmoL/mL, compared to 2.68 ± 0.1, 3.33 ± 0.8 and 2.54 ± 0.2 mmoL/mL for the Tgp, respectively (Table 1). However, there were differences in amplitudes recorded on days 28 and 35 in Cgp (0.1 and 0.4 mmoL/mL, respectively) and (0.3 and 0.8 mmoL/mL, respectively), in the Tgp (Table 1). The acrophases in Cgp on days 28, 35 and 42 were all restricted to the photophase, but fluctuated between the early photophase (3.2 h) at day 28 and late photophase (15.6 h) at day 42 of the study period. The acrophases, however, in the Tgp on day 28, 35 and 42 of study period were all restricted to the early photophase (7.9 h, 6.4 h and 7.4 h, respectively) (Table 1). In the present study, taurine significantly increased serum calcium and therefore, decreased the sodium/calcium ratio which is associated with thermoregulation (Denbow and Eden, 1980). Popoola *et al.* (2020) suggested that ionic imbalances could increase body temperature and alienate body chemistry. Calcium is reported to play a vital role in activation and maturation of lymphocytes (Negulescu *et al.*, 1994) and production of IL-2 which enhance immune status of the broiler chickens under HS. Yan *et al.*, (2023) reported that serum phosphate rhythm may enhance and translate to enhanced egg shell quality. The observation by Yan *et al.*, (2023), may apply to calcium rhythm which is closely associated with phosphorus in egg shell formation. It is plausible to suggest that the modulating activity of taurine could be exploited to elevate daily serum calcium levels and rhythm for improved bone and egg shell calcification during the hot-dry season.

Table 1: Rhythm characteristics of serum calcium ion concentration of taurine-supplemented male broiler chickens at days 28, 35 and 42 of age during the hot-dry season

Day	Groups	Mesor (mmoL/mL)	Amplitude (mmoL/mL)	Acrophase (h)
28:	Control	2.32 ± 0.2[a]	0.1	3.2
	Treatment	2.68 ± 0.1[b]	0.3	7.9

35:	Control	2.68 ± 0.1[a]	0.4	10.4
	Treatment	3.33 ± 0.4[b]	0.8	6.4
42:	Control	1.70 ± 0.1[a]	0.2	15.6
	Treatment	2.54 ± 0.2[b]	0.2	7.4

[a, b, =]Values with different superscript letters along the same row differ significantly $P < 0.05$

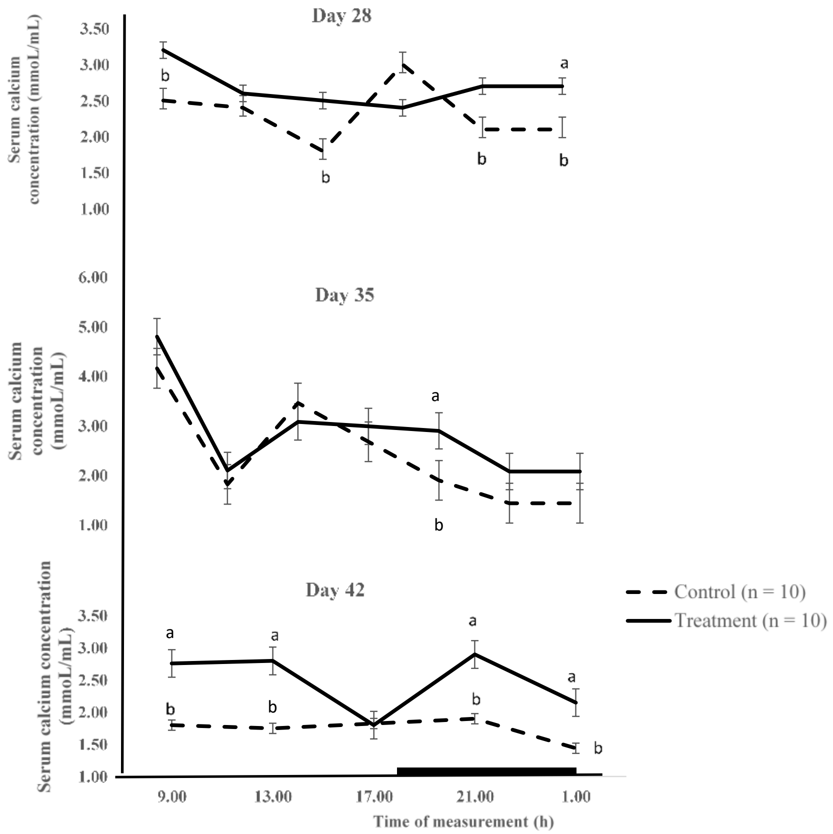

Figure 4.21: Diurnal variation in serum calcium ion concentration of taurine-supplemented male broiler chickens at days 28, 35 and 42 of age during the hot-dry season

Note: Each data point represents the Mean ± SEM of 10 broiler chickens at each period of measurement. The black horizontal bar denotes the dark phase of the prevailing light/dark cycle

Conclusion

It was concluded taurine modulated the rhythms of serum calcium in all age groups. The finding may be beneficial in combating low calcium ionization during heat stress, thereby improving calcium levels, regulating body temperature and improving immunity during the hot-dry season.

REFERENCES

Abbass, A., Khan, M. J., Naeem, M., Ayaz, M., Sufyan, A., Somro, M. H. (2012). Cation anion balance in avian diet: (a review). *Agricultural Science. Research Journal*, 2: 302 – 307.

Ayo, J. O., Obidi, J. A., Rekwot, P. I. (2010). Seasonal variations in feed consumption, hen day, mortality and culls of Bovan Black chickens. In: Proceedings of the 35th Annual Conference of the Nigerian Society of Animal Production. University of Ibadan pp. 415 – 418.

Borges, S. A., Fisher da Silva, A. V., Majorka, A., Hooge, D. M., Cummings, K. R. (2004). Physiological responses of broiler chickens to heat stress and dietary electrolyte balance (sodium plus potassium minus chloride, milliequivalents per kilogram) *Poultry Science,* 83: 1551 – 1558.

Denbow, D. M. and Edens, F. W. (1980). Effects of intraventricular injections of sodium and calcium on body temperature in the chicken. *American Journal of Physiology,* 239: 62 - 65.

Molcan, L. (2019). Time distribution data analysis by Cosinor. Online application. Doi.org/10.1101/805960.

Negulescu, P. A., Shastri, N. and Cahalan, M. D. (1994). Intracellular calcium dependence of gene expression in single T lymphocytes. *Proceedings of National Academy of Science,* United Stata of America. 91: 2873 – 2877.

Popoola, I. B, Popoola, O. R., Ojeniyi, M. O., Olajide, O. O. and Iyayi, E. A. (2020). The roles of key electrolytes in balancing blood acid-base and nutrient in broiler chickens reared under tropical conditions. *Natural Science,* 12(1): 4 – 11.

Scanes, N. A. (2015). Sturkies Avian Physiology (Chapter 37)- Regulation of body temperature: Strategies and Mechanisms. Sixth ed. Academic Press USA, pp. 869 – 905.

Tao, X. and Xin, H. (2003). Acute synergistic effects of air temperature, humidity and velocity on homoestasis of market-size broiler. *Transactions of the American Society of Agricultural and Biological Engineers,*46: 491-497.

Yan, J., Wang, J., Chen, J., Shi, H., Liao, X., Pan, C., Liu, Y., Yang, X., Ren, Z. and Yang, X (2023). Adjusting phosphate feeding regimen according to daily rhythm increases eggshell quality via enhancing medullary bone remodeling in laying hens. *Journal of Animal Science and Biotechnology,* 14: 17

Yosi, F., Widjastuti, T., Setiyatwan,H. (2017). Performance and physiological responses of broiler chickens supplemented with potassium chloride in drinking water under environmental heat stress. Asian Journal of Poultry Science, 11: 31 – 37.