Modulatory Role of Vitamin A on Individual and Diurnal Fluctuations in Rectal Temperature of Black Harco Pullets

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KEY WORDS: Pullets; rectal temperature fluctuations; hot-dry season; vitamin

ABSTRACT

Experiments were performed with the aim of determining the effect of vitamin A administration on rectal temperature (RT) fluctuations in pullets during the hot-dry season. RTs of 29 experimental and 20 control Black Harco pullets were measured hourly for 3 days, 3 days apart, from 06:00 h to 19:00 h with a clinical thermometer. The experimental pullets received vitamin A administered orally at a daily dose of 1,200 IU/kg, while the control pullets were given only water. The lowest hourly RT of 40.82 ± 0.09 oC was obtained in experimental pullets at 06:00 h and 07:00 h, while the highest value of 41.18 ± 0.04 oC was recorded at 15:00 h and 16:00 h (P < 0.001). In control pullets, the RT rose significantly from 41.00 ± 0.08 oC at 06:00 h to the maximum value of 41.73 ± 0.04 oC at 16:00 h (P < 0.001). The maximum RT value in experimental pullets was lower (P < 0.001) than that of the control pullets. It is concluded that vitamin A, by reducing the RT values, ameliorated the thermally stressful effect of the hot-dry season in pullets.

INTRODUCTION

[20, 4, 14] The intensity and duration of stress factors precipitated by high ambient temperature (AT) and high relative humidity (RH) vary with hours of the day, and their actions on pullets have been shown to induce heat stress which adversely affects poultry production. [7, 16, 5, 6] It has been established that heat stress is evaluated by measuring the rectal temperature (RT), which is a true reflection of the internal body temperature and a reliable index of thermal balance. Birds maintain a relatively constant body temperature under normal conditions, but when the internal heat production and heat gain from the environment are greater than the rate of heat dissipation, body temperature rises. [12, 24, 2, 19] In the case of heat stress, free radicals are generated in the body in such a large quantity that the natural antioxidants in the tissues are either overwhelmed or reduced significantly. [2] This results in lipid peroxidation of cytomembranes; and, consequently, cell damage and destruction. [1, 21, 13, 15] It has been established that antioxidant supplementation provides beneficial effects against stress-induced tissue damages. [17] Palozza and Krinsky showed that carotenoids such as β-carotene, the precursor of vitamin A, act as antioxidants by quenching singlet oxygen triplet excited states. [8] Buettner hypothesized that β-carotene acts not as a chain-breaking donor antioxidant, such as ascorbate and tocopherol, but rather as a radical trap. [4, 5, 15] It has been shown that supplementation of the antioxidant vitamin C ameliorated the thermally stressful effect of the dry season and road transportation stress in pullets. The Black Harco breed is commonly reared in Nigeria, and it is known for

Table 1: *Ingredients and nutritive contents of growers' mash ration fed to Black Harco pullets during the hot-dry season.*

Ingredients	Amount in % by Weight
Maize	72.0
Soybeans (roasted)	21.5
Fish meal	3.5
Bone meal	1.5
Limestone	1.0
Common salt	0.25
*Growers premix	0.25
Total	100.0
**Nutrient contents, (%):	
Dry matter	91.9
Crude protein	18.05
Crude fiber	7.5
Lipid	6.2
Ash	8.9
Nitrogen free extract	56.3

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**Premix supplied per kg of diet: Vit A, 8,000 IU; Vit D, 1,500 IU; Vit E, 7mg; Vit K, 1.5mg; Vit B12, 0.01mg; Niacin, 15mg; Pantothenic acid, 5.5mg; Biotin, 0.25mg; Folic acid, 0.5mg; Cu, 3mg; Mn, 40mg; Zn, 31mg; Fe, 21mg; Iodine, 1mg; Cobalt, 0.2mg; Choline, 175mg; Selenium, 0.2mg.*

its high production of eggs and large egg-size. Data on the effect of vitamin A on RT variation in poultry species during the hot-dry season is currently lacking in the available literature.

The aim of the present study was to determine the effect of vitamin A supplementation on fluctuations in RT values of pullets during the hot-dry season.

MATERIALS AND METHODS

The study was performed on Black Harco pullets reared with the deep litter system in a Poultry Farm in Soba (10o 29/N, 08o 03/E), Kaduna State, located in the Northern Guinea Savannah zone of Nigeria. The pullets were obtained at one-day-old from a commercial farm in Kaduna (11o 10/N, 07o 38/E), Nigeria. Routine vaccinations of the birds against common infectious diseases at the recommended doses were carried out. The meteorological data for this locality from the study period are given in Table 2. The maximum and minimum AT, sunshine duration and wind direction were collated from the Department of Geography, Federal College of Education, Zaria, located about 40 km from the experimental site.

Forty-nine Black Harco pullets, aged 12 weeks and weighing 1.04 ± 0.03 kg served as subjects. [23] On each experimental day at 05:45 h, 29 pullets that served as experimental birds were individually administered vitamin A (Pharco Pharmaceuticals, Sidi Gaber Alex-Egypt) orally at the dose of 1,200 IU/kg mixed with sterile water. Thereafter, the 29 experimental pullets were given access to water ad libitum. The remaining 20 pullets that served as control birds were given access to normal drinking water ad libitum, without vitamin A supplementation, throughout the experimental period. During the period, all pullets were fed standard growers' mash (Table 1) ad libitum. Measurements of RT in pullets were taken for 3 days, 3 days apart, every hour from 06:00 - 19:00 h in March, 2005 using standard digital clinical thermometers (The Hartman's Company PLC, UK), inserted about 2 cm via the cloaca into the rectum. In the poultry house, the dry-bulb temperature (DBT) and wet-bulb temperature were taken using dry- and wet-bulb thermometers (Brannan, UK), every hour, concurrently with the RT measurement of pullets. The hourly RH values were obtained from the calculated depression values of the DBT and wet-bulb temperature. Each bird was restrained lightly and calmly, and the duration of each hourly recording was about 15 min. Feed and water were withdrawn during the measurements.

The values obtained were subjected to Student's t-test and Pearson's correlation analysis. Data were expressed as mean ±

Table 2: *Meteorological data from the study period.*

	Day			
Meteorological Parameter	1	2	3	Mean ± SEM
***Ambient Temperature, oC*:**				
***Maximum**	37	37	37	37.0 ± 0.0
***Minimum**	24	24	24	24.0 ± 0.0
***Sunshine Duration, h/day**	8	9	9	8.7 ± 0.3
***Wind Direction**	North-East	North-East	North-East	

**Data collated from the Department of Geography, Federal College of Education, Zaria, Nigeria.*

Table 3: Individual variations in rectal temperature of Black Harco Pullets administered with vitamin A during the hot-dry season, oC (n = 29).

Pullets	Rectal temperature			
	Mean ± SEM	Maximum	Minimum	Range
E1	41.06 ± 0.08	41.53	40.00	1.53
E2	41.07 ± 0.05	41.41	40.16	1.25
E3	41.07 ± 0.06	41.46	40.00	1.46
E4	40.98 ± 0.07	41.48	40.09	1.39
E5	40.97 ± 0.08	41.46	40.00	1.46
E6	41.12 ± 0.05	41.60	40.36	1.24
E7	40.99 ± 0.08	41.50	40.00	1.50
E8	41.04 ± 0.07	41.68	40.00	1.68
E9	41.13 ± 0.04	41.40	40.32	1.08
E10	41.15 ± 0.05	41.62	40.00	1.62
E11	41.01 ± 0.06	41.46	40.00	1.16
E12	40.99 ± 0.07	41.53	40.30	1.53
E13	41.04 ± 0.06	41.50	40.00	1.50
E14	41.03 ± 0.07	41.81	40.00	1.81
E15	41.09 ± 0.05	41.42	40.00	1.32
E16	40.98 ± 0.07	41.55	40.10	1.45
E17	41.01 ± 0.07	41.60	40.10	1.57
E18	40.97 ± 0.07	41.60	40.03	1.57
E19	41.08 ± 0.06	41.47	40.03	1.31
E20	41.03 ± 0.06	41.55	40.16	1.55
E21	41.00 ± 0.07	41.43	40.00	1.43
E22	41.06 ± 0.06	41.48	40.00	1.46
E23	41.09 ± 0.06	41.51	40.02	1.34
E24	41.06 ± 0.07	41.41	40.17	1.41
E25	41.00 ± 0.07	41.47	40.00	1.37
E26	41.10 ± 0.06	41.70	40.10	1.40
E27	41.06 ± 0.06	41.47	40.12	1.38
E28	41.09 ± 0.06	41.49	40.10	1.39
E29	41.06 ± 0.06	41.60	40.01	1.59
Mean ± SEM	41.05 ± 0.01	41.52 ± 0.02	40.09 ± 0.02	1.44 ± 0.03

standard error of the mean (mean ± SEM). Values of $P<0.05$ were considered significant.

RESULTS

The results are presented in Figures 1-8 and Tables 2-5. The meteorological data from the study period are given in Table 2 and Figures 1-2. The AT ranged between 24 – 37 oC and the DBT was 27.3 ± 0.9 oC. The RH fluctuated between 46.2 ± 4.0% and 85.0 ± 1.3%, with an overall mean of 69.6 ± 11.9%. The sunshine duration was 8.7 ± 0.3 h/day, while the wind direction was North-east (Table 2). The extent of individual pullet's variations in the experimental and control groups are shown in Tables 3 and 4, respectively. The mean RT value of the individual experimental pullets was highest (41.15 ± 0.05 oC) in pullet E10, and the lowest value of 40.97 ± 0.08 oC was recorded in pullets E5 and E18 (Table 3). In control pullets, the highest individual mean RT value of 41.50 ± 0.08 oC was obtained in two pullets (C6 and C14), while the lowest value of 41.27 ± 0.09 oC was recorded in pullet C20 (Table 4).

The overall mean hourly RTs in the experimental and control pullets were 41.05 ± 0.02 oC and 41.40 ± 0.06 oC, respectively ($P < 0.001$). In both experimental and control pullets, the overall mean value of the maximum RT was significantly ($P < 0.001$) higher than that of the minimum RT. The diurnal range between minimum and maximum RT of experimental pullets was 1.30 ± 0.06 oC, while that of the control pullets, with very close minimum and maximum RT values, was 1.14 ± 0.1 oC ($P < 0.001$). The hourly mean RT recorded in experimental pullets (Fig. 3) was lowest at 06:00 h and 07:00 h, with the value maintained at 40.82 ± 0.09 oC, but highest at 15:00 h and 16:00 h with the value of 41.18 ± 0.04 oC (P < 0.001). In control pullets, the hourly mean RT rose significantly (P < 0.001) from 41.00 ± 0.08 oC at 06:00 h to the maximum of 41.73 ± 0.04 oC at 16:00 h (Fig. 3). In experimental and control pullets, the RT parameters, except the range and experimental maximum values, increased concurrently with hours of the day (P < 0.001) (Fig. 4 and 5). The relationships between hours of the day, meteorological conditions, and RT parameters were generally stronger in control than experimental pullets (Table 7). There was a significant (P < 0.001) difference between the highest mean RT value in experimental and that of control pullets.

The overall mean RT values recorded on day 1, 2 and 3 in control pullets were 41.45 ± 0.057 oC, 41.42 ± 0.079 oC and 41.34 ± 0.086 oC, respectively. The values, which did not differ significantly from one another among the control pullets, were higher than the corresponding values of 41.07 ± 0.02 oC, 41.05 ± 0.043 oC and 41.02 ± 0.058 oC obtained in experimental pullets on day 1, 2 and 3, respectively. The RT values recorded in experimental pullets also did not differ (P > 0.05) from one day to another (Figs. 7 and 8).

DISCUSSION

[11, 3, 4] The meteorological data obtained from the study period were characterized by high AT and high RH, established for the hot-dry season in the Northern Guinea Savannah zone of Nigeria. [20, 9] The AT recorded during the study period were outside the established thermoneutral zone of 12 – 24 °C and 20.9 – 28.5 °C in poultry species reared in the temperate and tropical regions of the world, respectively. The meteorological conditions prevailing during the hot-dry season were unfavorable for the rearing of the pullets in the zone. Therefore, measures aimed at reducing the adverse effects of the conditions on pullets may enhance their productivity in the zone.[22] The results of the present study indicate that RT parameters of Black Harco pullets were within the established normal range of 39.5-42 °C for the temperate breeds of poultry species. The

Table 4: *Individual variations in rectal temperature of control Black Harco Pullets (not administered with Vitamin A) during the hot-dry season, oC (n = 20)***.**

Pullets		Rectal temperature		
	Mean ± SEM	Maximum	Minimum	Range
C1	41.34 ± 0.08	41.90	40.22	1.68
C2	41.39 ± 0.07	41.90	40.40	1.50
C3	41.43 ± 0.09	41.95	40.60	1.35
C4	41.45 ± 0.08	41.96	40.60	1.36
C5	41.33 ± 0.09	41.98	40.20	1.78
C6	41.50 ± 0.08	41.98	40.50	1.48
C7	41.44 ± 0.06	41.90	40.80	1.10
C8	41.40 ± 0.09	41.90	40.20	1.70
C9	41.43 ± 0.09	41.90	40.20	1.70
C10	41.35 ± 0.09	41.99	40.50	1.49
C11	41.40 ± 0.07	41.96	40.60	1.36
C12	41.47 ± 0.09	41.97	40.30	1.37
C13	41.46 ± 0.07	41.96	40.60	1.36
C14	41.50 ± 0.09	41.97	40.18	1.79
C15	41.41 ± 0.10	41.98	40.00	1.98
C16	41.48 ± 0.09	42.00	40.22	1.78
C17	41.40 ± 0.07	41.95	40.56	1.39
C18	41.29 ± 0.08	41.86	40.10	1.76
C19	41.29 ± 0.07	41.80	40.29	1.51
C20	41.27 ± 0.09	41.90	40.10	1.80
Mean ± SEM	41.40 ± 0.02	41.94 ± 0.01	40.36 ± 0.05	1.56 ± 0.05

Figure 1 *Mean daily fluctuations in dry-bulb temperature (DBT) and relative humidity (RH) during the experimental period.*

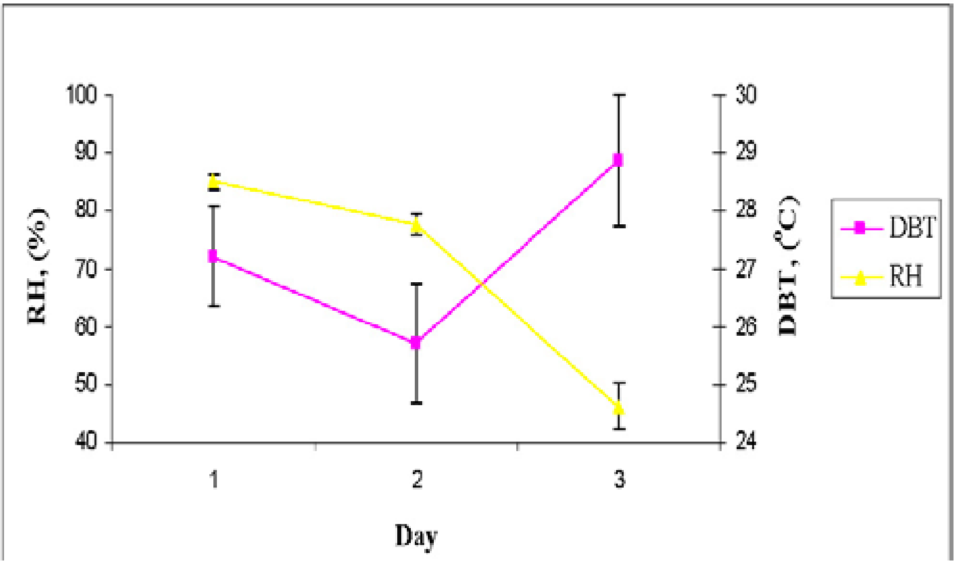
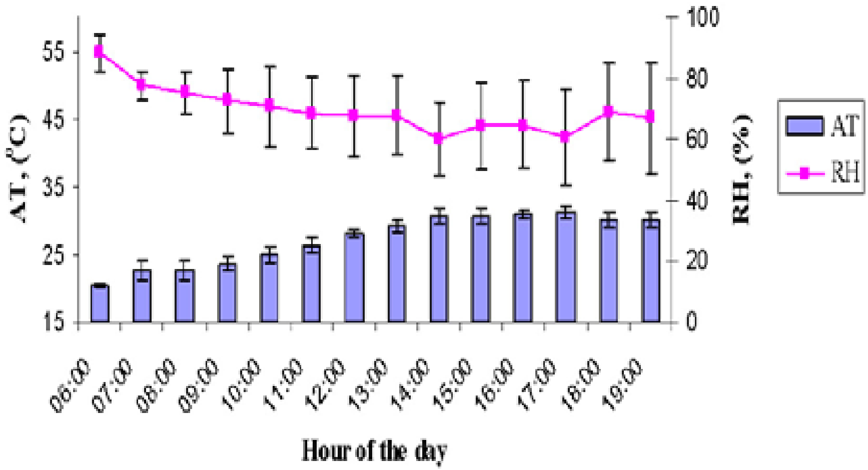


Figure 2 *Diurnal fluctiuations in ambient temperatures (AT) and relative humidity (RH) during the experimental period*



overall mean RT, due to individual variation with lower SEM than that of the diurnal variation, showed that the variations in RT values recorded in the present study were predominantly due to diurnal rather than individual variations. [10, 6] This finding is consistent with that obtained in cattle in the Gambia, and in goats in Nigeria. [4, 14] The distinct diurnal fluctuations observed in RT values of the pullets were in agreement with the findings demonstrating that RT values vary with AT and hours of the day in poultry breeds. [18] The results also agreed with the observation that such variation is classical of most mammals and birds, and that it is controlled by a biological clock in the brain. Unlike in the experimental pullets, with mean hourly RT value relatively maintained at about 41 °C (40.80 – 41.18 °C) throughout the experimental period, the mean hourly RT in control pullets rose significantly during the peak hours of the day, from 12:00 h to 19:00 h. The difference is due to the hypothermic effect of vitamin A, which was manifested not immediately after its administration to the pullets, but about 6 hours later; that is, from 12:00 h to 19:00 h (Fig. 3). The fact that the relationships between the meteorological and RT

Figure 3 *Hourly fluctuations in mean rectal temperature of control and experimental (administered with vitamen A) Black HArco pullets during the hot-dry season °C*

breed

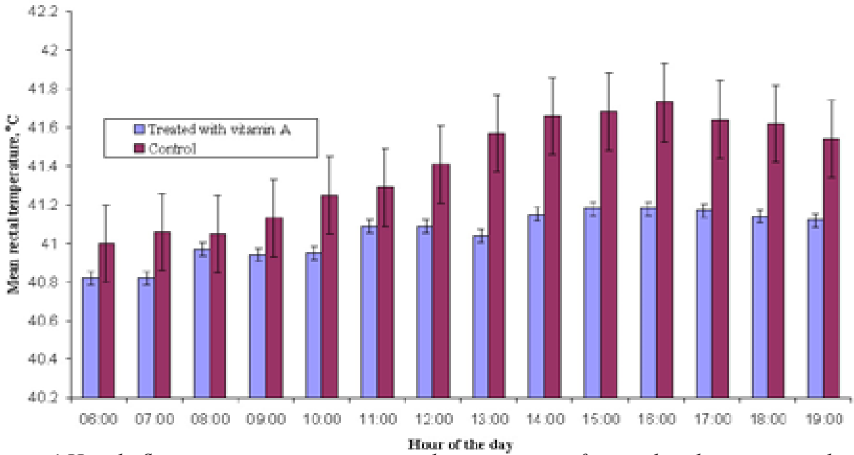
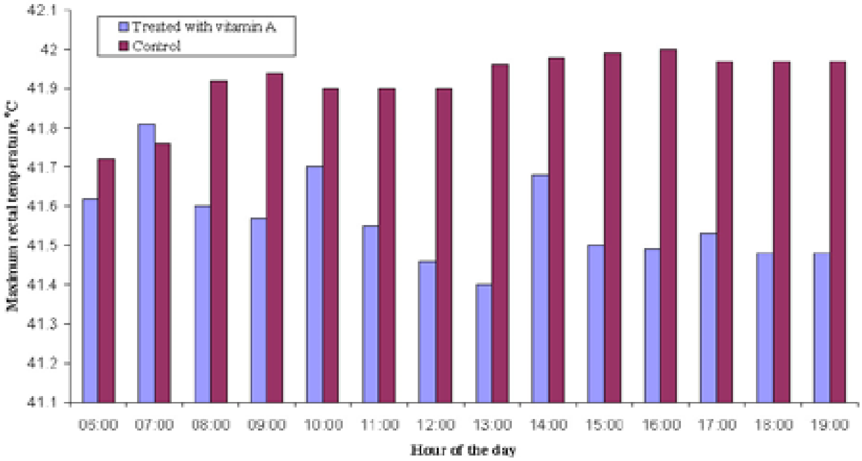


Figure 4 *Hourly fluctuations in maximum rectal temperature of control and experimental (administered with vitamen A) Black HArco pullets during the hot-dry season °C*



parameters were generally stronger in control than experimental pullets (Table 7) indicates that vitamin A administration reduced the risk of adverse effects of high AT and RH on the pullets during the hot-dry season.

[4] The findings on the hypothermic effect of vitamin A agree with the observation that the antioxidant vitamin C minimized the risk of adverse effects of heat stress in pullets by lowering their body temperature during the hot-dry season. The results obtained in the present study also show that oral administration of vitamin A may be beneficial to birds when they are unavoidably subjected to additional stress, especially during the hot-dry season. The results suggest strongly that the exotic Black Harco possesses effective thermoregulatory mechanisms, and has successfully adapted to the stressful hot-dry season. [22] This was evidenced in the relative maintenance of the body temperature values of the pullets within the established normal range of 39.5-42 °C. [5, 4] Similar adaptational responses were obtained in Bovan Nera pullets during the harmattan season and in Shaver Brown pullets during the hot-dry season in the Northern Guinea Savannah zone of Nigeria.

The results demonstrate that the meteorological impact on the birds for the duration of recording was minimal, since the daily RT values recorded did not show any

Figure 5 *Hourly fluctuations in mini mum rectal temperature of control and experimental (administered with vitamen A) Black HArco pullets during the hot-dry season °C*

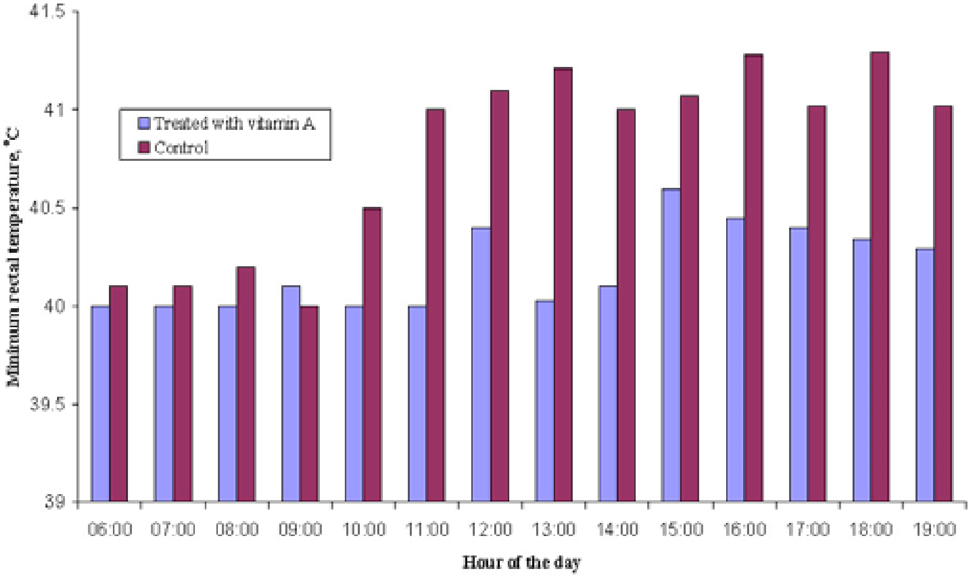
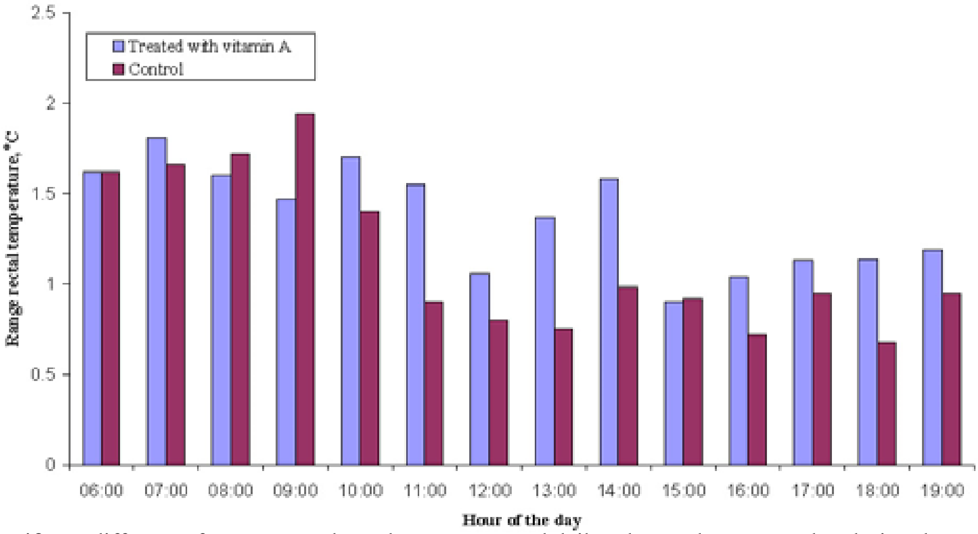


Figure 6 *Hourly fluctuations in range rectal temperature of control and experimental (administered with vitamen A) Black Harco pullets during the hot-dry season °C*



significant difference from one another. The RT values obtained from control pullets on each experimental day were lower than those recorded in vitamin A-treated pullets, which shows that vitamin A exerted its hypothermic effect on the birds for each day of the recording. Thus, the findings show the ameliorative role of vitamin A in heat-stressed pullets individually, hourly and daily. The results suggest that during the afternoon hours of the day (12:00 - 17:00 h) in the hot-dry season, concomitant actions of other stress factors on pullets should be avoided, especially in birds not administered vitamin A, in order to reduce the risk of adverse effects of heat stress. Further studies are required on the antioxidant modulatory role of vitamin A during

Figure 7 *Mean daily fluctuations in dry-bulb temperature (DBT) and rectal temperature of experimental (EXPT) and control (CNTRL) pullets.*

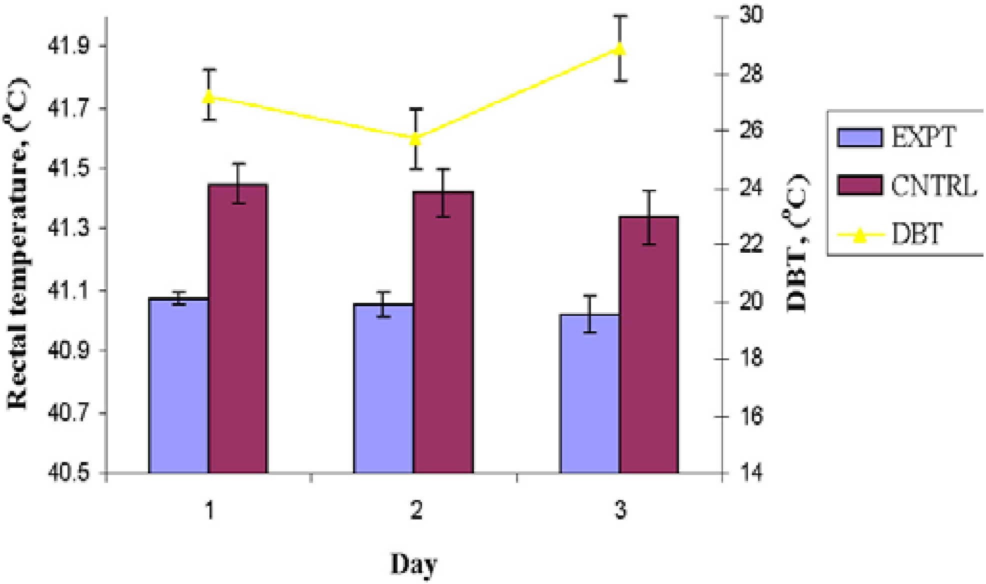
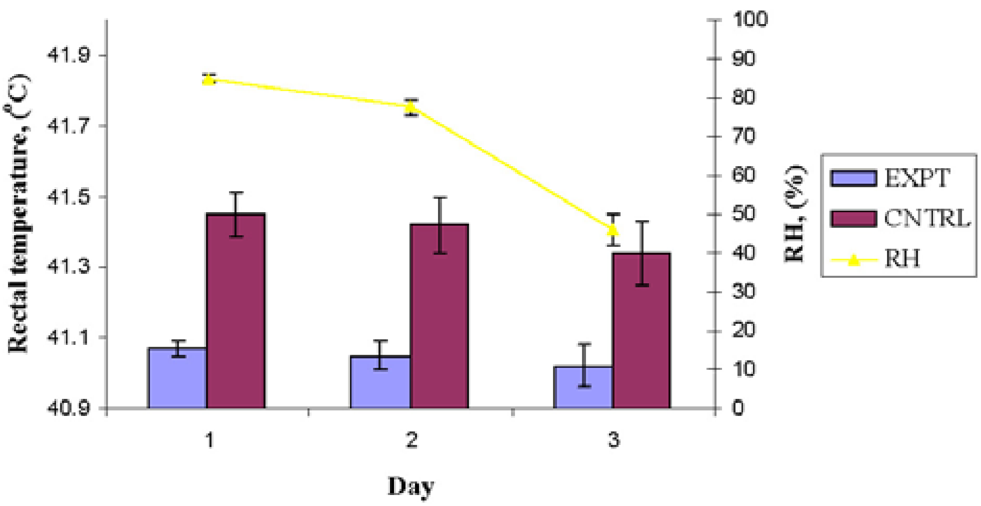


Figure 8 *Mean daily fluctuations in relative humidity (RH) and rectal temperature of experimental (EXPT) and control (CNTRL)pullets.*



stress in poultry production, either singly or in combination with other antioxidants. The results obtained in the present study, which elucidated for the first time the influence of vitamin A on the pattern of RT fluctuations in pullets during the hours of the day, have shed more light on the mechanism of action of vitamin A in alleviating heat stress.

CONCLUSION

It is concluded that the risk of adverse effects of high AT and RH on pullets in hot-humid zones may be reduced by vitamin A administration.

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Table 5: Relationships between meteorological and rectal temperature parameters in control and experimental (administered with vitamin A) Black Harco pullets during the study period.

Correlated parameters	**Correlation coefficients**	
	Experimental (n=29)	**Control (n = 20)**
Hour of the day and mean rectal temperature	0.884***	0.905***
Hour of the day and maximum rectal temperature	-0.607**	0.788***
Hour of the day and minimum rectal temperature	0.719***	0.843***
Hour of the day and range rectal temperature	-0.762***	-0.795***
Dry-bulb temperature and mean rectal temperature	0.940***	0.986***
Dry-bulb temperature and maximum rectal temperature	-0.576*	0.833***
Dry-bulb temperature and minimum rectal temperature	0.722***	0.912***
Dry-bulb temperature range rectal temperature	-0.752***	-0.863***
Relative humidity and mean rectal temperature	-0.892***	-0.857***
Relative humidity and maximum rectal temperature	0.382^{NS}	-0.871***
Relative humidity and minimum rectal temperature	-0.569*	-0.758***
Relative humidity and range rectal temperature	0.566*	0.683**

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