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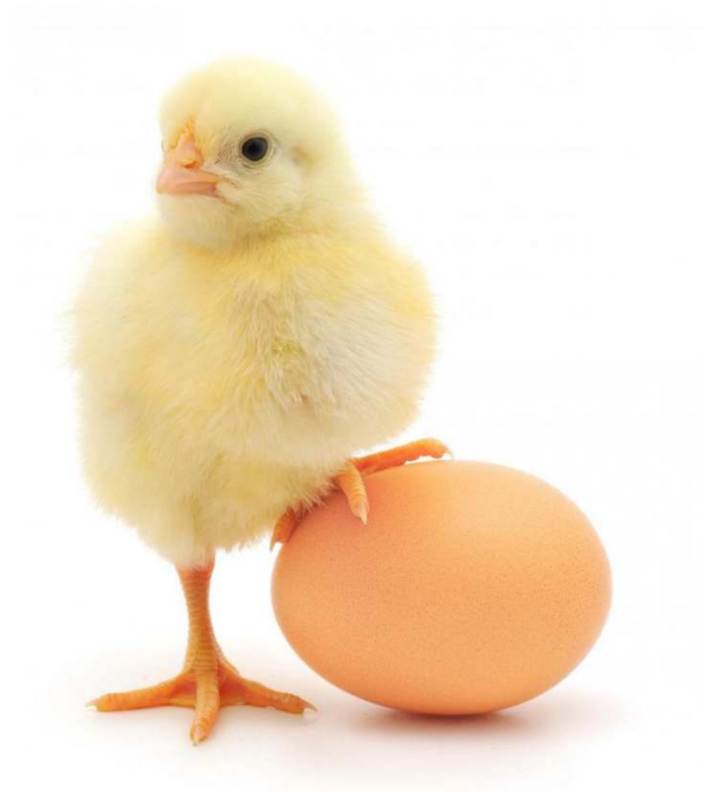

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Diurnal Fluctuations in Rectal Temperature of Black Harco Pullets Administered with Vitamins A and C During the Hot-Dry Season

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Abstract: Experiments were performed with the aim of determining the effect of co-administration of vitamins A and C 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 three days, three days apart, from 06:00 to 19:00 h with a standard digital clinical thermometer. The experimental pullets were administered individually with vitamins A and C orally at a daily dose of 1,200IU/kg and 50mg/kg, respectively. The control pullets were given only water, without the addition of vitamins A and C. The lowest hourly RT of 40.96±0.03°C was obtained in experimental pullets at 06:00 h, while the highest value of 41.28±0.02°C was recorded at 16:00 h ($P < 0.001$). In control pullets, the RT rose significantly from 40.97±0.05°C at 06:00 h to the maximum value of 41.61±0.03°C at 15:00 h ($P < 0.001$). There was a positive and very highly significant ($P < 0.001$) correlation between hours of the day and RT values obtained both in experimental ($r = 0.834$) and control ($r = 0.884$) pullets. The overall RT of pullets administered with vitamins A and C was significantly ($P < 0.05$) lower than that of control pullets (41.16±0.02°C and 41.39±0.05 C°, respectively). The dry-bulb temperature was significantly ($P < 0.001$) and positively correlated with RT in both experimental ($r = 0.936$) and control ($r = 0.969$) pullets. The pullets administered with vitamins A and C had consistently lower RT values than those of control pullets, especially during the hot hours of the day, from 13:00-18:00 h, with mean values fluctuating between 41.19±0.02°C and 41.28±0.02°C. The RT of both experimental and control pullets showed distinct diurnal fluctuations. It is concluded that vitamins A and C, by reducing the RT values, ameliorated the thermally stressful effect of the hot-dry season and this mechanism may be partly involved in the enhancement of poultry productivity and health during the season by antioxidant vitamins.

Key words: Diurnal fluctuations, hot-dry season, rectal temperature, vitamins A and C

INTRODUCTION

Heat stress is a major limiting factor to poultry productivity in hot-humid zones of the world (Bianca, 1976; Ubosi and Gandu, 1995; Piccione and Caola, 2002). The adverse effects of heat stress on pullets is pronounced during the hot-dry season when there are marked fluctuations in ambient temperature (AT) and relative humidity (RH) (Ayo *et al.*, 2005). The fluctuations naturally occur during the AT and RH change from day to night time (Leeson, 2000; Teeter *et al.*, 2005). The rectal temperature (RT) is an important indicator of heat stress in poultry because it truly reflects the internal body temperature and it is a reliable index of thermal balance (Bianca, 1976; Ozkan *et al.*, 2003). Prolonged high AT during the day causes panting in pullets for several hours in an attempt to dissipate excessive body heat through evaporative cooling (Freeman, 1988; Balnave, 1998). However, the presence of high RH in the poultry house during the hot-dry season makes evaporative cooling practically impossible (Sinkalu *et al.*, 2006b). The high AT and high RH prevailing in the microenvironment of the poultry house in the tropics are unfavourable for efficient poultry production. There is a need to search for safe, inexpensive and readily available compounds that can effectively counter the adverse effects of heat stress in chickens. The body requirement in vitamin C during heat stress in poultry is greater than the amount synthesized by normal tissues, and its administration may be beneficial to the body during heat stress (Sahota and Gillani, 1995; Balogun *et al.*, 1996). Vitamin A is a dietary requirement in birds. There is paucity of information in the available literature on administration of vitamin A as an antioxidant during heat stress. Zdunczyk *et al.* (2002) administered the vitamin to turkeys and found that it sufficiently reduced fat oxidation in tissues. Vitamin A may act as an antioxidant by quenching singlet oxygen triplet excited states (Palozza and Krinsky, 1992). Alan and Leif (1997) demonstrated that the vitamin reacts with free radicals by at least two parallel pathways:

(i) Formation of an adduct between the vitamin and free radicals; and
(ii) Electron transfer yielding the carotenoid radical cation.

It has been shown that vitamin C (Sinkalu *et al.*, 2006b) or A (Sinkalu *et al.*, 2006a) supplementation alone to pullets during the hot-dry season ameliorated the adverse effects of the season on birds by maintaining their body temperature responses within the normal values.

Data on the modulatory role of co-administration of vitamins A and C on fluctuations in RT of pullets during the hot-dry season in the tropics are currently lacking in the available literature.
The aim of the present study was to determine the modulatory role of co-administration of vitamins A and C on fluctuations in RT of Black Harco pullets during the hot-dry season.

MATERIALS AND METHODS

The study was performed on Black Harco pullets reared in a Poultry Farm in Soba (10°29′N, 08°03′E), Kaduna State, located in the Northern Guinea Savannah zone of Nigeria. The pullets were obtained at day old from a commercial farm in Kaduna, Nigeria. Routine vaccinations of birds against common infectious diseases at the recommended doses were carried out. The meteorological data for this locality during the study period are given in Table 1. They were collated from the Department of Geography, Federal College of Education, Zaria, located about 40km from the experimental site. 49 Black Harco pullets, aged 15 weeks and weighing between 0.8-1.6 (1.45±0.03) kg served as subjects. On the experimental day at 05:45 h, 29 of the pullets were co-administered vitamins A and C at the dose of 1,200I.U./kg (Zdunczyk *et al.,* 2002) and 50mg/kg (Chervyakov *et al.*, 1977), respectively. Each of the 29 pullets was individually administered the vitamins dissolved in 1ml of water orally. Thereafter, the 29 experimental pullets were given water *ad libitum.* The remaining 20 pullets, which served as control birds, were given normal water *ad libitum,* without vitamins A and C supplementation throughout the experimental period. During the period, all pullets were fed standard growers' mash (Table 2) *ad libitum.* Feeds and water were withdrawn during the measurements. Measurements of RT in pullets were taken for three days, three days apart, every hour from 06:00-19:00 h in April, 2005 using standard digital clinical thermometers (The Hartman's Company PLC, England), inserted about 2 cm via the cloaca into the rectum. In the poultry house, the dry- and wet-bulb temperatures were taken every hour and concurrently with RTs of pullets. Each bird was restrained lightly and calmly and the hourly recordings lasted 15 min.
The values obtained were subjected to Student's t-test and Pearson's correlation analysis. Data were expressed as mean±standard error of the mean (mean±SEM). Values of $P < 0.05$ were considered significant.

RESULTS

The meteorological data from the study period are given in Table 1. The pullets were exposed to high AT of 21-40°C with a wide diurnal range of 19°C (Table 1). The RT minima and maxima together with the standard errors and ranges, shown in Tables 3 and 4 described the extent of between-pullet variation in the experimental and control pullets, respectively. There were variations in the individual RT values of the experimental pullets with the highest mean of 41.22±0.03°C recorded in two pullets (E9 and E16). The lowest value of 41.10±0.03°C was recorded in pullet E24 (Table 3). In control pullets, the highest individual mean RT value of 41.46±0.06°C was obtained in pullet C18, while the lowest value of 41.30±0.05 °C was recorded in pullet C12 (Table 4). The overall mean hourly RTs for the experimental and control pullets were 41.16 ± 0.02°C and 41.39 ± 0.05°C, respectively ($P < 0.001$) (Tables 5 and 6). In both experimental and control pullets, the mean maximum RT was significantly ($P < 0.001$) higher than the mean minimum RT. The diurnal range between minimum and maximum RT of experimental pullets was 0.71±0.04°C, while that of control pullets was 0.79±0.04°C ($P < 0.001$) (Tables 5 and 6). The recorded hourly mean RT in experimental pullets (Table 5) was lowest at 06:00 h with the value of 40.96±0.03°C, but highest at 16:00 h with the value of 41.28±0.02°C ($P < 0.001$). In control pullets, the hourly mean RT rose significantly ($P < 0.001$) from 40.97±0.05°C at 06:00 h to the maximum RT value of 41.61±0.03°C at 15:00 h (Table 6). Unlike in the experimental pullets with mean hourly RT of about 41°C throughout the experimental period, the mean hourly RT in control pullets was maintained at about 41.5-41.6°C from 12:00-19:00 h. In experimental and control pullets, the RT parameters, except the range values, increased concurrently with hours of the day and the DBT ($P < 0.001$) (Table 7).

DISCUSSION

The high AT, ranging from 21-40°C and mean RH of 76.07±4.64% obtained during the study period predominantly were outside the thermoneutral zone of 12-24°C established for the chicken in the temperate (Selyansky, 1975) and 20.9-28.5°C in tropical regions (Oluyemi and Adetowun, 1979). The values indicated that the microclimatic conditions prevailing in the poultry house during the hot-dry season were thermally stressful, particularly to birds who lack sweating ability. Although mortality was not observed during the study period. Zapata and Gernat (1995) showed that at temperatures exceeding 28.5°C, thermotolerance was overcome leading to marked mortality (Zapata and Gernat, 1995). The meteorological results obtained in the present study thus indicated a need to ameliorate the risk due to the adverse effects of the hot-dry season on poultry production in the zone.
The adverse effects of high AT and high RH were more pronounced in the control pullets. This was evidenced by

Table 1: Meteorological Data from the Study Period

Meteorological Parameter	Day 1	Day 2	Day 3	Mean±SEM
Ambient Temperature, °C:				
*Maximum	37	39	40	38.67±0.88
*Minimum	21	23	22	22.00±0.58
Dry-Bulb	28.93±1.09	28.21±1.02	33.29±1.17	30.14±1.59
Relative Humidity, %	79.29±1.77	82.00±1.18	66.93±2.10	76.07±4.64
Sunshine Duration, h/day	9	9	8	8.67 ± 0.34
*Wind Direction	North-East	South-East	North-East	

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

Table 2: Ingredients and nutritive contents of growers' mash ration fed to the pullets

Ingredients	Amount in % by Weight
Maize	72.0
Soybeans (roasted)	21.5
Fish meal	3.5
Bone meal	1.5
Common salt	0.5
Limestone	1.0
Total	100.0
*Nutrient contents, (%):	
Dry matter	91.9
Crude protein	18.05
Crude fiber	7.5
Oil	6.2
Ash	8.9
Nitrogen free extract	56.3

*Analyzed in the Biochemical Laboratory, Department of Animal Science, Ahmadu Bello University, Zaria, Nigeria.
*Premix supplied per kg of diet: Vit A, 8,000IU; Vit D, 1,500IU; Vit E, 7mg; Vit K, 1.5mg; Vit B_{12}, 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.

the classical fluctuations in RTs obtained as the hour of the day increased. The RT values rose from morning hours and peaked at 15.00 h. The decrease recorded at 16.00 h showed the attempts of the birds to maintain homeothermy. The findings were consistent with the report of Adenkola and Ayo (2006) that during heat stress the thermoregulatory mechanisms of the body are overwhelmed. The modulatory role of the vitamins showed synergism. This was, apparently, because vitamin C, apart from being an antioxidant itself, is capable of recycling carotenoid radicals back to the active form of vitamin A (Alan and Leif, 1997). Co-administration of vitamins A and C alleviated the meteorological stress of the hot-dry season on pullets as evidenced by lower correlation coefficient values between AT and RT, and RH and RT (0.936 and 0.355, respectively) in pullets treated with the two vitamins compared to those administered with vitamin A alone (Sinkalu *et al*., 2006a). The findings indicated that co-administration of the two vitamins was more beneficial to pullets subjected to heat stress than single administration of vitamin A. However, it is worth noting that the co-administration of vitamins A and C had a less effect on alleviation of the meteorological stress when compared with that obtained in pullets treated with vitamin C alone (Sinkalu *et al.,* 2006b). The vitamin C-treated pullets had lower correlation co-efficient values than those obtained in birds treated with vitamins A and C. The results of the present study demonstrated that single administration of vitamin C alone exerted a more potent ameliorative effect than co-administration of vitamins A and C. It is possible that synergistic effect of vitamins A and C may be delayed and become prominent in subsequent days post-administration. The use of this combination on industrial scale by poultry feed manufacturers and Veterinarians during thermally stressful conditions is strongly recommended. The administration may increase the profitability of poultry industry, especially during the hot-dry season in the tropical environments. Further studies are required to evaluate the mechanism of interactions between vitamins A and C in heat stress and the possible prolong ameliorative effect of co-administration of the two vitamins during the hot-dry season.

The overall mean RT value of 41.16±0.01°C recorded in the experimental group was significantly lower than 41.39±0.01°C ($P < 0.001$) obtained in the control. The finding demonstrated that environmental conditions prevailing in the poultry pen during the hot-dry season was thermally stressful to the birds and may adversely affect their health and productivity. The finding agreed with the report of Altan *et al.* (2003) that heat stress adversely affects the well-being of birds. Therefore, other stressors such as overcrowding, diseases, nutrient imbalance, molting and debeaking should be avoided or reduced in commercial operations during the afternoon hours of the hot-dry season. Vitamins A and C supplementation effectively lowered the RT values of the experimental birds subjected to the influence of high RT and RH prevailing during the hot-dry season in the Northern Guinea Savannah zone of Nigeria. The finding agreed with that of Abd-Ellah (1995), who found that the

Table 3: Between-Pullet Variations in Rectal Temperature of Black Harco Pullets administered with Vitamins A and C during the Hot-Dry Season, °C (n = 29)

Pullet	Mean±SEM	Maximum	Minimum	Range
E1	41.12±0.02	41.40	40.84	0.56
E2	41.11±0.03	41.41	40.60	0.81
E3	41.20±0.02	41.31	40.90	0.41
E4	41.19±0.03	41.40	40.61	0.79
E5	41.15±0.03	41.43	40.77	0.66
E6	41.16±0.04	41.50	40.15	1.35
E7	41.15±0.03	41.44	40.58	0.86
E8	41.18±0.04	41.50	40.70	0.80
E9	41.22±0.03	41.49	40.77	0.72
E10	41.11±0.04	41.37	40.65	0.72
E11	41.17±0.03	41.50	40.63	0.87
E12	41.14±0.04	41.45	40.60	0.85
E13	41.20±0.03	41.54	40.56	0.98
E14	41.18±0.03	41.50	40.80	0.70
E15	41.18±0.03	41.48	40.80	0.68
E16	41.22±0.03	41.42	40.65	0.77
E17	41.13±0.02	41.38	40.86	0.52
E18	41.15±0.03	41.40	40.80	0.60
E19	41.16±0.03	41.56	40.76	0.80
E20	41.14±0.03	41.41	40.66	0.75
E21	41.18±0.03	41.70	40.61	1.09
E22	41.16±0.03	41.50	40.68	0.82
E23	41.13±0.03	41.34	40.60	0.74
E24	41.10±0.03	41.50	40.58	0.92
E25	41.16±0.03	41.38	40.76	0.62
E26	41.11±0.02	41.42	40.84	0.58
E27	41.17±0.02	41.40	41.00	0.40
E28	41.17±0.02	41.31	40.76	0.55
E29	41.15±0.03	41.32	40.48	0.84
Mean±SEM	41.16±0.01	41.44±0.02	40.69±0.03	0.75±0.04

Table 4: Between-Pullet Variations in Rectal Temperature of Control Black Harco Pullets (not given Vitamins A and C) during the Hot-Dry Season, °C (n = 20)

Pullet	Mean±SEM	Maximum	Minimum	Range
C1	41.39±0.06	41.95	40.60	1.35
C2	41.38±0.07	41.90	40.35	1.55
C3	41.38±0.05	41.88	40.74	1.14
C4	41.38±0.06	42.00	40.60	1.40
C5	41.35±0.05	41.66	40.67	0.99
C6	41.34±0.06	41.89	40.77	1.12
C7	41.37±0.05	41.71	40.90	0.81
C8	41.37±0.06	41.86	40.68	1.18
C9	41.41±0.06	41.88	40.96	0.92
C10	41.37±0.06	42.00	40.76	1.24
C11	41.42±0.08	42.23	40.65	1.58
C12	41.30±0.05	41.71	40.70	1.01
C13	41.38±0.06	41.78	40.69	1.09
C14	41.39±0.05	41.71	40.90	0.81
C15	41.43±0.06	41.98	40.91	1.07
C16	41.38±0.06	42.00	40.66	1.34
C17	41.35±0.05	41.63	40.62	1.01
C18	41.46±0.06	42.04	40.98	1.06
C19	41.40±0.05	41.78	40.89	0.89
C20	41.44±0.05	41.89	40.77	1.12
Mean±SEM	41.39±0.01	41.87±0.03	40.74±0.15	1.13±0.05

vitamins markedly reduced mortality, and improved egg production, feed intake, egg weight and feed conversion during hot summer months when temperatures reached up to 43 °C in the experimental room. It is recommended that birds to be subjected to additional stress factors during the hot-dry season, especially at the hot-hours of the day (13:00-17:00), be administered the antioxidants in the morning hours of the day.

Table 5: Hourly Fluctuations in Rectal Temperature of Black Harco Pullets administered with Vitamins A and C during the Hot-Dry Season, °C (n = 29)

Hour	Mean±SEM	Maximum	Minimum	Range
06:00	40.96±0.03	41.30	40.56	0.74
07:00	41.05±0.01	41.30	40.15	1.15
08:00	41.09±0.02	41.30	40.65	0.65
09:00	41.10±0.01	41.32	40.70	0.62
10:00	41.10±0.01	41.35	40.60	0.75
11:00	41.15±0.02	41.70	40.48	1.22
12:00	41.19±0.02	41.51	40.80	0.71
13:00	41.20±0.02	41.54	40.95	0.59
14:00	41.22±0.02	41.46	40.76	0.70
15:00	41.25±0.03	41.50	40.87	0.63
16:00	41.28±0.02	41.56	41.00	0.56
17:00	41.26±0.02	41.54	41.00	0.54
18:00	41.20±0.02	41.50	40.87	0.63
19:00	41.17±0.02	41.42	41.00	0.42
Mean±SEM	41.16±0.02	41.45±0.02	40.74±0.05	0.71±0.04

Table 6: Hourly Fluctuations in Rectal Temperature of Control Black Harco Pullets (not given Vitamins A and C) during the Hot-Dry Season, °C (n = 20)

Hour	Mean±SEM	Maximum	Minimum	Range
06:00	40.97±0.05	41.34	40.35	0.99
07:00	41.11±0.04	41.72	40.60	1.12
08:00	41.14±0.03	41.50	40.83	0.67
09:00	41.20±0.03	41.60	40.76	0.84
10:00	41.30±0.03	41.66	41.00	0.66
11:00	41.38±0.04	41.95	41.09	0.86
12:00	41.45±0.04	41.89	41.20	0.69
13:00	41.51±0.04	41.96	41.21	0.75
14:00	41.57±0.03	42.00	41.37	0.63
15:00	41.61±0.03	41.90	41.38	0.52
16:00	41.55±0.03	41.98	41.16	0.82
17:00	41.59±0.04	42.23	41.28	0.95
18:00	41.50±0.03	42.00	41.20	0.80
19:00	41.49±0.03	42.04	41.25	0.79
Mean±SEM	41.39±0.05	41.84±0.05	41.05±0.07	0.79±0.04

Table 7: Relationships between Meteorological and Rectal Temperature Parameters in Black Harco Pullets administered with Vitamins A and C during the Hot-Dry Season

Correlated parameters	Experimental (n = 29)	Control (n = 20)
Hour of the day and mean rectal temperature	0.834***	0.884***
Hour of the day and maximum rectal temperature	0.575**	0.865***
Hour of the day and minimum rectal temperature	0.806***	0.839***
Hour of the day and range rectal temperature	-0.566**	-0.295^{NS}
Dry-bulb temperature and mean rectal temperature	0.936***	0.969***
Dry-bulb temperature and maximum rectal temperature	0.717**	0.885***
Dry-bulb temperature and minimum rectal temperature	0.807***	0.901***
Dry-bulb temperature range rectal temperature	-0.488^{NS}	-0.384^{NS}
Relative humidity and mean rectal temperature	0.355^{NS}	0.468^{NS}
Relative humidity and maximum rectal temperature	0.496^{NS}	0.386^{NS}
Relative humidity and minimum rectal temperature	0.186^{NS}	0.545*
Relative humidity and range rectal temperature	0.071^{NS}	-0.461^{NS}

^{NS} = Non-significant correlation (P > 0.05), * = P < 0.05, ** = P < 0.01, *** = P < 0.001

Conclusion: It is concluded that the adverse effect of high AT and RH on Black Harco pullets during the hot-dry season in hot-humid zones may be ameliorated by vitamins A and C co-administration and thus enhance their productivity and health.

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