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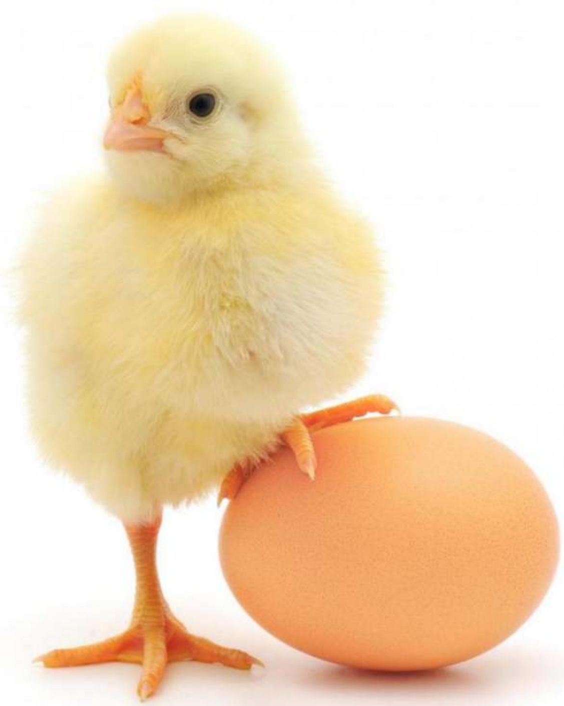

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Effect of Seasonal Temperatures and Ascorbic Acid Supplementation on Performance of Broiler Chickens Maintained in Closed and Open-Sided Houses

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Abstract: The efficacy of ascorbic acid in drinking water on performance of broiler chickens under closed and open-sided houses during hot (ambient temperature 36°C) and cool (ambient temperature 23°C) seasons were studied. The temperatures inside the poultry houses were 26°C (closed), 29°C (open-sided), 32°C (closed) and 37°C (open-sided) for cool and hot seasons, respectively. One-day-old chicks (432 birds) were housed in each closed and open-sided environment for each season. Birds were maintained under 23 hrs light and 1 hr dark cycle and offered *ad libitum* access water and feed. Broilers in both houses were randomly subjected to four drinking water treatments (9 birds in each 6 replicates/treatment): 0, 100, 200 and 300 ppm ascorbic acid. Feed intake, body weight gain, feed conversion ratio and rectal temperatures were recorded weekly. Ascorbic acid supplementation at 200-300 ppm was associated with a reduction in rectal temperatures during the hot season. Open-sided house depressed body weight gain and feed conversion ratio ($P < 0.05$) during hot season. Compared to the control group, ascorbic acid improved feed intake, body weight gain and feed conversion ratio by 6%, 9% and 3% (cool season) and 8%, 11% and 5% (hot season). Birds supplemented with 200 ppm ascorbic acid had ($P < 0.05$) higher feed intake, body weight gain and feed conversion ratio than the control group during the cool season, while 300 ppm ($P < 0.05$) improved broiler performance including feed intake, body weight gain and feed conversion ratio during the hot season. Bird's rectal temperature was higher ($P < 0.05$) during hot season in open-sided house and ($P < 0.05$) reduced by supplementing 200-300 ppm ascorbic acid. This study demonstrated that seasonal temperatures had a significant effect on broiler performance in open-sided house. Supplementation of drinking water with 200-300 ppm ascorbic acid ameliorated broiler performance in open-sided housing at high ambient temperatures.

Key words: Seasonal temperature, ascorbic acid, chicken performance, open-sided house

Introduction

High ambient temperature is one of the major stressors in poultry production in the tropical areas in general and in the Sultanate of Oman in particular, as it is can compromise the ability of birds to maintain homeostasis. Responses of birds to hot environments are in part mediated through changes in circulating levels of hormones, glucose, electrolytes and leucocytes and the function of organs (Blalock and Smith, 1985; Mitchell and Kettlewell, 1998). To minimize heat load, birds will reduce feed intake and increase evaporative heat loss. This will cause loss of CO_2 however will induce an increase in blood pH. As the heat load increases, the resulting increase in body temperature will lead to tissue damage and release of intracellular components into the circulation (Whitehead and Keller, 2003). Much of the tissue damage, particularly that involving cell membrane, arises from lipid peroxidation which is enhanced under very high ambient temperature conditions. Ascorbic acid is actively transported into tissues and its utilization and the body's demand for ascorbic acid increase during the hot season (Pardue, *et al.*, 1985; Pardue and Thaxton, 1986; Kutlu and Forbes, 1993). Although, ascorbic acid is not an essential nutrient, there has nevertheless been considerable interest in its possible role in maintaining homeostasis as the requirements for ascorbic acid may be elevated under hot environmental conditions (Pardue and Thaxton, 1986) and endogenous synthesis may not be adequate to meet the physiological needs of the birds. The effect of high ambient temperatures on poultry production is of great concern in the Sultanate of Oman but there is no information available on the relationship between seasonal temperature changes and ascorbic acid supplementation on poultry performance. The purpose of this study therefore, was to determine the potential of ascorbic acid to improve broiler performance associated with ambient temperatures in closed and open-sided houses in the Sultanate of Oman.

Materials and Methods

Environmental parameters: Weather data including average temperature and relative humidity were recorded by a weather monitoring station at the Agricultural Experiment Station of Sultan Qaboos University. The experimental period was divided into two seasons. The cool season (January-February) with an average temperature of 23°C and a relative humidity of 58% and the hot season (August-September) with an average temperature of 33°C and a relative humidity of 50%.

Birds and housing: Four-hundred and thirty two (one day old) broiler chickens (Cobb 500 strain) were used for each season and randomly allotted to 24 pens, nine birds per pen. Two houses were used: a closed and an open-sided. The closed house was well insulated by double aluminum layer with fiberglass between them. Cooling water pads system with expel fans were used. The open-sided house was a natural ventilated shed constructed from galvanized iron with profiled steel shed roofing. Chicken mesh panels and a block work protection up to one meter height were fixed on all sides. It was equipped with four sets of electric wall fans for air circulation. Shade cloths were used to screen direct sunrays during midday. Each house was subdivided into 24 pens bedded with wood-shaving litter. Each pen was equipped with a plastic feeder and drinker to provide *ad libitum* access to feed and water. Lighting of 23-hour light and 1 hour dark was provided in the closed house. The house temperature and relative humidity were recorded 3 times daily at 8:00, 1300 and 23:00 hours.

Ascorbic acid preparation: Four levels of ascorbic acid (0, 100, 200, 300 ppm) were prepared by mixing of L-Ascorbic acid (BDH Laboratory Supplies Poole, England) with fresh water. Each pen was randomly assigned to one of four treatments (6 replicates per treatment).

Parameters measured: On the first day of the experiment, two birds identified by their respective wing bands from each pen (a total of 96 birds: 12/treatment) in closed and open-sided houses were randomly selected. The rectal temperature of each bird was recorded weekly for six weeks thereafter using a digital thermometer. Body weight and feed consumption of each pen were recorded weekly to calculate body weight gain, feed intake and feed conversion ratio.

Statistical analysis: Statistical analysis was carried out using analysis of variance procedure (Ott, 1993), to evaluate the effect of seasonal temperature and ascorbic acid levels and their interaction on performance of meat chickens maintained in closed and open-sided houses using GLM procedures of SAS (1993). Significant differences between treatment means were assessed using the least-significant-difference procedure. Interaction between the treatments was excluded from the model when not significant ($P > 0.05$).

Results and Discussion

Ambient temperatures: Ambient temperatures were similar in closed and open-sided houses during the first two weeks of both seasons. From week 3 to 6, the average ambient temperatures in the open-sided housing was about 7 to 8°C higher in the hot season than during the cool season (Fig. 1), while the relative humidity throughout ranged 60-65%. However, the recorded ambient temperatures in an open-sided house indicated that the range of temperatures during the hot season were well above the birds' thermo-neutral zone. During the hot season in open-sided house, birds were often observed signs of heat stress such as panting and wing lifting. Birds receiving 200-300 ppm supplemental ascorbic acid exhibited fewer behavioural changes related to the heat stress. Similarly Kutlu and Forbes (1993) reported that heat-stressed birds supplemented with 250 ppm ascorbic acid exhibited relatively less panting than their un-supplemented counterparts. This may suggest that ascorbic acid improves the ability of the bird to tolerate higher heat loads.

Rectal temperature: Ascorbic acid supplementation significantly ($P < 0.05$) influenced rectal temperatures especially during the hot season and in open-sided house (Fig. 2). Birds receiving 200-300 ppm ascorbic acid birds had significantly ($P < 0.05$) lower temperatures than those receiving 0 and 100 ppm during the hot season in the open-sided house. Elevation in body temperature is one of the responses of birds to high ambient temperature. The bird maintains a constant body temperature but when the internal heat production and heat gain from the environment are greater than the rate of heat dissipation, body temperature increase. There are several reports which demonstrated that supplemental ascorbic acid reduces rectal temperatures in heat-stressed birds (Attia, 1976; Kutlu and Forbes, 1993). Similarly, Ahmad *et al.* (1967) reported significantly lower body temperatures in ascorbic acid supplemented birds at environmental temperatures of 29.4 and 35.0°C. Ascorbic acid supplementation at 100, 50, 25 or 0 mg/kg diet resulted in body temperature increases of 0.33, 0.39, 0.56 and 0.89°C, respectively in birds maintained at 32°C over an initial ambient temperature of 15°C (Attia, 1976). This finding would suggest that ascorbic acid either decreases heat load by lowering heat production or increases heat loss by influencing a venues of thermal exchange between the body and the environment (Change *et al.,* 1993). However it should be noted that Pardue *et al.* (1985) reported no significant differences in cloacae temperatures of chicks supplemented with 1000 ppm ascorbic acid compared with un-supplemented chicks maintained at 22°C or exposed to temperature of 43°C.

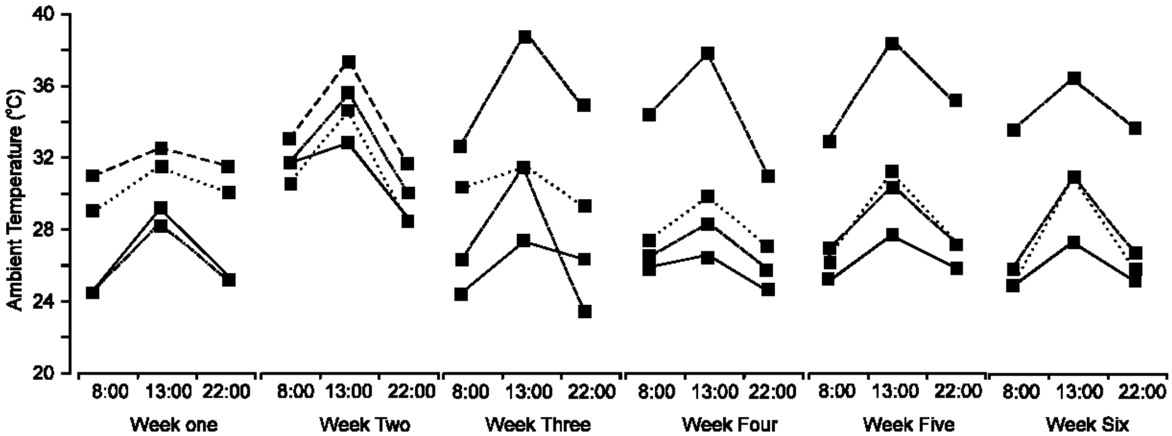

Fig. 1: Broiler closed open-sided house's ambient temperatures measured three times every day at 8, 13 and 22 hrs and a weekly average was calculated for each time (open-sided during cold season—■— open-sided during hot season --■-- closed during cold season --■-- closed during hot season ···■···

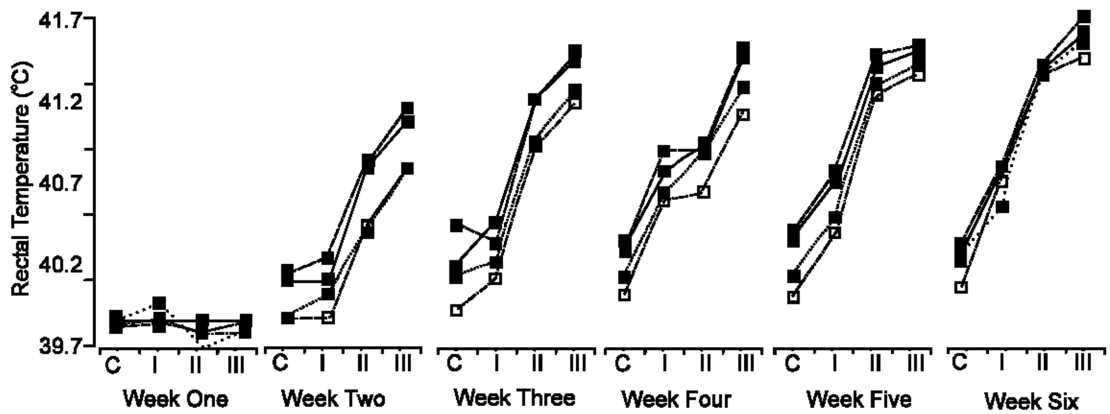

Fig. 2: Effects of ascorbic acid supplementation on broiler rectal temperatures (means of two birds °C) of broiler reared in closed house during cool season (C), hot Season (I), open-sided house during cool season (II) and hot season (III) (control 00 ppm), --■--, 100ppm —■— 200 ppm ···■··· 300 ppm —■—

Bird's performance: Seasonal temperature differences had a significant ($P < 0.05$) effect on broiler performance raised in open-sided house (Tables 1 and 2). The differences in ambient temperatures between the open-sided and closed house during the hot season were 7-8°C. Birds reared in an open-sided house during the hot season had significantly ($P < 0.05$) lower feed intake, body weight gain and feed conversion ratio than those reared during the cool season. The effects on body weight gain and feed conversion ratio are in agreement with those reported by Donkoh (1989) and Gross (1988). Drastic decreases in feed intake, body weight gain and feed conversion ratio have also been reported during summer months in countries with hot and temperate climates (Bonnet *et al.*, 1997; Yalcin *et al.*, 1997; Ozkan, *et al.*, 2003). Feed efficiency was also reduced which was probably due to decreased efficiency of nutrient utilization due to high energy requirements needed to dissipate extra heat load (Howlider and Rose, 1987), reduced protein retention and/or enhanced lipid deposition (Bonnet *et al.*, 1997; Sands and Smith, 1999). Similar to Ozkan *et al.* (2003) and Daghir (1995), the present study showed that detrimental effects of high seasonal temperatures were more pronounced in broilers between 3-6 weeks of age. Heat stressed birds reduce feed consumption to lower the thermogenic effect associated with nutrient absorption, assimilation and utilization (Withers, 1992). In addition, reduced blood flow to the gastrointestinal tract during heat-induced peripheral vasodilatation may impair nutrient absorption (Bottie and Harrison, 1987). Ascorbic acid supplemented birds (200-300 ppm) had significantly ($P < 0.05$) higher body weight gain, feed intake and better feed conversion ratio than those with no supplementation (Tables 1 and 2). The 300 ppm ascorbic acid in the open-sided house during hot season gave better performance than other levels. The practical benefits of ascorbic acid supplementation have been investigated in a number of countries where extreme climatic conditions that can depress broiler

Table 1: Effects of ascorbic acid supplementation on feed intake (FI), body weight gain (BWG) and feed conversion ratio (FCR) at various stage of development of broiler chickens reared in closed and open-sided houses during cool season

		Closed House					Open-Sided House				
		Ascorbic acid (ppm)					Ascorbic acid (ppm)				
Parameters		000	100	200	300	SEM	000	100	200	300	SEM
Week 1	FI g/b/d	18.0	18.4	18.3	18.3	0.72	18.1	18.7	18.7	18.9	0.77
	Gain g/b/d	16.7^{a}	17.3^{ab}	17.8^{b}	17.3^{ab}	0.29	16.9^{a}	17.3^{ab}	17.9^{b}	17.6^{b}	0.37
	FCR (FI/G)	1.07^{bc}	1.06^{b}	1.03^{a}	1.06^{b}	0.06	1.07^{bc}	1.08^{c}	1.04^{a}	1.07^{b}	0.05
Week 2	FI g/b/d	49.0	50.1	50.7	50.3	1.79	49.4	50.3	50.9	50.3	1.81
	Gain g/b/d	36.9^{a}	38.1^{b}	39.3^{c}	38.3^{bc}	0.85	36.9^{a}	38.3^{b}	39.7^{c}	38.9^{bc}	0.90
	FCR (FI/G)	1.33^{c}	1.31^{b}	1.29^{a}	1.31^{b}	0.03	1.34^{c}	1.31^{b}	1.28^{a}	1.29^{a}	0.04
Week 3	FI g/b/d	83.4^{a}	85.3^{ab}	86.9^{b}	85.9^{ab}	2.15	82.6^{a}	85.1^{ab}	86.4^{b}	84.9^{ab}	2.38
	Gain g/b/d	54.0^{a}	56.0^{ab}	58.7^{b}	56.0^{ab}	1.98	53.9^{a}	55.4^{ab}	58.3^{b}	56.7^{ab}	2.09
	FCR (FI/G)	1.54^{c}	1.52^{b}	1.48^{a}	1.53^{bc}	0.04	1.53^{bc}	1.54^{b}	1.48^{a}	1.50^{a}	0.05
Week 4	FI g/b/d	122.4^{b}	125.9^{c}	128.1^{c}	127.3^{c}	2.25	112.6^{a}	119.9^{b}	120.7^{b}	120.0^{b}	2.94
	Gain g/b/d	69.1^{b}	73.3^{c}	75.9^{c}	74.4^{c}	2.36	63.6^{a}	68.9^{b}	70.0^{b}	69.6^{b}	2.76
	FCR (FI/G)	1.77^{d}	1.72^{b}	1.69^{a}	1.71^{ab}	0.05	1.77^{d}	1.74^{c}	1.72^{b}	1.72^{b}	0.04
Week 5	FI g/b/d	145.3^{d}	148.6^{c}	150.4^{c}	149.7^{c}	2.39	137.3^{a}	142.7^{b}	145.4^{b}	142.1^{b}	3.90
	Gain g/b/d	75.6^{b}	78.6^{c}	79.9^{c}	78.4^{cd}	2.68	70.1^{a}	74.1^{b}	77.3^{bc}	74.9^{b}	2.41
	FCR (FI/G)	1.92^{b}	1.89^{ab}	1.88^{a}	1.91^{b}	0.06	1.95^{d}	1.93^{bd}	1.88^{a}	1.90^{ab}	0.05
Week 6	FI g/b/d	159.0^{b}	166.0^{c}	169.0^{c}	167.0^{c}	2.34	153.3^{a}	155.6^{ab}	159.5^{b}	157.4^{ab}	3.79
	Gain g/b/d	80.0^{b}	84.7^{c}	88.7^{c}	86.1^{c}	1.29	75.0^{a}	79.7^{b}	82.1^{b}	80.9^{b}	1.14
	FCR (FI/G)	1.99^{c}	1.96^{bc}	1.91^{a}	1.94^{b}	0.06	2.04^{d}	1.95^{b}	1.94^{b}	1.95^{b}	0.04
Whole period	FI g/b/d	98.1^{bc}	102.1^{c}	105.6^{c}	102.8^{c}	3.52	92.2^{a}	95.4^{ab}	96.9^{b}	95.6^{ab}	2.16
	Gain g/b/d	55.2^{ab}	58.0^{bc}	61.1^{c}	58.4^{bc}	1.45	52.7^{a}	55.6^{ab}	56.6^{b}	55.4^{ab}	1.54
	FCR (FI/G)	1.77^{b}	1.76^{b}	1.72^{a}	1.76^{b}	0.03	1.75^{b}	1.72^{a}	1.71^{ab}	1.73^{a}	0.04

SEM: residual standard deviation.. Means with the same row with different letters were significant ($P<0.05$).

Table 2: Effects of ascorbic acid supplementation on feed intake (FI), body weight gain (BWG) and feed conversion ratio (FCR) at various stage of development of broiler chickens reared in closed and open-sided houses during hot season

		Closed House					Open-Sided House				
		Ascorbic acid (ppm)					Ascorbic acid (ppm)				
Parameters		000	100	200	300	SEM	000	100	200	300	SEM
Week 1	FI g/b/d	14.0	14.1	14.7	14.7	0.45	11.2	11.3	11.3	11.3	0.50
	Gain g/b/d	12.7^{b}	13.1^{bc}	13.7^{c}	13.9^{c}	0.36	11.0^{a}	11.3^{a}	11.5^{a}	11.7^{a}	0.34
	FCR (FI/G)	1.10	1.08	1.07	1.06	0.05	1.02	1.00	0.98	0.97	0.04
Week 2	FI g/b/d	36.6	36.6	40.6	42.4	0.74	33.9	34.7	36.4	37.0	0.81
	Gain g/b/d	26.1^{a}	26.4^{ab}	29.8^{b}	31.6^{b}	0.47	24.1^{a}	24.9^{a}	26.7^{ab}	28.0^{b}	0.51
	FCR (FI/G)	1.40^{b}	1.39^{b}	1.36^{ab}	1.34^{a}	0.04	1.41^{b}	1.39^{b}	1.36^{ab}	1.32^{a}	0.02
Week 3	FI g/b/d	72.7^{bc}	74.9^{c}	77.9^{d}	79.9^{d}	0.99	65.7^{a}	68.9a^{b}	69.4^{b}	70.1^{b}	1.73
	Gain g/b/d	51.4^{c}	53.7^{d}	56.9^{d}	58.7^{d}	1.05	40.1^{a}	42.9^{ab}	44.0^{ab}	45.7^{b}	1.14
	FCR (FI/G)	1.41^{b}	1.39^{ab}	1.37^{a}	1.36^{a}	0.05	1.64^{e}	1.61^{de}	1.58^{d}	1.53^{c}	0.05
Week 4	FI g/b/d	109.9^{c}	112.7^{d}	116.6^{d}	119.0^{d}	1.15	85.6^{a}	86.6^{a}	89.8^{ab}	95.1^{b}	1.89
	Gain g/b/d	64.1^{c}	66.1^{cd}	69.4^{d}	72.6^{d}	1.09	49.3^{a}	50.6^{ab}	53.0^{ab}	56.4^{b}	1.16
	FCR (FI/G)	1.71^{bc}	1.70^{b}	1.68^{b}	1.64^{a}	0.06	1.73^{c}	1.71^{bc}	1.69^{b}	1.68^{b}	0.07
Week 5	FI g/b/d	140.6^{c}	141.1^{c}	142.3^{cd}	146.4^{c}	1.98	120.7^{a}	122.7^{a}	125.9^{b}	128.3^{b}	2.04
	Gain g/b/d	69.9^{c}	70.6^{cd}	73.9^{d}	76.3^{d}	1.35	56.7^{a}	58.3^{ab}	60.1^{b}	62.6^{b}	1.80
	FCR (FI/G)	2.01^{b}	1.99^{b}	1.93^{a}	1.92^{a}	0.08	2.13^{d}	2.10^{d}	2.09^{d}	2.05^{c}	0.07
Week 6	FI g/b/d	153.4^{c}	155.3^{cd}	157.9^{d}	158.3^{d}	3.89	137.9^{a}	140.3^{a}	144.9^{b}	146.9^{b}	5.61
	Gain g/b/d	74.6^{c}	78.1^{cd}	80.4d	81.9^{d}	2.01	62.3^{a}	65.0^{a}	70.0^{b}	75.0^{c}	2.70
	FCR (FI/G)	2.06^{b}	1.99^{b}	1.96^{ab}	1.93^{a}	0.07	2.21^{e}	2.16^{d}	2.07^{b}	1.96^{c}	0.09
Whole period	FI g/b/d	85.5	88.1	91.7	93.5	1.41	75.8	77.4	79.6	81.5	1.38
	Gain g/b/d	50.0	51.8	54.08	55.8	0.69	41.6	43.2	45.2	46.9	0.77
	FCR (FI/G)	1.71	1.70	1.68	1.68	0.06	1.82	1.79	1.76	1.74	0.05

SEM: residual standard deviation.. Means with the same row with different letters were significant ($P<0.05$).

performance and are similar to Oman. Cier *et al.* (1992) reported improved growth in bird reared during hot (44°C) and humid weather in Israel when diets were supplemented with 150 mg ascorbic acid/kg diet. In Malaysia, Kassim and Norziha (1995) reported that addition of ascorbic acid to diets (400 or 600 mg/kg) improved body weight gain and fed conversion ratio in broilers reared under hot environment (20-35°C) and humid conditions. In Egypt, adding ascorbic acid at 0.5 g/L to drinking water or 200 mg ascorbic acid /kg to diet increased growth of broiler reared at 38°C by 7-10% (Sayed and Shoeib, 1996). In Pakistan, supplementation of 100 mg ascorbic acid/kg improved BWG, FI and livability of broilers (Raja and Qureshi, 2000). During periods of hot environment and compromised FI, micronutrients consumption would be insufficient to support optimum performance (Ferket and Qureshi, 1992). Ascorbic acid may be important to facilitate utilization of nutrients under hot environment by bringing non-enzymatic scission of plant cell wall polysaccharides to induce hydroxyl radicals (Fry, 1998), which it may lead to better nutrient digestion. Marron *et* *al.* (2001) observed a 20% decrease in *in vivo* viscosity of ileal digesta in broilers fed a diet supplemented with 250 mg ascorbic acid/kg diet, which indicate that it may influence pathways of energy metabolism (Runho *et al.*, 1997; McKee *et al.*, 1997). Ascorbic acid was also suggested to improve digestive enzyme activity, microbial phytase activity, increased pancreatic secretion increased growth of the gastrointestinal mucosa (Dibner and Buttin, 2002) and promotes enteric absorption of nutrients in ligated duodenal loops (Combs and Pesti, 1976). Also, ascorbic acid deficiency leads to impaired calcium and phosphorous deposition during bone matrix formation (Church and Pond, 1976). These results are in agreement with those reported by Jafar and Blaha (1996), Alisheihov (1980), Kafri and Cherry (1984), Njoku (1986), Orban *et al.* (1993), Mckee *et al.* (1997), Blaha *et al.* (2000), Marron *et al.* (2001) and Aengwabich *et al.* (2003). In contrast, Puron *et al.* (1994) found that dietary 200 mg ascorbic acid/kg did not improve broiler performance in open-sided housing at 36^{0}C. However the amount of heat stress experienced by birds is not only dependent on ambient temperature but also on air movement and humidity. The lack of consistency findings of the present study and Puron's finding may be due to management such as a method of ascorbic acid preparation, type of ascorbic acid used and the vitamin's innate instability. Moreover, in the present study, using the drinking water for supplementing may have been a more suitable choice because water consumption increases during high ambient temperatures to facilitate evaporative cooling.

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