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THE USE OF EARLY-AGE FEED RESTRICTION AND/OR POTASSIUM CHLORIDE FOR ALLEVIATING THE ADVERSE EFFECTS OF HEAT STRESS ON BROILER CHICKS: 2- EFFECTS ON SOME PHYSIOLOGICAL PARAMETERS, BLOOD CONSTITUENTS And Digestibility Of Nutrients.

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ABSTRACT

The present study was carried out to investigate the possibility of alleviating the adverse effects of heat stress to which broiler chicks are exposed during the summer season by means of early-age feed restriction (EFR) and/or dietary supplementation with potassium chloride (KCl). Three hundred and sixty, one-day-old, broiler-type Hubbard chicks were randomly divided into two halves, each of which was assigned to four treatments (T), and given starter diets from 1 to 21 days of age, then, the birds were switched to grower diets from 22 to 42 days of age. Two feeding regimens were imposed on these birds. Chicks of the first half (T1, T2, T3 and T4) were full-fed (FF), during the entire experimental period from 0 to 6 weeks of age, while birds of the other half (T5, T6, T7 and T8) were subjected to feed restriction; only during the first week of life. Each of the starter and grower diets were isocaloric and isonitrogenous, and originally contained about 0.8% K. Diets of T1 and T5 were unsupplemented with KCl and served as controls, while diets for chicks of T2 and T6, T3 and T7 or T4 and T8, were supplemented with KCl at levels of 0.75, 1.5 and 2.25%, respectively. Thus, in these diets supplemental KCl plus basal K provided dietary K levels of 0.8, 1.2, 1.6 or 2.0%, respectively.

The criteria of response were some physiological changes, levels of some blood constituents and nutrients digestibility. The obtained results can be summarized as follows: Early-age feed restriction (during the first week) of broiler chicks decreased significantly ($P \leq 0.01$) body temperature, panting rate, blood pH and sedimentation rate, and plasma corticosterone ($P \leq 0.05$), but increased ($P \leq 0.01$) the activity of alkaline phosphatase and plasma concentrations of k and T3. However, blood hemoglobin, concentrations of plasma total protein, total lipids, glucose, cholesterol, Na, Cl, and T4 were not affected. Supplemental KCl decreased significantly ($P \leq 0.01$) body temperature, panting rate, and blood pH and sedimentation rate, but increased ($P \leq 0.01$) the activity of alkaline phosphatase, and the concentrations of plasma total protein, Na, K, T3 and T4. However, blood hemoglobin, and plasma concentrations of total lipids, glucose, cholesterol, Cl and corticosterone were not affected. Early-age feed restriction did not affect digestibility of crude fiber (CF), organic matter (OM), ether extract (EE), nitrogen free extract (NFE), nitrogen retention, ash retention, or k retention, but decreased dry matter (DM) and crude protein (CP) digestibility. Supplemental KCl did not affect nitrogen retention and the digestibility of CF or NFE, but the high level (2.25%) improved the digestibility of DM, OM, EE, and CP and ash and K retention. The use of early-age feed restriction with 2.25% dietary KCl level for broiler chicks in hot climate during the summer season was recommended.

Keywords: Broiler chicks, physiological parameters, early-age feed restriction, dietary KCl.

INTRODUCTION

The term "heat stress" is often used to define the birds' response to warmer environments where some different or abnormal physiological response, such as panting, is observed. Some reports indicated that factors other than reduced feed intake contributed to the growth depression in chicks associated with high environmental temperature (Ain Baziz *et al.,* 1990; and Geraert *et al.,* 1996a).

The reduction of chicks growth and feed efficiency in hot environments was partly explained on the basis of decreased metabolic utilization of nutrients, increased heat production, and reduced protein retention (Ain Baziz *et al.*, 1996 and Geraert *et al.,* 1996a). The reduction in feed efficiency might also be due primarily to lower feed digestibility; the first step of feed utilization. It is well established that thyroid hormones are important growth promoters in chicks (McNabb and King, 1993) and the concentrations of circulating triiodothyronine (T3) and thyroxine (T4) are reduced at high ambient temperatures (Williamson *et al.*, 1985; and Yahav *et al.*, 1996).

At high ambient temperature the accelerated panting rate increases the loss of carbon dioxide (CO_2) from the lungs of birds, which leads to reduction in the partial pressure of CO2 (pCO_2), and thus a reduction in bicarbonate (HCO_3) and concentration of hydrogen (H) ion in blood plasma, causing a rise in blood plasma pH, and produces an acid-base disturbance termed respiratory alkalosis (Richards, 1970; Bottje *et al.*, 1983; Bottje and Harrison, 1985; Teeter *et al.*, 1985; and Teeter and Smith, 1986). Departure from normal acid-base balance through respiratory alkalosis reduced feed intake and weight gain in chicks (Hurwitz *et al*, 1973, and Maskrey, 1984). It has been reported that the respiratory alkalosis induced by heat stress has been related to negative mineral balance for K as well as Na (Belay *et al.*, 1990) and elevated blood corticosterone (Bowen and Washburn, 1985). The occurrence of respiratory alkalosis in response to thermal stress, however, has not been consistently observed in all studies with chicks. The NRC (1994) recommended dietary K levels of 0.15% for laying hens and 0.35% for 3 to 6-week old broiler chicks, under normal conditions. Indeed, dietary K levels of 0.6% for laying hens (Deetz and Ringrose, 1976) and 1.5% for broiler chicks (Smith and Teeter, 1987) are needed to prevent a K imbalance under conditions of chronic heat stress.

Heat stress is usually regulated by the control of environmental factors such as house temperature and ventilation. However, sophisticated housing designs cannot always be accommodated because of economic and other considerations. In these circumstances alternate strategies need to be considered. Nutritional manipulation is one of such options, and recently a number of nutritional procedures have been identified which can help in ameliorating the effect of heat stress on broiler chicks and laying hens. Therefore, the present study was carried out to investigate the possibility of alleviating the adverse effects of heat stress to which broiler chicks are exposed during the summer season by means of early-age feed restriction and/or dietary supplementation with potassium chloride.

MATERIALS AND METHODS

The present study was conducted (from June to August 2000) at the Poultry Farm; Agricultural Researches and Experiments Station; Faculty of Agriculture, Mansoura University.

Experimental birds and diets:

Type of birds and experimental diets were the same as described previously by Raya *et al.* (2003). Three hundred and sixty, one-day-old, unsexed broiler-type Hubbard chicks, having an average body weight of 47.5g, were wing-banded and randomly divided into two halves, each of which was assigned to four treatments (T) of three replicates containing 15 chicks each. The chicks were raised during the brooding and growing periods in batteries with wire-floor decks, placed in a naturally ventilated rearing room, provided with a continuous florescent illumination. During the first two weeks of the brooding period, however, a supplemental heat was provided to chicks. The chicks were vaccinated against New-Castle and Gumboro diseases, reared under similar environmental conditions, and given the experimental starter diets from 0 to 3 weeks of age (1-21 days old) and grower diets from 3 to 6 weeks of age (22-42 days old).

The experimental diets were formulated to be isonitrogenous and isocaloric; where starter diets contained about 21.6% CP and ME of 3000 Kcal/kg, and grower diets contained 19.6% CP with ME content of 2955 Kcal/kg (Table 1). Two feeding regimens were imposed on the experimental birds. Chicks of the first half (treatment groups of T1, T2, T3 and T4) were full-fed (FF); on *ad libitum* basis, throughout the entire experimental period (0 to 6 weeks of age), while feed of the other half (treatment groups of T5, T6, T7 and T8) was restricted; only during the first week, to meet their daily maintenance requirements for energy with a concomitant achievement of some growth; as calculated according to the following equation (Plavnik and Hurwitz, 1989): 1.5 Kcal X $BW^{0.66}$; where BW is the body weight in grams. These early-age feed restricted (EFR) chicks had a free access to feed after the first week and up to the end of the experimental period. This feed restriction amounted to 40% of normal *ad libitum* feeding. All chicks, however, had a free access to drinking water. Both starter and grower diets had originally about 0.8% potassium. From 1 to 6 weeks of age (8-42 days old), diets of chicks on both the two feeding regimens (FF and EFR) were either unsupplemented with KCl for those in T1 and T5 which served as controls, or supplemented with KCl at levels of 0.75, 1.5,and 2.25% of diets for chicks of T2 and T6, T3 and T7 or T4 and T8, respectively. Thus, in these diets, supplemental KCl plus basal K provided dietary K levels of 0.8, 1.2, 1.6 or 2.0%, respectively.

The criteria of response were some physiological changes, levels of some blood constituents and nutrients digestibility. Also, daily ambient temperature and relative humidity fluctuations were recorded during the experimental periods. Furthermore, records of prevailing temperature and relative humidity in Dakahliyah Governorate during the experimental period were quoted from the annual reports of Egyptian weather-Forecast

Administration (2000). These records showed that during the growing period from 3 to 6 weeks of age, the experimental chicks were subjected to means of minimum and maximum daily temperatures of 24°C and 33.43°C, respectively. While the relative humidity ranged from 60 to 80% inside the rearing room. Thus, the chicks might suffer from such naturally occurring summer heat stress.

Table 1: Chemical composition of the experimental diets.

Ingredients %	Starter diets				Grower diets			
	Supplemental KCl levels				Supplemental KCl levels			
	0	0.75	1.50	2.25	0	0.75	1.50	2.25
Yellow corn	59.70	59.95	58.40	56.65	60.80	61.75	61.40	61.15
Soybean meal (44%)	27.10	27.10	27.30	27.70	25.40	25.50	25.70	25.70
Wheat bran	3.80	2.60	2.50	2.50	7.60	5.70	4.90	4.00
Fish meal (70%)	5.50	5.70	5.80	5.80	2.80	3.00	3.10	3.30
Limestone (38% Ca)	0.88	0.88	0.88	0.88	0.90	0.90	0.90	0.90
Bone meal (29.8% Ca)	1.62	1.62	1.62	1.62	1.50	1.50	1.50	1.50
Sunflower oil	0.50	0.50	1.10	1.70	0.30	0.20	0.30	0.50
Common salt	0.40	0.40	0.40	0.40	0.30	0.30	0.30	0.30
Vit. & Min. Premix*	0.30	0.30	0.30	0.30	0.30	0.30	0.30	0.30
DL-methionine	0.20	0.20	0.20	0.20	0.10	0.10	0.10	0.10
KCl	0.00	0.75	1.50	2.25	0.00	0.75	1.50	2.25
Total	100	100	100	100	100	100	100	100
Calculated analysis (air dry basis):								
ME; kcal/kg	3001	3000	3002	3001	2954	2960	2953	2955
Crude protein %	21.56	21.55	21.56	21.58	19.55	19.55	19.57	19.56
C/P ratio	139	139	139	139	151	151	151	151
Ether extract %	3.67	3.54	4.19	4.73	3.32	3.22	3.30	3.48
Crude fiber %	3.65	3.64	3.51	3.50	3.97	3.79	3.71	3.61
Ca %	1.04	1.04	1.04	1.04	0.95	0.95	0.95	0.95
Total P %	0.68	0.67	0.67	0.67	0.66	0.64	0.64	0.63
K	0.83	1.20	1.58	1.96	0.82	1.18	1.55	1.92
Lysine %	1.21	1.22	1.22	1.22	1.04	1.05	1.05	1.06
Methionine %	0.60	0.61	0.61	0.60	0.44	0.45	0.45	0.45
Meth. + Cyst. %	0.94	0.94	0.94	0.94	0.77	0.77	0.77	0.77
Determined analysis:								
Moisture %	8.56	8.69	8.41	8.37	8.50	8.77	8.77	8.65
Dry matter %	91.44	91.31	91.59	91.63	91.50	91.23	91.23	91.35
Crude protein %**	23.89	23.91	23.88	23.92	21.52	21.54	21.55	21.54
Ether extract %**	3.93	3.86	4.59	4.96	3.67	3.61	3.65	3.89
Crude fiber %**	4.22	4.16	3.98	4.01	4.55	4.43	4.32	4.21
Ash %**	6.36	6.67	6.89	7.33	6.47	6.59	6.96	7.35
NFE %**	61.60	61.40	60.66	59.78	63.79	63.83	63.52	63.01
K %**	---	---	---	---	0.91	1.34	1.71	2.07
Cost of 1 kg feed; L.E.***	0.865	0.925	0.994	1.06	0.745	0.804	0.864	0.927

*: Each 3 Kg premix contain: Vit. A 12000000 I.U.; Vit. D_3 2500000 I.U.; Vit. E 10g; Vit. K 2.5g; Vit. B_2 5g; Vit. B_6 1.5g; Vit. B_{12} 10 mg; Biotin 50 mg; Folic acid 1g; Nicotinic acid 30 mg; Pantothenic acid 10 g; Antioxidant 10g; Mn 60g; Cu 10g; Zn 55g; Fe 35g; I 1g; Co 250 mg; Se 150 mg.

**: Determined on dry matter basis.

***: Calculated according to the prevailing market prices of feed ingredients during the experimental period, including the price of supplemental KCl.

Some physiological changes and levels of some blood constituents:

Rectal and skin temperature and panting rate:

Both rectal and skin temperatures and panting rates of chicks were measured; using 10 and 5 birds/treatment/day through three consecutive days in the afternoon during the 5^{th} and 6^{th} weeks of age, respectively. Rectal temperature of chicks was recorded by a digital thermometer inserted approximately 3 cm into the cloaca, while their skin temperature was measured by a thermometer placed under the wing. Panting rates of chicks were measured by counting the chest movement for one minute.

Blood constituents:

At the termination of the feeding trial at 6 weeks of age; 5 chicks were randomly selected from each treatment for blood sampling. Blood samples were collected from the jugular vein into heparinized tubes. Then blood samples were divided into two parts, as in one part the plasma was isolated by centrifugation at 3000 rpm for 15 minutes. Concentrations of plasma total protein, total lipids, glucose, cholesterol and activity of plasma alkaline phosphatase, and blood hemoglobin were determined colorimetricaly; using commercial kits of diagnostic examination (Biomerieux, Spinreact, and Randox Co., imported from France, Spain and United Kingdom, respectively) according to the methods described by Gornall *et al*, (1968), Bragdon (1960), Trinder (1960), Watson (1960), Kind and King (1954), and Van Kampen and Zijlstra (1961), respectively. Concentrations of plasma Na and Cl, and K were also determined colorimetrically, using commercial Kits of Teco diagnostics (ANAHEIM, CA, France) according to the method described by Henry (1974) and Tietz (1974), respectively. Blood sedimentation rate was measured following the procedure described by Brown (1980), whereas blood pH was measured by a pH-meter (CG 728 SCHOTT). Total concentrations of plasma T3 and T4 were determined, using commercial Kits of diagnostic examination (Equipar, Italy) according to the methods described by Sterling (1975) and Liewendahi (1990), respectively. Plasma corticosterone level was also determined, using commercial Kits of Diagnostic examinations [Diagnostic products corporation (DPC), Los Angeles, U.S.A.] according to the method described by Sainio *et al* (1988).

Digestibility trials:

At 7 weeks of age, a total of 5 chicks were selected from each treatment on the basis of average body weight. Each group of birds was placed separately into battery unit served as a metabolic cage, and fed its respective experimental diet for a period of two days to allow the birds to become adjusted to cages. Then, the excreta were quantitatively collected for a 3 days period during which feed consumption data were also recorded. The excreta of each group of birds were collected in foil-lined aluminum trays put beneath cages. Just after collection, the excreta were sprayed with 1% boric acid to eliminate nitrogen loss due to a possible ammonia release. Any feather or foreign debris occasionally existed in excreta were removed out. The excreta were then dried in a forced-air oven at 70°C for 48 hours. Then, the excreta were allowed to equilibrate in moisture with atmospheric air before being weighed, finely ground, and stored in plastic bags in pledge of further analysis. Chemical analyses of the experimental diets and excreta were carried out according to the official methods (A.O.A.C. 1980). The procedure described by Jakobsen *et al* (1960) was used for separating the fecal protein in excreta samples. This procedure depends on the controlled oxidation of uric acid to allantoin by potassium permanganate followed by the precipitation of the protein by trichloroacetic acid. Precipitated protein represents its undigested part in the excreta. Urinary organic matter was calculated according to Abou-Raya and Galal (1971). They originated the factor 2.62 to be multiplied by the urinary nitrogen to obtain the urinary organic matter. Digestibility coefficients for CP and OM were calculated according to the following equation: Digestion coefficient % = [(Nutrient intake; g – Fecal nutrient content; g) / Nutrient intake; g] × 100., while those for D M, E E, C F and NFE were calculated as follows: [(Nutrient intake; g – Excreta nutrient content; g) / Nutrient intake; g] × 100. Nitrogen retention was calculated from the following equation: N retention % = [(N intake, g – N excreted, g) / N intake, g] × 100., and similarly retention of ash and K was calculated.

Statistical analysis:

For data processing, QUATTRO PRO software program (Borland International, Inc, 1990) was applied. Statistical analyses were performed, using a multi-factor analysis of variance by the STATGRAPHIC software program (Rockville, 1991). The differences were considered significant at $P \leq 0.05$ or at $P \leq 0.01$.

RESULTS AND DISCUSSION

Some physiological parameters of experimental chicks:

Results of the effects of feeding regimen and dietary KCl level on some physiological parameters in 6-week old experimental chicks; including measurements of body temperature, panting rate, some blood constituents, blood acid-base balance, and some hormones in plasma (Tables 2, 3 and 4) are discussed herein below.

Rectal and skin temperatures, and panting rate:

Table 2 shows the effects of feeding regimen and dietary KCl level, and their interaction on rectal and skin temperatures, and panting rate of chicks during the 5^{th} and 6^{th} weeks of age. Significant ($P \leq 0.01$) differences were detected among groups of chicks in their rectal and skin temperatures, and panting rate due to the effect of feeding regimen. This was associated with concomitant lower panting rates for EFR-chicks than those of FF-chicks during the 5^{th} and 6^{th} weeks of age. Also, EFR decreased significantly rectal and skin temperatures of chicks during the 5^{th} and 6^{th} weeks of age.

Regardless of feeding regimen, significant ($P \leq 0.01$) differences were existed also in rectal and skin temperatures, and panting rate of chicks, due to the effect of dietary KCl level. Data in Table 3, showed that body temperature and respiration rate of chicks were significantly ($P \leq 0.01$)

decreased upon feeding KCl-supplemented diets; with a linear reduction observed in these variables, being markedly pronounced with the highest dietary KCl level (2.25%). This may indicate that supplemental KCl alleviated the adverse effects of high ambient temperatures on the performance of chicks reared under the conditions of the present study. Highly significant ($P \leq 0.01$) differences were observed in body temperature (rectal and skin temperature), and panting rate of chicks, due to feeding regimen by dietary KCl level interaction, during the 5^{th} and 6^{th} weeks of age. These results indicate that both the two factors synergistically exerted their effects on these variables.

Table 2: Means and standard errors for rectal and skin temperatures, and panting rate of experimental chicks at the 5^{th} and 6^{th} week of age.

Treatments	Measurements					
	5^{th} week of age			6^{th} week of age		
	Rectal temperature °C	Skin temperature °C	Panting rate; Respirations /min.	Rectal temperature °C	Skin temperature °C	Panting rate; respirations /min.
Main factors:						
Feeding regimen A						
1 Full feeding	42.26^a	40.65^a	94.80^a	42.14^a	40.68^a	96.50^a
2 Early-age feed restriction	41.70^b	40.33^b	69.80^b	41.56^b	40.28^b	68.85^b
SE	00.03	00.04	00.64	00.04	00.06	00.40
Significance level[1]	**	**	**	**	**	**
KCl level % B						
1 0.00	42.61^a	41.07^a	122.48^a	42.65^a	40.88^a	126.73^a
2 0.75	42.05^b	40.61^b	80.11^b	41.93^b	40.55^b	78.96^b
3 1.50	41.90^c	40.43^b	66.45^c	41.83^b	40.52^b	64.96^c
4 2.25	41.37^d	39.85^c	60.16^d	40.99^c	39.97^c	60.03^d
SE	00.04	00.06	00.91	00.06	00.09	00.57
Significance level[1]	**	**	**	**	**	**
Interaction AB						
T No.						
T1 1×1	43.15	41.43	161.66	43.22	41.12	169.13
T2 1×2	42.09	40.50	85.56	42.01	40.56	84.86
T3 1×3	42.13	40.44	67.16	41.88	40.56	67.20
T4 1×4	41.68	40.24	64.80	41.46	40.48	64.80
T5 2×1	42.06	40.71	83.30	42.08	40.64	84.33
T6 2×2	42.02	40.73	74.66	42.86	40.55	73.06
T7 2×3	41.67	40.42	65.73	41.78	40.48	62.73
T8 2×4	41.05	39.45	55.53	40.52	39.46	55.26
SE	00.07	00.09	01.28	00.09	00.13	00.81
Significance level[1]	**	**	**	**	**	**
Overall mean	41.98	40.49	82.30	41.85	40.48	82.67
SE	00.02	00.03	00.45	00.03	00.04	00.28

a-d: Means in the same column having different superscripts are significantly different at $P \leq 0.05$. 1: **= Significant at $P \leq 0.01$.

It was reported that the mechanism whereby fasting or feed restriction increases survival of chicks in hot environments lies in the reduction of body temperature was attributed to reduced feed intake (Teeter *et al*, 1987). It is not clear, however, whether early-age feed restriction has or not a carry-over effect on body temperature of chicks later at marketing age.

In the present study, it was apparent that, early-age feed restriction significantly ($P \leq 0.01$) reduced both body temperature and respiration rate of chicks later in life at marketing age, as compared with *ad libitum* feeding. However, Yahav and Plavnik (1999) reported that early-age feed restriction from 7 to 14 days of age, significantly decreased body temperature of broiler chicks reared at 26 ^{o}C as compared with their *ad libitum*-fed control, but when chicks were thermally challenged (35 ^{o}C for 6 h) at 42 days of age, this difference was not observed. This discrepancy between the current result and that of Yahav and Plavnik (1999) may stem from the differences in the age at which feed restriction was imposed on chicks, or in type and extent of heat stress. In the work of Yahav and Plavnik (1999) feed restriction was practiced on chicks between 7 and 14 days of age and, thereafter chicks were challenged by acute heat stress only at 42 days of age, while in the present study, the feed of chicks was restricted at an earlier age from one to 7 days of age, and chicks were grown continuously under normally occurring heat stress of the summer season throughout the whole experimental period.

From the present result, it may be concluded, however, that EFR-chicks had the ability to maintain their body temperature and respiration rate lower than FF-chicks at the termination of the experiment at 6 weeks of age. This may indicate that EFR-chicks became tolerant to high ambient temperatures than their FF-counterparts, under the conditions of the present study. However, this conclusion is speculative, since the method by which this was accomplished is not clearly understood. But it seems likely reasonable to suggest that the early-age feed restriction program; which was practiced in the present study, partially alleviated the deleterious effects of high ambient temperatures during the summer season on the performance of experimental chicks, at least through lowering body temperature and panting rate of chicks. This could be evidenced by the insignificant enhancement of growth and viability, and the significant improvement of feed efficiency of EFR-chicks as compared with their FF-counterparts (Raya *et al*., 2003).

Some reports indicated that enhancement of weight gain, feed efficiency, and survivability of broiler chicks which were subjected to either acute, cycling or constant high ambient temperatures by supplementation of their drinking water or diets with K; especially in the form of KCl (Teeter and Smith, 1986; Smith and Teeter, 1987; Smith and Teeter, 1993; and Deyhim and Teeter, 1991) was associated with an increased water consumption and a reduced body temperature (Smith and Teeter, 1993; Deyhim and Teeter, 1991; and Ait-Boulahsen *et al*, 1995). This beneficial effect of supplemental K on performance and survivability of broilers grown in hot environments was attributed, in part, to an increased water consumption, which acts as a heat sink (Smith and Teeter, 1987; and Smith and Teeter, 1993).

In view of the above-mentioned reports; even though in the present study water consumption of experimental chicks was not determined, it could be postulated that chicks fed the KCl- supplemented diets probably consumed more water, and that this increased water intake acted as a heat sink; resulting in a reduction of body temperature and panting rate, and an improvement in the performance and viability of these chicks, compared with their counterparts received no supplemental KCl under the conditions of the present study. It is worth noting that Raya *et al.* (2003) previously s howed that t he d ata o f t he p erformance f or b ody w eight a nd f eed c onversion a nd mortality rate of these experimental chicks of these experimental chicks at 6 weeks of age were as summarized in the following Table:

Feeding regimen	Full-feeding (FF)				Early age feed restriction (EFR)			
Supplemental KCl levels %	0.0	0.75	1.50	2.25	0.0	0.75	1.50	2.25
Items / Treatments	T1	T2	T3	T4	T5	T6	T7	T8
Average body weight, g	1769^{c}	1835^{c}	1953^{a}	1981^{a}	1840^{bc}	1921^{ab}	1961^{a}	1954^{a}
Feed conversion	2.22^{e}	2.13^{d}	1.96^{abc}	1.92^{a}	1.99^{bc}	2.02^{c}	1.97^{abc}	1.94^{ab}
Mortality rate %	15.55	4.44	2.22	2.22	4.44	2.22	2.22	0.00

Some blood constituents of 6-week old experimental chicks:

Data in Table 3 shows the effects of feeding regimen and dietary KCl level, and their interaction on blood sedimentation rate and hemoglobin level, and concentrations of plasma total protein, t otal l ipids, g lucose, c holesterol and alkaline phosphatase in 6-week old experimental chicks. No significant differences were detected among groups of chicks in concentrations of blood hemoglobin, and plasma total protein, total lipids, glucose or cholesterol, while those in blood sedimentation rate and plasma alkaline phosphatase were significant ($P \leq 0.01$), due to the effect of feeding regimen.

Irrespective of feeding regimen, dietary KCl level had no significant effect on the level of blood hemoglobin, and concentrations of plasma total lipids, glucose or cholesterol, while it exerted a significant ($P \leq 0.01$) effect on blood sedimentation rate, concentration of plasma protein and plasma alkaline phosphatase activity in experimental chicks. Chicks fed diets containing 1.5 or 2.25% KCl showed similar blood sedimentation rates of 97 and 93 mm/24h, respectively, which were significantly less than that of chicks fed 0.75% KCl-supplemented diet (104 mm/24h), whereas chicks fed no supplemental KCl (0.0%) exhibited the highest blood sedimentation rate (110 mm/24h). A linear increase was observed in total protein level in plasma of chicks with increasing supplemental KCl level in their diets from 0.0, 0.75, 1.5 to 2.25%, respectively, yet no significant differences were detected between chicks fed 0.0 and 0.75% KCl-containing diets, or among those fed 0.75, 1.5, and 2.25%KCl-supplemented diets. Chicks fed 0.0 and 0.75% KCl-supplemented diets exhibited similar values for plasma alkaline phosphatase, which were significantly less than that of chicks fed the 1.5% KCl-diet, and all were significantly less than that exhibited by chicks fed the 2.25% KCl-diet. Analysis of variance for blood constituents of chicks revealed that, with the exception of blood sedimentation rate and plasma total protein, the effects of feeding regimen and dietary KCl level on concentrations of blood hemoglobin, plasma total lipids, glucose and cholesterol were not interrelated.

It is generally accepted that some changes in plasma constituents of birds may occur during exposure to high environmental temperature.

However, some authors have reported decreases in total plasma protein concentration (Deaton *et al*, 1969; Vo *et al*, 1978; and Yahav *et al*, 1997), in blood hemoglobin and hematocrit value (Deaton *et al*, 1969; and Yahav *et al*, 1997), in blood cell number and packed cell volume (Furlan *et al,* 1999) in broiler chicks with increasing rearing temperature. Others found no changes (Squibb *et al,* 1959) or increases in plasma protein (Pardue *et al,* 1985), or no changes in hematocrit value (Huggins and Lewis, 1978). In addition, a rise in serum glucose, no change in plasma triglycerides and phospholipids (Geraert *et a l,* 1 996b), a nd a decline in serum cholesterol (Zulkifli *et al,* 1999) were observed in broiler chicks in response to heat stress; and this may probably be due to a reduced lipolysis at high ambient temperature of 32 ^{o}C (Geraert *et al,* 1996b).

Table 3:Means and standard e rrors f or b lood s edimentation r ate (Sd. R.), hemoglobin (Hb), plasma total protein (TP), total lipids (TL), cholesterol (Chol.), glucose (Glu.) and alkaline phosphatase (AP) in 6 weeks old experimental chicks.

Treatments	Measurements						
	Sd. R.; mm/24 Hours	Hb g/dl	TP g/dl	TL g/dl	Chol. mg/dl	Glu. mg/dl	AP IU/l
Main factors:							
Feeding regimen A							
1 Full feeding	108^{a}	8.23	3.00	0.79	102	254	63.15^{b}
2 Early-age feed restriction	93^{b}	8.10	3.11	0.77	94	252	66.31^{a}
SE	1.02	0.21	0.09	0.01	2.8	3.4	1.03
Significance level[1]	**	NS	NS	NS	NS	NS	**
KCl level % B							
1 0.00	110^{a}	8.07	2.69^{b}	0.78	99	253	47.12^{c}
2 0.75	104^{b}	8.13	3.03^{ab}	0.80	94	253	47.24^{c}
3 1.50	97^{c}	7.95	3.25^{a}	0.76	98	252	57.81^{b}
4 2.25	93^{c}	8.50	3.27^{a}	0.79	99	256	106.76^{a}
SE	1.44	0.31	0.12	0.01	3.9	4.7	1.46
Significance level[1]	**	NS	**	NS	NS	NS	**
Interaction AB							
T No.							
T1 1×1	123	7.94	2.57	0.81	100	259	45.53
T2 1×2	111	8.33	3.27	0.82	104	259	46.52
T3 1×3	100	7.82	2.92	0.75	97	247	56.01
T4 1×4	99	8.80	3.29	0.80	104	250	104.56
T5 2×1	96	8.19	2.80	0.75	99	246	48.70
T6 2×2	96	7.92	2.84	0.78	84	246	47.96
T7 2×3	95	8.06	3.58	0.77	98	256	59.60
T8 2×4	88	8.20	3.25	0.78	94	261	108.96
SE	2.04	0.43	0.17	0.02	5.6	6.8	1.54
Significance level[1]	**	NS	*	NS	NS	NS	NS
Overall mean	101	8.16	3.06	0.78	98	253	64.73
SE	0.72	0.15	0.06	0.01	1.9	2.4	1.01

[a-c]: Means in the same column having different superscripts are significantly different at P ≤0.05.

[1]: NS= Not significant; *= Significant at P≤0.05; **= Significant at P≤0.01.

In general, feed restriction at any age, results in a decreased serum glucose and an increased level of plasma free fatty acids in poultry (Praharaj, 1996); this is probably due to increased lipolysis, whereas, Squibb *et al* (1959) reported that a short-term feed restriction at five weeks of age had no effect on plasma protein level in chicks. As for the effect of early-age feed restriction on blood constituents of chicks reared in hot environments, few reports are available. Therefore, the comparison between the current result and those of other investigators may lose its validity. However, in this connection, early-age feed restriction; practiced during the first two weeks of age, was found to moderate the hematocrit value (Yahav and Plavnik, 1999), and to increase plasma cholesterol or had no effect on concentration of plasma glucose (Zulkifli *et al,* 2000) in boiler chicks challenged by heat stress later at 5 and 6 weeks of age. In the present study, however, early-age feed restriction resulted in significant reduction of blood sedimentation rate and increase in plasma alkaline phosphatase activity in EFR-chicks, with no change in concentrations of blood hemoglobin, plasma total protein, total lipids, glucose and cholesterol at 6 weeks of age, in comparison with their FF-counterparts.

Acid-base balance of 6-week old experimental chicks:

Data of effects of feeding regimen and dietary KCl level, and their interaction on blood acid-base balance; as assessed by blood pH value, and concentrations of plasma K, Na and Cl in 6-week old experimental chicks are shown in Table 4. No significant differences were detected among groups of chicks in concentrations of plasma Na and Cl, while the variations observed in blood pH value and level of plasma K were significant ($P \leq 0.01$), due to the effect of feeding regimen.

Regardless of feeding regimen; with the exception of plasma Cl level, significant ($P \leq 0.01$) differences were detected in blood pH value, and concentrations of plasma K and Na of experimental chicks, due to the effect of dietary KCl level. Chicks fed diet with no supplemental KCl (0.0% KCl) showed a significantly higher pH value than those fed KCl-supplemented diets (0.75, 1.5 and 2.25% KCl), yet no significant differences were observed among these latter three groups. Chicks fed diets containing 0.0 or 0.75% KCl had similar plasma Na concentrations, which were significantly less than those exhibited by chicks fed on 1.5 or 2.25 % KCl-supplemented diets. As for plasma K level, it was proportionally associated with supplemental KCl inclusion rate, since plasma K concentrations of 1.84, 1.98, 2.11 and 2.33 mEq/l were found in chicks fed diets containing 0.0, 0.75, 1.5 and 2.25% KCl, respectively, with significant differences. Analysis of variance showed that the effects of feeding regimen and dietary KCl level on blood acid-base balance in experimental chicks were not interrelated.

Even though, it has been established that at high ambient temperature the accelerated panting rate increases the blood pH value and produces an acid-base disturbance in blood of broiler chicks, termed respiratory alkalosis (Richards, 1970; Bottje *et al* , 1983; Bottje and Harrison, 1985; Teeter *et al*, 1985; Teeter and Smith, 1986; and Yahav *et al*, 1997). Occurrence of respiratory alkalosis and change in blood pH of chicks have not been observed in response to thermal stress in other studies (Siegel *et al*, 1974; and Deyhim and Teeter, 1991). Also, Yahav *et al* (1997) reported that plasma Cl concentration did not differ in broiler chicks reared at various ambient temperatures. In this connection, Teeter *et al* (1985) reported that reasons for discrepancies in the results of different workers are not clear, but may be attributed to the degree of thermal stress, type of stress (acute *vs.* chronic), the length of thermal stress period, the degree to which the birds had been acclimatized to the conditions, blood collection site and sampling time relative to the respiratory state of birds.

The current results, however, showed that FF-chicks exhibited less feed efficiency and increased mortality rate (Raya *et al.*, 2003), and in addition a higher blood pH value than their EFR-counterparts. This response may be attributed to the increased body temperature and panting rate of FF-chicks as compared with those of EFR-chicks. Thus, it would appear that FF-chicks suffered, to some extent, more than EFR-chicks from high ambient temperatures, under the conditions of the present study.

Proportions of plasma Na, K and Cl are important determinants of acid-base balance (Hurwitz *et al*, 1973; Cohen and Hurwitz, 1974; and Sauveur and Mongin, 1978). Departure from normal acid-base balance through respiratory alkalosis induced by heat stress reduced feed intake and weight gain in chicks (Cohen and Hurwitz, 1974; Hurwitz *et al*, 1973; and Maskrey, 1984). It has been reported that this respiratory alkalosis is related to negative mineral balance especially for K as well as Na (Belay *et al*, 1990).

In partial agreement with the present result, Teeter and Smith (1986); Deyhim and Teeter (1991); and Smith and Teeter (1993) reported that 0.15 to 0.7% KCl-supplemented drinking water enhanced the performance of 4 to 7-week old broiler chicks which were subjected to cycling (24 to 35°C, or 26.6 to 36.7°C) or constant (35°C) temperatures, and in addition lowered blood pH and HCO_3 (Deyhim and Teeter, 1991), or did not alter blood pH (Teeter and Smith, 1986; and Smith and Teeter, 1993) of these heat-stressed chicks. In partial keeping with the present result also, Ait-Boulahsen *et al*, (1995) showed that supplementing drinking water with 0.6% KCl reduced the heat stress- related responses in 5 to 7-week old broiler chicks exposed to acute heat stress (37°C or 41°C for 4h/day), as evidenced by a more favorable blood acid-base balance (lower blood pH and higher pCO_2 values), a modulated plasma Na and osmolality, a moderate increments in plasma K, Cl and Ca, a reduced body temperature and increasing prostration time.

But it seems likely that the beneficial effect of supplemental KCl may not be attributed to K cation alone, and the effect of the accompanying Cl anion may be involved and cannot be ruled out. In this connection, it was reported that supplementing the drinking water of chronically heat-stressed (35°C) broilers with 0.15% K as K_2CO_3 (Teeter and Smith, 1986) reduced their weight gain, but with 0.15% K as KCl there weight gain was improved, while supplementing the drinking water of 7-week old, acutely heat-stressed (37°C or 41°C for 4h/day) broiler chicks with 0.8% $KHCO_3$ (equimolar amount of K as 0.6% KCl) as was reported by Ait-Boulahsen *et al*, (1995) aggravated respiratory alkalosis, and failed to influence either body temperature or plasma electrolytes of these chicks. Therefore, these authors (Teeter and Smith, 1986; and Ait-Boulahsen *et al*, 1995) suggested that the beneficial effect of supplemental KCl may in part be attributed to the accompanying Cl anion.

Under the conditions of the present study one could hardly state, however, that experimental chicks experienced respiratory alkalosis. But chicks fed diets with no supplemental KCl exhibited significantly inferior performance for weight gain and feed conversion, increased mortality, higher body temperature, panting rate and blood pH value, and lower plasma K level compared with chicks fed KCl-supplemented diets, and such adverse consequences are apparently similar to those of respiratory alkalosis. Therefore, it could be concluded that dietary supplementation with KCl; especially at a level of 1.5 or 2.25%, ameliorated, to a great extent, the deleterious effects of high ambient temperatures of the summer season on viability and performance of experimental chicks for weight gain and feed conversion, under the conditions of the present study.

Some hormones in plasma of 6-week old experimental chicks:

Data in Table 4 showed that, significant differences were observed among groups of chicks in concentrations of plasma T3 ($P \leq 0.01$) and corticosterone ($P \leq 0.05$), with no change in plasma T4 level, due to the effect of feeding regimen. From this result, it was apparent that the concentration of plasma T3 was significantly decreased while that of corticosterone was concomitantly increased in FF-chicks, and the opposite was true in EFR-chicks.

Irrespective of feeding regimen, significant ($P \leq 0.01$) differences were existed in concentrations of plasma thyroid hormones, but no significant variations were observed in plasma corticosterone level among groups of chicks, due to the effect of dietary KCl level. No significant difference was detected in plasma T4 between chicks fed either 0.75 or 1.5% KCl-supplemented diets. This result showed that both concentrations of plasma T3 and T4 were linearly elevated with increasing supplemental KCl level in the diet. Concentrations of plasma corticosterone decreased for chicks fed 0.0, 0.75, 1.5 and 2.25% KCl-supplemented diets, with no significant differences. In this regard, Deyhim and Teeter (1991) reported that supplementing the drinking water with 0.5% KCl reduced the concentration of plasma corticosterone in 5 to 7-week old broiler chicks during heat stress (35°C).

Analysis of variance revealed that both effects of feeding regimen and dietary KCl level on plasma T3 concentration were significantly ($P \leq 0.01$) interrelated. While no significant interactions of feeding regimen by dietary KCl level on concentrations of plasma T4 and corticosterone were detected. However, FF-chicks fed diet with no supplemental KCl (0.0% KCl) had the lowest concentration of plasma T4 (5.82) and the highest level of plasma corticosterone (15.80), in comparison with the other treatment-groups of chicks.

Table 4: Means and standard errors for blood pH value, and levels of plasma Na, K, Cl, T3, T4 and corticosterone in 6 weeks old experimental chicks.

Treatments		Measurements					
	pH	Na mEq/l	K mEq/l	Cl mmol/l	T3 ng/ml	T4 ng/ml	Corticos-terone ng/ml
Main factors:							
Feeding regimen A							
1 Full feeding	7.47[a]	118.5	1.90[b]	102.70	1.31[b]	8.16	13.25[a]
2 Early-age feed restriction	7.44[b]	119.8	2.22[a]	98.25	1.54[a]	9.12	11.05[b]
SE	0.008	1.32	0.03	1.83	0.05	0.40	0.69
Significance level[1]	**	NS	**	NS	**	NS	*
KCl level % B							
1 0.00	7.53[a]	113.4[b]	1.84[d]	102.17	0.92[d]	5.92[c]	13.60
2 0.75	7.45[b]	111.7[b]	1.98[c]	96.77	1.25[c]	7.98[b]	11.70
3 1.50	7.43[b]	127.1[a]	2.11[b]	101.00	1.53[b]	9.05[b]	10.90
4 2.25	7.42[b]	124.4[a]	2.33[a]	102.00	1.97[a]	11.63[a]	12.40
SE	0.01	1.86	0.04	2.58	0.07	0.57	0.98
Significance level[1]	**	**	**	NS	**	**	NS
Interaction AB							
T No.							
T1 1×1	7.54	112.8	1.78	108.12	1.10	5.82	15.80
T2 1×2	7.46	110.0	1.82	95.98	1.10	7.68	12.00
T3 1×3	7.44	127.8	1.91	105.00	1.26	9.02	11.20
T4 1×4	7.46	123.4	2.10	102.00	1.76	10.14	14.00
T5 2×1	7.52	114.0	1.90	96.22	0.75	6.02	11.40
T6 2×2	7.43	113.4	2.14	97.56	1.41	8.28	11.40
T7 2×3	7.41	126.4	2.31	97.00	1.80	9.08	10.60
T8 2×4	7.38	125.4	2.55	102.24	2.18	13.12	10.80
SE	0.01	2.64	0.06	3.65	0.10	0.80	1.39
Significance level[1]	NS	NS	NS	NS	**	NS	NS
Overall mean	7.45	119.15	2.06	100.48	1.42	8.64	12.15
SE	0.005	0.93	0.02	1.29	0.03	0.28	0.49

a-d: Means in the same column having different superscripts are significantly different at P ≤0.05.

1: NS= Not significant; *= Significant at P≤0.05; **= Significant at P≤0.01.

The present result is in partial keeping with other reports which indicated that circulating T3 and T4 are reduced in *ad libitum*-fed chicks reared at high ambient temperatures (Williamson *et al*, 1985; Yahav *et al*, 1996; and Yahav, 2000). Some other reports showed that prolonged exposure of chicks to elevated temperatures decreased plasma T3, while causing no change (Cogburn and Harrison, 1980; and Klandorf *et al*, 1981) or a reduction (Williamson *et al*, 1985) in plasma T4 concentrations. It was reported also, that reduction of plasma T3 in chicks during heat stress is associated with elevated plasma corticosterone (Bowen and Washburn, 1985; Williamson and Davison, 1987; and Geraert *et al*, 1996b).

As for the effect of feed restriction, Newcombe *et al* (1992) reported that; under thermoneutral conditions, early age feed-restricted (from 4 to 11 days of age) broiler chicks showed an elevated plasma T4 and a depressed plasma T3 concentrations during the feed restriction period, but thereafter they displayed levels of plasma T3 and T4 similar to those of *ad libitum* fed chicks during the refeeding period to 49 days of age. On the other hand, Yahav and Plavnik (1999) found that early-age feed restriction (from 7 to 14 days of age) imposed on broiler chicks reared at 26°C, resulted in a significant drop in plasma T3 concentration continued to 41 days of age, but did not alter plasma T3 level upon exposing chicks to acute heat stress (35°C for 6 h) at 42 days of age, as compared with *ad libitum*-fed control. Conditions of the present experiment are different, and therefore the comparison between the current result and those of Newcombe *et al* (1992); and Yahav and Plavnik (1999), however, may lose its validity, since the experimental chicks were subjected to a prolonged period of normally elevated ambient temperatures during the summer season, and their feed was restricted at an earlier age from one to 7 days of age. It is speculative, however, to indicate that FF-chicks decreased their plasma T3 level in an attempt to reduce metabolic heat production (Etches *et al*, 1995) to alleviate the heat s tress, under the conditions of the present study.

Digestibility of nutrients:

Data of effects of feeding regimen and dietary KCl level, and their interaction on nutrients digestibility of experimental diets and retention of ash, K and nitrogen are illustrated in Table 5. Significant ($P \leq 0.01$) differences were detected only in DM and CP digestibility, due to the effect of feeding regimen. Even though, FF- and EFR-chicks; in the digestibility trial, consumed statistically similar amounts of feed (122.09 and 126.59 g DM/bird/day, respectively), they voided significantly different quantities of excreta (29.56 and 32.14g DM/bird/day, respectively), this resulted in DM ratios of 0.24 and 0.25, respectively, with significant differences. Consequently, FF- and EFR-chicks exhibited DM digestibility coefficients of 75.78 and 74.67%, respectively, with significant ($P \leq 0.05$) difference. Values of CP digestibility were 92.18 and 91.74% in FF- and EFR- chicks, respectively, with significant ($P \leq 0.05$) difference. It could be concluded that, the early- age feed restriction program which was practiced in the current experiment, did not adversely affect nutrients digestibility in 7-week old experimental chicks, under the conditions of the present study.

Regardless of feeding regimen, with the exception of nitrogen retention, NFE and CF digestibility coefficients, significant differences were existed in the digestibility of the other nutrients, due to the effect of dietary KCl level. Even though, with 0.0% KCl-diet chicks exhibited the highest DM ratio and the lowest DM digestibility coefficient, they did not differ significantly from those fed on 0.75% KCl-diet, while the latter did not differ from those fed on 1.5 or 2.25% KCl-containing diets. Values of ash retention showed erratic significant differences, since no significant differences were observed in that respect between chicks fed 0.0 and 0.75% KCl-diets, or between chicks fed 0.75 and 1.5% KCl-diets, or between those on 0.75 and 2.25% KCl-diets. The least K retention being attained by chicks fed 0.0% KCl-diet, and the highest K retention was exhibited by chicks fed 2.25% KCl-diet, while intermediate K retention was achieved by those fed 0.75 and 1.5% KCl-diets. No significant difference was observed in EE digestibility between chicks fed 0.0 and 0.75% KCl-diets. No significant difference was observed in CP digestibility between chicks fed 0.75 and 1.5% KCl-diets. However, no significant differences were existed in OM digestibility, among chicks fed 0.0, 0.75 and 1.5% KCl-diets, or between those fed 1.5 and 2.25% KCl-supplemented diets. Analysis of variance revealed that effects of feeding regimen and dietary KCl level on DM ratio, retention of ash, N and K, digestibility coefficients of DM, EE and NFE, CP, CF and OM in experimental chicks, were not interrelated.

Table 5: Nutrients digestibility % of experimental diets fed to 7 weeks old chicks, along with N, ash and K retention.

Items	Daily dry matter balance			Digestibility coefficients						Ash retention	N retention	K retention
	Feed intake; g DM/bird/day	Excreta voided; g DM/bird/day	DM ratio	DM	OM	CP	EE	CF	NFE			
Main factors:												
Feeding regimen A												
1 Full feeding	122.09	29.56[b]	0.24[b]	75.7[a]	78.17	92.18[a]	78.56	15.15	84.22	38.07	74.37	29.82
2Early-age feed restriction	126.59	32.14[a]	0.25[a]	74.6[b]	77.54	91.74[b]	79.28	15.28	84.68	37.97	67.84	27.62
SE	2.41	0.55	0.002	0.28	0.51	0.08	0.45	0.77	1.43	0.48	4.15	0.82
Significance level[1]	NS	**	*	*	NS	*	NS	NS	NS	NS	NS	NS
KCl Level % B												
1 0.00	129.89[a]	33.84[a]	0.26[a]	73.9[b]	76.35[b]	91.22[c]	76.18[c]	14.31	82.94	36.51[c]	70.72	24.24[c]
2 0.75	115.64[b]	28.75[b]	0.25[ab]	75.1[ab]	77.32[b]	91.67[b]	76.14[c]	15.82	83.52	38.90[ab]	73.35	29.10[b]
3 1.50	127.35[a]	31.01[b]	0.24[b]	75.6[a]	78.09[ab]	91.93[b]	80.42[b]	15.06	83.88	37.22[bc]	75.14	28.31[b]
4 2.25	124.47[ab]	29.79[b]	0.24[b]	75.9[a]	79.66[a]	93.01[a]	82.94[a]	15.67	87.48	39.46[a]	65.21	33.24[a]
SE	3.41	0.78	0.004	0.41	0.73	0.11	0.64	1.08	2.02	0.68	5.87	1.17
Significance level[1]	*	**	*	*	*	**	**	NS	NS	*	NS	**
Interaction AB												
T No.												
T1 1×1	123.46	31.52	0.25	74.44	76.81	91.46	76.59	14.51	83.19	36.79	72.14	26.99
T2 1×2	102.23	25.27	0.24	75.25	77.63	91.76	74.14	15.34	84.23	38.33	72.45	29.17
T3 1×3	124.92	29.58	0.23	76.29	78.71	92.21	80.70	15.96	84.43	38.45	75.45	29.14
T4 1×4	137.75	31.86	0.23	76.86	79.57	93.29	82.80	14.78	85.04	38.70	77.04	33.96
T5 2×1	136.34	36.16	0.26	73.43	75.91	90.98	75.78	14.11	82.69	36.22	69.32	21.48
T6 2×2	129.06	32.23	0.25	74.98	77.01	91.57	78.14	16.28	82.79	39.46	74.25	29.02
T7 2×3	129.78	32.44	0.24	75.01	77.47	91.66	80.13	14.17	83.32	35.98	74.42	27.46
T8 2×4	111.20	27.72	0.24	75.05	79.76	92.73	83.07	16.56	89.93	40.22	53.39	32.50
SE	4.82	1.11	0.005	0.57	1.03	0.16	0.91	1.54	2.85	0.96	8.31	1.65
Significance level[1]	**	**	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Overall mean	124.34	30.85	0.24	75.16	77.85	91.96	78.92	15.22	84.45	38.02	71.11	28.72
SE	1.71	0.39	0.002	0.20	0.36	0.05	0.32	0.54	1.01	0.34	2.93	0.58

[a-c]: Means in the same column having different superscripts are significant different at P ≤0.05. [1]: NS= Not significant; *= Significant at P≤0.05; **= Significant at P≤0.01.

Some studies have documented that heat stress exposure decreases nutrients utilization and digestibility in chicks, through reductions of blood flow to the intestinal tract (Wolfenson, 1986), gastrointestinal size (Savory, 1986; and Mitchell and Carlisle, 1992), digestive tract motility (Tur and Rial, 1985), digestive enzymes secretion (Hai *et al*, 2000), or ash retention (El-Husseiny and Creger, 1981; and Belay and Teeter, 1996). In contrast to these reports, it appeared that nutrients utilization and digestibility were not adversely affected in chicks under the conditions of the present study. Therefore, the lack of significant differences between FF- and EFR-chicks, and the slight improvement which was observed (apart from it was significant in some cases) upon supplementation of diets with KCl in nutrients utilization and digestibility, are not sufficient to indicate that the effect of either feeding regimen or supplemental KCl could be involved in their beneficial effects which were exerted on the performance of experimental chicks for growth and feed conversion, under the conditions of the present study (Raya *et al.*, 2003).

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استخدام تحديد العلف المبكر وكلوريد البوتاسيوم لتخفيف الآثار السيئة للإجهاد الحراري علي كتاكيت اللحم

٢ـ التأثيرات علي المقاييس الفسيولوجية، مكونات الدم، وهضم المركبات الغذائية.

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قسم إنتاج الدواجن ـ كلية الزراعة ـ جامعة المنصورة.

تم إجراء هذه الدراسة بهدف بحث إمكانية تخفيف الآثار السيئة للإجهاد الحراري الذي تتعرض له كتاكيت اللحم خلال فصل الصيف باتباع بعض الوسائل الغذائية وذلك باستخدام إما تحديد العلف في العمر المبكر أو تزويد العلف بكلوريد البوتاسيوم أو جمع الوسيلتين معاً. استخدم عدد ٣٦٠ كتكوت عمر يوم من هجين هبرد. وزعت الكتاكيت عشوائياً إلي نصفين (مجموعتين). وزعت كل مجموعة إلي أربعة معاملات تجريبية. أعطيت الكتاكيت علائق بادئ متماثلة في الطاقة والبروتين من ١ حتى ٢١ يوما من العمر ثم أعطيت علائق نامي متساوية في الطاقة والبروتين أيضاً من ٢٢ حتى ٤٢ يوما من العمر. طيور المجموعة الأولي المحتوية علي المعاملات التجريبية ١، ٢، ٣، ٤ غذيت بحرية علي العلائق من عمر يوم حتى نهاية التجربة عمر ٦ أسابيع. طيور المجموعة الثانية المحتوية علي المعاملات التجريبية ٥، ٦، ٧، ٨ تم تحديد العلف لها (٤٠% من الاستهلاك الحر) في الأسبوع الأول فقط وغذيت بحرية بعد ذلك حتى نهاية التجربة (عمر ٦ أسابيع). احتوت العلائق التجريبية (البادئة والناهية) علي ٠,٨% بوتاسيوم طبيعياً من مواد العلف. تم تكوين أربعة علائق تجريبية في فترة البادئ وأربعة علائق في فترة النامي مزودة بأربعة مستويات من كلوريد البوتاسيوم وهي صفر% للمعاملات التجريبية الأولي والخامسة والتي اعتبرت كنترول، ٠,٧٥% للمعاملات التجريبية الثانية والسادسة، ١,٥% للمعاملات التجريبية الثالثة والسابعة، ٢,٢٥% للمعاملات التجريبية الرابعة والثامنة والتي تم التغذية عليها من عمر أسبوع حتى نهاية التجربة (عمر ٦ أسابيع). وبالتالي بعد إمداد العلائق بكلوريد البوتاسيوم أصبح مستوي البوتاسيوم بالعلائق سواء البادئة أو النامية ٠,٨%، ١,٢%، ١,٦% أو ٢,٠% علي الترتيب.

تم تقدير بعض المقاييس الفسيولوجية وبعض مركبات الدم كما تم حساب معاملات هضم المركبات الغذائية. ويمكن تلخيص أهم النتائج المتحصل عليها في الأتي: ـ تحديد العلف المبكر (خلال الأسبوع الأول) لكتاكيت اللحم أدي إلي نقص معنوي في كل من درجة حرارة جسم الطيور، معدل لهث الطيور، درجة حموضة (pH) الدم، سرعة ترسيب الدم، وتركيز البلازما من الكورتيكوستيرون. لكنه أدي إلي زيادة معنوية لكل من نشاط إنزيم الفوسفاتيز القلوي، تركيز البلازما من البوتاسيوم وهرمون الترا ىأيودوثيرونين. بينما كل من هيموجلوبين الدم، ومحتوي البلازما من البروتينات والليبيدات والجلوكوز والكولسترول والصوديوم والكلور وهرمون الثيروكسين لم تتأثر. إضافة كلوريد البوتاسيوم الغذائي أدي إلي نقص معنوي في كل من درجة حرارة جسم الطيور، معدل لهث الطيور، درجة حموضة (pH) الدم، سرعة ترسيب الدم، لكنه أدي إلي زيادة معنوية في كل من نشاط إنزيم الفوسفاتيز القلوي، تركيز البلازما من البروتينات والصوديوم والبوتاسيوم وهرمونات الغدة الدرقية. بينما كل من هيموجلوبين الدم، وتركيز البلازما من الدهون الكلية والجلوكوز والكوليسترول والكلور والكورتيكوستيرون لم تتأثر. تحديد العلف المبكر لم يؤثر علي هضم كل من الألياف والمادة العضوية والرماد والدهن الخام والمستخلص الخالي من الأزوت واحتجاز النيتروجين البوتاسيوم. بينما خفض معاملات هضم كل من المادة الجافة والبروتين. إضافة كلوريد بوتاسيوم الغذائي لم يؤثر علي احتجاز النيتروجين ومعامل هضم الألياف. لكن المستوي العالي (٢,٢٥%) من كلوريد البوتاسيوم أدي إلي تحسين معاملات هضم كل من الدهن الخام والمادة الجافة والبروتين والمادة العضوية واحتجاز كل من الرماد والبوتاسيوم. وعلي ذلك يوصي باستخدام تحديد العلف المبكر مع مستوي ٢,٢٥% كلوريد بوتاسيوم بالغذاء لكتاكيت اللحم أثناء الجو الحار خلال فصل الصيف.