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IMPACTS OF DIETARY ELECTROLYTE BALANCE ON EGG PRODUCTION, SHELL QUALITY AND SOME PHYSIOLOGICAL PARAMETERS OF LAYING HENS REARED IN HOT CLIMATE CONDITIONS

By

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Abstract: *The present study was conducted using a 4 x 2 x 2 factorial design to investigate the effect of dietary electrolyte balance (DEB) on Gimmizah laying chickens performance under hot climate condition. One hundred and sixty laying hens and eighty cocks of Gimmizah strain at 45 weeks of age were used. Hens and cocks were randomly assigned into 16 dietary treatments. Four DEB levels (175, 200, 225 and 250 mEq/kg diet) with two levels of Na (0.16 and 0.18%) and two levels of K (0.80 and 0.90%) were used. The DEB levels were adjusted by using NaCl, $NaHCO_3$, KCl, and NH_4Cl. Each dietary treatment was represented to 10 hens and 5 cocks which were housed and fed in individual cages. The experiment was terminated at 53 weeks of age during summer season (house temperature ranged between 34° and 40°C and relative humidity ranged between 60 and 80%).*

Results indicated that increasing DEB from 175 to 225 mEq/kg diet significantly increased egg production percentage, egg weight, egg mass, body weight gain and improved feed intake and feed conversion ratio. Moreover, egg shell quality, yolk weight and Haugh units were significantly improved with increasing DEB level. All semen physical properties were significantly improved with increasing DEB level from 175 to 225 mEq/kg diet. Likewise, plasma Ca, P, K and Mg levels were significantly increased, whereas, Cl was significantly decreased as DEB level increased from 175 to 225 mEq/kg diet in both sexes. Red blood cells count, hemoglobin and hematocrit levels were increased, while, white blood cells count significantly decreased with increasing DEB level in both sexes. Moreover, blood pH value increased with increasing DEB level to 250 mEq/kg diet in both sexes. Nevertheless, increasing DEB level from 225 to 250 mEq/kg either had no further effect or negatively affected the previous production and physiological parameters. Also, increasing Na level from 0.16 to 0.18% and K level from 0.80 to 0.90%in the diets had no significant impact on most of the previous production parameters. It could be concluded that 225 mEq/kg diet is the optimal DEB level with Na level of 0.16% and K level of 0.90% to maximize performance, egg production, egg shell and interior quality, some of semen physical properties and physiological characteristics of Gimmizah strain under hot climate conditions.

INTRODUCTION

Hot climate condition is a problem in many countries all over the world, including Egypt especially during the summer season. Poultry are naturally homoeothermic and thus, they try to maintain a relatively constant deep body temperature. As indicated by **Summers and Leeson (1983) and Yoruk *et al.* (2004)**, high ambient temperatures affect laying hens performance, physiological traits, egg production, egg weight and egg shell quality. However, using dietary electrolyte balance (DEB) may have some positive effects especially under heat stress conditions **(Deaton, 1983; Odom, 1989; Dibartola 1992; Carlson 1997 and Nobakht *et al.*, 2006)**.

Ambient temperature and diet can influence the acid-base balance in poultry. At high ambient temperature (over 31°C), bird's body temperature rises and respiratory rate increases (panting) to dissipate extra heat via evaporative cooling, therefore, partial pressure of CO_2 decreases in the blood plasma. In turn, the bicarbonate buffer system decrease the concentration of carbonic acid ($H_2 CO_3$) and hydrogen (H^+), causing a rise in plasma pH **(Teeter *et al.*, 1985)**. In response to that kidneys increase $H CO_3^-$ excretion and reduce H^+ excretion as an attempt to keep bird's acid-base balance within the normal range. Excretion of negatively charged bicarbonate in the urine requires coupling with positively charged sodium or potassium ions. Thus, respiratory alkalosis has been related to negative mineral balance for K^+ as well as Na^+ **(Belay and Teeter 1996)**. Chemical manipulation of blood acid-base balance by supplementing diet and/or water with electrolytes (Na, K, and HCO_3) that are lost during heat stress was proven beneficial to minimize the deleterious effects of heat stress **(Olanrewaju *et al.*, 2006)**. In laying hens, egg shell is affected by acid-base balance in the blood because it is a restricted factor for accumulation of Ca CO_3 in egg shell **(Mehner and Hartfiel, 1983)**. Therefore, it is important to provide bird with the proper DEB level to achieve best performance. For hens, the proper DEB level should not only maintain acid-base homoeostasis but also achieve optimal egg production, feed conversion and egg shell quality **(Hughes, 1988)**. Also, **Borges *et al.* (2003a)** showed that dietary electrolyte balance (Na+ K – Cl) is essential for synthesis of tissue proteins, maintenance of intracellular and extracellular homeostasis and electric potential cell membranes, enzymatic reactions, osmotic pressure and acid-base balance. Increasing dietary electrolyte balance (DEB) to 360 mEq/kg in heat stress can improve egg shell quality of laying hens in late laying period **(Nobakht *et al.*, 2006)**. Recently, **Abdallah *et al.* (2010)** found that using dietary DEB from 150 to 225 mEq/kg diet is the optimal DEB level with Na level of 0.16% and K level of 0.80% for laying hens reared in moderate weather to maximize performance. Therefore, this research was carried out to complete our previous work **(Abdallah *et al.*, 2010)** by investigation the effect of different DEB, Na, K and Cl levels on performance of local laying hens and cocks reared on hot climate conditions.

MATERIALS AND METHODS

Experimental design and birds

A 4 x 2 x 2 factorial design experiment was used in this study. Four dietary electrolyte balance (DEB) levels (175, 200, 225 and 250 mEq/kg diet) were used with 2 levels of Na (0.16 and 0.18%) and 2 levels of K (0.80 and 0.90%) as described in Table 1. The DEB levels were adjusted by using Na Cl, $NaHCO_3$, KCl and NH_4Cl salts and calculated as milliequivalent (mEq) per kg diet. The DEB mEq/kg diet = $Na^+ + K^+ - Cl^-$, whereas, each ion expressed as mEq/kg diet that can be calculated using the following equation: mEq/kg diet of the ion = (%ion in the diet x 10000 x valence)/atomic weight. Analysis of the drinking water revealed very low quantities of Na, K, and Cl; therefore, the intake of these elements via drinking water was neglected in the calculation. One hundred and sixty Gimimzah laying hens (Egyptian developed strain) and eighty cocks of the same age and strain were housed in individual cages. Every group was individually fed on one of the 16 experimental dietary treatments (Table 1); each dietary treatment was represented to 10 hens and 5 cocks. Composition and calculation of the basal diet are presented in Table 2. The experiment started at 45 weeks of age and lasted to 53 weeks of age during summer season (July and August) , whereas, house temperature ranged between 34° and 40°C and relative humidity ranged between 60 and 80%.

Performance parameters

Egg production and egg weights were recorded daily and data were summarized on weekly basis. Feed consumption and feed conversion were calculated weekly for individual bird. Eighty eggs (5 eggs/ treatment) were collected randomly every four weeks to determine egg weight, shell weight, shell thickness, and interior quality (albumen and yolk weight and albumen height). Haugh units were calculated according to **Haugh (1937)**. Interval data were pooled and presented for the whole experimental period.

Semen physical properties

Semen was collected at 49 and 53 weeks of age using abdominal massage procedure **(Burrows and Quinn, 1937)**. Ejaculate volume was measured to the nearest 0.01 ml according to **Allen and Champion (1955)**. The initial pH value was measured by pH comparative paper with accuracy of 0.1 pH. Mass motility was scored in rang of 0 to 5 according to vigor of sperm waves according to **Parker *et al.* (1942)**. Alive and dead sperms were determined according to **Tienhoven and Steel (1957)**. Sperm count was calculated by conventional method using the improved Nueubour Hemocytometer.

Blood Samples collection and analytical procedure:

At 49 and 53 weeks of age, blood samples were obtained in heparinized tubes from the brachial vein for ten birds (5 females and 5 males)/each treatment. Red blood cells (RBC`s), Hemoglobin (Hb), hematocrit, White blood cells (WBC`s) count and pH value were determined. Blood samples were centrifuged at 3000 rpm for 15 minutes to separate clear plasma which was stored at – 20 °C to determine calcium (Ca), phosphorous (P), sodium (Na), potassium (K), chloride (Cl) and magnesium(Mg) concentrations using available commercial Kits.

Statistical analyses

Statistical analysis was conducted using GLM procedure of SAS® software **(SAS institute, 1996)**. A 4 x 2 x 2 factorial design of the treatments using the following model: Y_{ijkl}= □ + T_i + L_j + S_k + TL_{ij} +TS_{ik} + LS_{jk} + TLS_{ijk} + e_{ijkl} where Y_{ijkl}= observation measured; T_i= dietary electrolyte levels (i=4; 175, 200, 225 and 250 mEq/kg), L_j= sodium levels (j=2; 0.16 and 0.18%), S_k= potassium levels (k=2; 0.80 and 0.90%), (TL_{ij}, TS_{ik}, LS_{jk} and TLS_{ijk})= the interactions among the main effects, and e_{ijkl}= the random error term. The significant differences among treatment means were separated using Duncan's multiple range test **(Duncan, 1955)**.

RESULTS AND DISCUSSION

Egg production parameters and Performance

Egg production (%), egg weight and mass were significantly increased ($P \leq 0.05$) as DEB level increased from 175 to 225 mEq/kg (Table 3). Feed intake and feed conversion were significantly ($P \leq 0.05$) improved when DEB level increased from 175 to 225 mEq/kg diet (Table 3). Also, body weight gain of hens during 45 to 53 weeks of age was significantly ($P \leq 0.05$) increased as DEB level was increased in the diet. These results agreed partially with those reported by **Gezen *et al.* (2005)** who found a significant increase ($P \leq 0.05$) in egg weight with increasing DEB level from 170 to 256 mEq/kg diet (59.20 vs. 62.76 g). Also, **Balnave and Muhereeza (1997) and Choct *et al.* (1999)** obtained the highest egg weight when hens were fed diets with DEB equal to 182 mEq/kg. Recently, results obtained by **Abdallah *et al.* (2010)** indicated that increasing DEB level from 150 to 225 mEq/kg significantly ($P \leq 0.05$) improved egg production, feed conversion and body weight gain of local laying hens reared in moderate weather.

Moreover, increasing Na level from 0.16 to 0.18% and K level from 0.80 to 0.90% had no significant effect on feed intake, feed conversion, body weight gain, egg production percentage, egg weight and egg mass (Table 3). The lack of response of Na and K levels on performance and production parameters may be due to the narrow ranges of Na and K which were designed intentionally to be within the recommended levels for commercial laying hens. **Murakami *et al.* (2003b)** indicated that sodium level of 0.12 % for 205 mEq/kg diet in the first production period and 0.13 % for 174 mEq/kg diet for laying hens in the second production cycle are sufficient in providing a good productive performance. The interactions between DEB level and K level were significant ($P \leq 0.05$) for feed intake, feed conversion, body weight gain, egg production percentage, egg weight and egg mass. In broiler chickens, **Borges *et al.*(2003a,b)** found that body weight increased with increasing DEB up to 240 mEq/kg then, it decreased thereafter which in a good agreement with the present results despite of the differences in the strain and age. Moreover, they indicated that electrolytes play major roles in the synthesis of tissue proteins, maintenance of electric potential of cell membranes as well as in enzyme and nerve functioning. **Mongin (1980) and Leeson and Summers (2001)** found that dietary electrolyte balance (DEB) of 250 mEq/kg is recomended for an optimum performance.

Egg shell and interior quality

Egg weight, shell weight, shell weight percentage and shell thickness were significantly ($P \leq 0.05$) improved as DEB increased from 175 to 225 mEq/kg diet with no further improvement when DEB level increased from 225 to 250 mEq/kg diet (Table 4). These results agree with those reported by **Nobakht *et al.* (2006)** who found that increasing DEB to 360 mEq/kg in laying hens diet can significantly ($P \leq 0.05$) improve egg shell quality under heat stress condition in late period of production. **Gezen *et al.* (2005)** found that increasing DEB level from 170 to 256 mEq/kg diet improved egg shell quality as determined by egg shell weight and shell thickness. **Deaton (1983) and Odom (1989)** reported that high temperature has negative effects on egg shell thickness; however, balancing dietary electrolytes may overcome this negative effect. This improvement in the egg shell quality may be due to the fact that optimal activity of carbonic anhydrase that plays an important role in egg shell formation can be achieved in slightly alkaline medium. Moreover, an excessive chloride intake which associated with lower DEB level can limiting calcium transport to shell gland and reduce bicarbonate concentration in gland lumen **(Chen and Balnave, 2001)**.

Yolk weight and Haugh units that represent the interior quality of eggs were significantly ($P \leq 0.05$) increased as DEB increased from 175 to 225 mEq/kg diet (Table 4). These results agreed partially with those reported by **Abdallah *et al.* (2010)** who indicated that increasing DEB level from 150 to 225 mEq/kg in the diets significantly ($P \leq 0.05$) increased yolk weight while, albumin weight and Haugh units were not significantly affected. On contrast, **Lesson and Caston (1997)** reported that no effect on albumen height or weight when hens were fed diet containing acid- base balance of 150, 200, 250 and 300 mEq/kg.

Decreasing Na level from 0.18 to 0.16% significantly ($P \leq 0.05$) increased shell weight percentage and yolk weight, while, albumin weight significantly ($P \leq 0.05$) decreased. While, increasing K level from 0.80 to 0.90% significantly ($P \leq 0.05$) increased egg weight, egg shell weight, egg shell percentage, shell thickness, yolk weight and Haugh units (Table 4). The interactions between DEB and Na, DEB and K levels or DEB, Na and K levels significantly ($P \leq 0.05$) increased egg shell quality (as determined by shell weight and shell thickness) and interior egg quality. These finding agreed with that obtained by **Murakami *et al.* (2003a) and Abdallah *et al.* (2010).**

Semen physical properties

Semen physical properties of Gimmizah cocks fed different DEB levels are presented in Table 5. Increasing DEB level from 175 to 225 mEq/kg diet significantly ($P \leq 0.05$) improved ejaculate volume, pH values, sperm concentration, mass motility and alive sperm. Inversely, dead sperm percentage was significantly ($P \leq 0.05$) decreased. Decreasing either Na level from 0.18 to 0.16 % or K level from 0.90 to 0.80 % significantly ($P \leq 0.05$) increased alive sperm percentage while, dead sperm percentage significantly ($P \leq 0.05$) decreased. The interactions between DEB with Na and DEB with K were significant with all semen physical properties. Also, the interactions among DEB, Na and K level was significant and observed on mass motility only. The present results agree with those reported by **Abdallah *et al.* (2010)** who showed that increasing DEB level from 150 to 225 mEq/kg diet has improved semen quality as determined by volume, concentration of sperms, massive motility, number of live sperms and pH values, but, significantly decreased the number of dead sperms.

Blood mineral levels

Plasma calcium and phosphorous concentrations in laying hens and cocks were significantly ($P \leq 0.05$) increased in a linear manner as DEB level increased from 175 to 225 mEq/kg diet (Tables 6 and 7). Likewise, plasma potassium and magnesium levels in hens and cocks were linearly increased as DEB level increased from 175 to 250 mEq/kg diet. However, a further increase in DEB from 225 to 250 mEq/kg diet had no impact on plasma potassium and magnesium concentrations in laying hens or cocks. Also, plasma sodium level in laying hens was significantly ($P \leq 0.05$) decreased with DEB levels at 175 mEq/kg diet compared with other DEB levels (200, 225, and 250 mEq/kg diet), while, plasma sodium level in cocks increased with increasing DEB level from 175 to 225 mEq/kg diet, this effect was not significant (Tables 6 and 7). In laying hens, these results support the previous results

(Table 4) which indicated that egg shell quality as determined by shell weight and thickness were significantly improved with increasing DEB level. Also these results agreed with those reported earlier by **Abdallah *et al.* (2010)** who reported that plasma calcium, phosphorous, potassium, sodium and magnesium levels were significantly ($P \leq 0.05$) increased as DEB level increased from 150 to 250 mEq/kg diet in laying hens reared in moderate weather. **Ghorbani and Fayazi (2009)** indicated that there was a positive correlation between sodium bicarbonate $NaHCO_3$ and increased plasma potassium under chronic heat stress. In contrast, **Gezen *et al.* (2005)** showed that no variations of plasma ion concentrations (sodium, potassium and calcium) were noticed according to dietary electrolyte balance over 170 mEq/kg diet.

On the other hand, plasma chloride concentration was significantly ($P \leq 0.05$) decreased as DEB level increased from 175 to 250 mEq/kg diet. It has been reported that an excessive chloride intake which associated with lower DEB level can limit calcium absorption and transportation to shell gland and reduce bicarbonate concentration in gland lumen **(Sauveur and Mongin, 1978 and Chen and Balnave, 2001)**. Increasing Na level from 0.16 to 0.18% or K level from 0.80 to 0.90% had no significant impact on Na, K, Cl and Mg concentrations in laying hens and cocks. Also, increasing K level from 0.80 to 0.90% significantly ($P \leq 0.05$) increased plasma Ca and P in laying hens, while, significantly decreased plasma P level in cocks. The interaction between DEB and Na was significant for plasma Ca and P in laying hens and cocks. Also, the interaction between DEB and K was significant for plasma Ca, P, K and Mg levels in cocks.

Blood hematological parameters

Effects of DEB level on RBC's, WBC's, hemoglobin, hematocrit, and blood pH value in laying hens and cocks are presented in Tables 8 and 9. As DEB level increased from 175 to 225 mEq/kg diet, RBC's, hemoglobin and hematocrit were significantly ($P \leq 0.05$) increased while WBC's count significantly decreased. The increase in RBC's, hemoglobin and hematocrit indicates an increase in oxygen-carrying capacity of blood leading to better performance of the birds. As DEB level increased in the diet blood pH value increased in a linear manner in laying hens and cocks (Tables 8 and 9). Several researchers **(Austic, 1984; Chen and Balnave, 2001)** reported that excessive dietary Cl^- that associated with low DEB level decrease blood pH and the related parameters and cause a decrease in egg shell quality. Blood alkalinity increases Ca absorption and neutralizes the acidosis case that occurs after liberation of H^+ during the unification of Ca^{++} with HCO_3^- in the shell formation allowing more molecules to be formed; consequently, egg shell quality is improved. It has been reported that two H^+ are generated with each molecule of $CaCO_3$ synthesized in shell gland leading to acidosis case **(Mongin, 1978)**. There is an inverse relationship between blood Cl^- and HCO_3^- concentration, as Cl^- goes up HCO_3^- goes down. The present results also agreed with those reported by **Hamilton and Thompson (1980) and Gezen *et al.* (2005)** who reported an increase of blood pH with increasing DEB level in the diet. **Borges *et al.* (2004)** indicated that the high DEB level of 360 mEq/kg diet increased blood pH before and after heat stress.

The improvement in blood parameters should increase nutrients absorption and utilization. This may partially explain the improvement in birds performance as determined by egg production parameters, feed conversion, egg shell quality and semen physical properties as discussed earlier. However, Increasing Na level from 0.16 to 0.18% in laying hens (Table 8) had no significant impact on blood hematological parameters except hematocrit percentage that was significantly ($P \leq 0.05$) decreased. Nevertheless, increasing K level from 0.80 to 0.90% had no significant effect on red and white blood cells count, whereas, blood hemoglobin and hematocrit levels were significantly ($P \leq 0.05$) increased and blood pH value was significantly ($P \leq 0.05$) decreased. In cocks, increasing Na level from 0.16 to 0.18% (Table 9) had no significant impact on blood hematological parameters, while, increasing K level from 0.80 to 0.90% significantly ($P \leq 0.05$) increased white blood cells count and has no significant effect on other hematological parameters. The interaction between DEB level and Na level was significant for blood hematocrit and pH value in laying hens while, this significant effect was observed in cocks for red blood cells count, hemoglobin, hematocrit and blood pH value. Also, the interaction between DEB and K was significant for hematological parameters and blood pH value in laying hens and cocks except blood pH value in cocks.

Finally, it can be recommended that 225 mEq /kg diet is the optimal DEB level with Na level of 0.16% and K level of 0.90 % for maximum egg production, egg shell and semen quality and some physiological characteristics of Gimmizah chickens strain during the late period of egg production under hot climate conditions.

Table 1: Dietary treatments and mineral supplementations in the basal diet.

Dietary treatments				Dietary Mineral Salt Supplementations (%)[1]			
DEB[2]	Na^+ (%)	K^+ (%)	Cl^- (%)	NaCl	$NaHCO_3$	KCl	NH_4Cl
175	0.18	0.90	0.48	0.37	---	0.20	0.19
175	0.16	0.90	0.44	0.32	---	0.20	0.19
175	0.18	0.80	0.38	0.36	---	---	0.19
175	0.16	0.80	0.35	0.32	---	---	0.19
200	0.18	0.90	0.39	0.36	---	0.20	0.06
200	0.16	0.90	0.36	0.32	0.03	0.20	0.07
200	0.18	0.80	0.30	0.36	0.03	---	0.08
200	0.16	0.80	0.26	0.30	0.03	---	0.07
225	0.18	0.90	0.30	0.28	0.13	0.20	---
225	0.16	0.90	0.27	0.22	0.13	0.20	---
225	0.18	0.80	0.21	0.28	0.13	---	---
225	0.16	0.80	0.17	0.22	0.13	---	---
250	0.18	0.90	0.21	0.12	0.35	0.20	---
250	0.16	0.90	0.18	0.07	0.35	0.20	---
250	0.18	0.80	0.12	0.12	0.35	---	---
250	0.16	0.80	0.09	0.07	0.35	---	---

[1]Dietary mineral salt supplementations of each DEB level were mixed with amount of $CaCO_3$ to complete 1 kg premix. This premix was used at rate of 1% of diets.
[2]Dietray electrolyte balance (DEB, mEq/kg) = {%Na × 10,000/23* + %K × 10,000/39* − %Cl × 10,000/35.5*} (* atomic weight).

Table 2: Composition and calculated analysis of hens and cocks basal diets.

Ingredients (%)	Hens diet	Cocks diet
Yellow corn	63.95	66.58
Soybean meal (44%)	25.10	16.50
Wheat bran	---	12.00
Di-Ca-P	1.45	1.30
Limestone	8.10	1.30
Vit. &Min.Mix[1]	0.30	0.30
DL-Met 98%	0.10	-----
Na Cl	----	0.05
K_2SO_4	----	0.52
$MgSO_4$	----	0.45
Mineral salt supplementations[2]	1.00	1.00
Total	100	100
Calculated Analysis:		
Crude Protein, %	16.50	14.19
ME, Kcal/kg	2700	2750
Ca, %	3.50	0.90
Available P %	0.40	0.40
Met + Cys %	0.66	0.50
Lys %	0.89	0.72
Mg %	0.32	0.32
Na %	0.04	0.04
K %	0.80	0.80
Cl %	0.04	0.04
Dietary electrolyte balance (DEB, mEq/kg)	211	211

[1]Supplied per kg of the diet: Vit A, 12000 IU; Vit D, 2000 IU; Vit. E, 40mg; Vit K_3, 4mg; Vit B_1, 3mg; Vit B_2, 6mg; Vit B_6, 4mg; Vit B_{12}, 0.3mg; niacin, 30mg; pantothenic acid, 12mg; folic acid, 1.5mg; biotin, 0.08mg; choline, 300mg; Mn, 100mg; Cu, 10mg; Fe, 40mg; Zn, 70mg; Se, 0.3 mg,; I, 1.5mg; Co, 0.25mg.

[2]Different dietary mineral supplementations as described in Table 1 were added to adjust the required DEB levels (175-250 mEq/kg).

Table 3: Egg production and performance of Gimmizah laying hens fed different dietary electrolyte balance.

Treatments	Egg production (%)	Egg weight (g)	Egg mass (g/ hen/day)	Feed intake (g/ hen/day)	Feed conversion (g feed/g egg)	Body weight gain (g)
DEB levels (mEq/kg)						
175	39.64^{c}	55.63^{d}	22.05^{c}	110.5^{c}	5.00^{a}	5.70^{c}
200	47.94^{b}	57.19^{c}	27.42^{b}	113.1^{b}	4.11^{b}	9.55^{b}
225	56.87^{a}	59.48^{a}	33.83^{a}	114.8^{a}	3.38^{c}	13.35^{a}
250	47.23^{b}	58.22^{b}	27.50^{b}	110.0^{c}	3.96^{b}	7.75^{cb}
Na^+ levels (%)						
0.18	47.76	57.89	27.65	112.10	4.03	9.30
0.16	48.08	57.38	27.58	112.14	4.03	8.87
K^+ Levels (%)						
0.90	47.76	57.79	27.58	113.18	4.07	8.27
0.80	48.08	57.47	27.63	111.06	3.91	9.90
Probability						
DEB	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Na^+	NS	NS	NS	NS	NS	NS
K^+	NS	NS	NS	NS	NS	NS
DEB*Na^+	NS	NS	NS	NS	NS	NS
DEB*K^+	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Na^+*K^+	NS	NS	NS	NS	NS	NS
DEB*Na^+*K^+	NS	NS	NS	0.0001	NS	NS

$^{a, b, c, d}$ Means with no common superscripts within each column are significantly different ($P \leq 0.05$).
NS= non significant.
Egg weight represents the average of all eggs laid by hens.

Table 4: Egg shell and interior egg quality as affected by feeding Gimmizah laying hens different dietary electrolyte balance.

Treatments	Egg weight (g)*	Shell weight (g)	Shell weight (%)	Shell thickness (mm)	Albumin weight (g)	Yolk weight (g)	Haugh units
DEB levels (mEq/kg)							
175	57.56^{c}	5.69^{c}	9.88^{c}	0.346^{c}	37.47	14.40^{c}	77.52^{ab}
200	58.98^{b}	6.28^{b}	10.64^{b}	0.365^{b}	37.59	15.11^{b}	78.40^{a}
225	60.57^{a}	6.98^{a}	11.52^{a}	0.388^{a}	37.45	16.14^{a}	78.68^{a}
250	58.93^{b}	6.32^{b}	10.72^{b}	0.365^{b}	37.42	15.19^{b}	76.47^{b}
Na^+ levels (%)							
0.18	59.04	6.29	10.67^{b}	0.368	37.57^{a}	15.18^{b}	77.71
0.16	58.97	6.34	10.79^{a}	0.364	37.39^{b}	15.24^{a}	77.83
K^+ Levels (%)							
0.90	59.37^{a}	6.46^{a}	10.86^{a}	0.374^{a}	37.50	15.43^{a}	78.74^{a}
0.80	58.64^{b}	6.19^{b}	10.55^{b}	0.358^{b}	37.46	14.99^{b}	76.80^{b}
Probability							
DEB	0.0001	0.0001	0.0001	0.0001	NS	0.0001	0.0046
Na^+	NS	NS	0.0089	NS	0.0052	0.0425	NS
K^+	0.0001	0.0001	0.0001	0.0010	NS	0.0001	0.0001
DEB*Na^+	0.0001	0.0001	0.0278	0.0081	0.0001	0.0001	NS
DEB*K^+	0.0001	0.0001	0.0001	0.0001	0.0152	0.0001	0.0001
Na+*K^+	0.0001	0.0319	NS	NS	0.0001	0.0070	NS
DEB*Na^+*K^+	0.0001	0.0004	NS	0.0272	0.0007	0.0001	NS

^{a,b,c} Means with no common superscripts within each column are significantly different ($P \leq 0.05$).
NS= non significant.
*Egg weight represents the average of eggs used to measure shell quality.

Table 5: Semen physical properties of Gimmizah cocks as affected by feeding on different dietary electrolyte balance.

Treatments	Ejaculate volume (ml)	pH value	Concentration (10^6/ml)	Mass motility (0 -5)	Alive sperms (%)	Dead sperms (%)
DEB levels (mEq/kg)						
175	0.173^{d}	7.05^{c}	2.71^{d}	3.185^{c}	73.70^{c}	26.30^{a}
200	0.192^{b}	7.20^{b}	3.50^{b}	3.325^{b}	78.90^{b}	21.10^{b}
225	0.219^{a}	7.33^{a}	4.32^{a}	4.158^{a}	87.06^{a}	12.94^{c}
250	0.184^{c}	7.07^{c}	3.02^{c}	3.121^{c}	73.86^{c}	26.14^{a}
Na^+ levels (%)						
0.18	0.193	7.16	3.13	3.375	78.02^{b}	21.98^{a}
0.16	0.191	7.15	3.16	3.347	78.75^{a}	21.25^{b}
K^+ Levels (%)						
0.90	0.195	7.16	3.11	3.380	77.89^{b}	22.11^{a}
0.80	0.188	7.16	3.17	3.342	78.87^{a}	21.13^{b}
Probability						
DEB	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Na^+	NS	NS	NS	NS	0.0126	0.0126
K^+	0.0055	NS	NS	NS	0.0011	0.0011
DEB*Na^+	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
DEB*K^+	0.0001	0.0001	0.0001	0.0001	0.0001	0.0001
Na^+*K^+	NS	NS	NS	0.0096	NS	NS
DEB*Na^+*K^+	NS	NS	NS	0.0472	NS	NS

[a,b,c,d] Means with no common superscripts within each column are significantly different ($P \leq 0.05$).
NS= non significant.

Table 6: Effect of feeding Gimmizah laying hens on different dietary electrolyte balance on blood mineral levels.

Treatments	Calcium (mg/dl)	Phosphorous (mg/dl)	Sodium (nmol/l)	Potassium (nmol/L)	Chloride (nmol/L)	Magnesium (nmol/L)
DEB levels (mEq/kg)						
175	7.09^{c}	3.82^{d}	146.47^{b}	4.21^{c}	112.52^{a}	1.36^{c}
200	7.66^{b}	4.58^{b}	146.77^{a}	4.34^{bc}	110.40^{a}	1.49^{b}
225	8.24^{a}	4.98^{a}	147.04^{a}	4.50^{ab}	103.17^{b}	1.59^{a}
250	7.75^{b}	4.37^{c}	146.80^{a}	4.53^{a}	102.81^{b}	1.62^{a}
Na+ Level (%)						
0.18	7.67	4.41	146.76	4.38	108.58	1.51
0.16	7.69	4.46	146.77	4.40	105.87	1.52
K+ Level (%)						
0.90	7.79^{a}	4.54^{a}	146.84	4.40	109.08	1.51
0.80	7.58^{b}	4.34^{b}	146.70	4.40	105.37	1.51
Probability						
DEB	0.0001	0.0001	0.0022	0.0001	0.0008	0.0001
Na+	NS	NS	NS	NS	NS	NS
K+	0.0001	0.0005	NS	NS	NS	NS
DEB*Na+	0.0014	0.0113	NS	NS	NS	NS
DEB*K+	0.0001	0.0001	0.0001	0.0001	NS	0.0002
Na+*K+	NS	NS	NS	NS	NS	NS
DEB*Na+*K+	0.0001	0.0050	NS	NS	NS	NS

[a,b,c,d] Means with no common superscripts within each column are significantly different ($P \leq 0.05$).
NS= non significant

Table 7: Effect of feeding Gimmizah cocks on different dietary electrolyte balance on plasma mineral levels.

Treatments	Calcium (mg/dl)	Phosphorous (mg/dl)	Sodium (nmol/l)	Potassium (nmol/L)	Chloride (nmol/L)	Magnesium (nmol/L)
DEB levels (mEq/kg)						
175	3.28^{c}	1.61^{c}	141.87	5.32^{c}	114.79^{a}	1.72^{c}
200	4.06^{b}	1.99^{b}	147.69	5.55^{b}	112.85^{ab}	1.85^{b}
225	5.14^{a}	2.42^{a}	148.08	5.80^{a}	110.07^{b}	1.98^{a}
250	2.82^{d}	1.30^{d}	147.81	5.87^{a}	102.51^{c}	1.98^{a}
Na+ Level (%)						
0.18	3.82	1.82	147.74	5.59	111.36	1.82
0.16	3.82	1.83	145.97	5.66	108.74	1.83
K+ Level (%)						
0.90	3.80	1.81^{b}	145.40	5.70	111.75	1.88
0.80	3.84	1.85^{a}	147.68	5.57	108.35	1.88
Probability						
DEB	0.0001	0.0001	NS	0.0001	0.0002	0.0001
Na+	NS	NS	NS	NS	NS	NS
K+	NS	NS	NS	NS	NS	NS
DEB*Na+	0.0002	0.0038	NS	NS	NS	0.0432
DEB*K+	0.0001	0.0001	NS	0.0004	NS	0.0001
Na+*K+	NS	NS	NS	NS	NS	NS
DEB*Na+*K+	NS	NS	NS	NS	NS	NS

a,b,c,d Means with no common superscripts within each column are significantly different ($P \leq 0.05$).
NS= non significant

Table 8: Blood hematological parameters and blood pH value of Gimmizah laying hens fed different dietary electrolyte balance.

Treatments	Red Blood Cells (x 10^6)	Hemoglobin (g/dl)	Hematocrit (%)	White Blood Cells (x10^3)	Blood pH value
DEB levels (mEq/kg)					
175	1.89^{c}	8.79^{c}	44.13^{c}	25.80^{a}	6.99^{d}
200	2.34^{b}	9.27^{b}	45.12^{b}	25.22^{b}	7.08^{c}
225	2.87^{a}	10.00^{a}	47.17^{a}	24.19^{c}	7.18^{b}
250	2.47^{b}	9.41^{a}	46.39^{a}	24.15^{c}	7.47^{a}
Na+ Level (%)					
0.18	2.36	9.33	45.61^{b}	24.86	7.16^{b}
0.16	2.42	9.41	45.80^{a}	24.81	7.20^{a}
K+ Level (%)					
0.90	2.48	9.57^{a}	46.01^{a}	24.83	7.11^{b}
0.80	2.31	9.16^{b}	45.39^{b}	24.85	7.25^{a}
Probability					
DEB	0.0001	0.0001	0.0001	0.0008	0.0001
Na+	NS	NS	0.0468	NS	0.0001
K+	0.0040	0.0001	0.0001	NS	0.0001
DEB*Na+	NS	NS	0.0001	NS	0.0374
DEB*K+	0.0001	0.0001	0.0001	0.0001	0.0001
Na+*K+	NS	NS	NS	NS	0.0194
DEB*Na+*K+	NS	NS	0.0003	NS	0.0244

a,b,c,d Means with no common superscripts within each column are significantly different ($P \leq 0.05$).
NS= non significant

Table 9: Blood hematological parameters and blood pH value of Gimmizah cocks fed different dietary electrolyte balance.

Treatments	Red Blood Cells ($x 10^6$)	Hemoglobin (g/dl)	Hematocrit (%)	White Blood Cells ($x10^3$)	Blood pH value
DEB levels (mEq/kg)					
175	3.56^c	11.46^c	43.72^c	26.10^a	7.09^d
200	4.23^b	12.42^b	45.18^b	25.22^b	7.17^c
225	5.34^a	14.22^a	46.12^a	23.80^d	7.29^b
250	3.78^d	10.84^d	42.22^d	24.15^c	7.47^a
Na+ Level (%)					
0.18	4.27	12.27	44.23	24.99	7.15
0.16	4.17	12.19	44.39	24.80	7.15
K+ Level (%)					
0.90	4.30	12.26	44.28	25.02^a	7.15
0.80	4.16	12.21	44.34	24.77^b	7.15
Probability					
DEB	0.0001	0.0001	0.0001	0.0001	0.0001
Na+	NS	NS	NS	NS	NS
K+	0.0455	NS	NS	NS	NS
DEB*Na+	0.0001	0.0001	0.0189	NS	0.0001
DEB*K+	0.0001	0.0001	0.0001	0.0001	NS
Na+*K+	NS	NS	NS	NS	NS
DEB*Na+*K+	NS	NS	NS	NS	NS

[a,b,c,d] Means with no common superscripts within each column are significantly different ($P \leq 0.05$).
NS= non significant

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الملخص العر بى

تأثير الاتزان الملحى فى العلف على انتاج البيض و جودة القشرة و بعض المقاييس الفسيولوجية فى الدجاج البياض المربى فى ظروف مناخية حارة.

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اجريت الدراسة الحالية باستخدام نظام احصائى عاملى ٤× ٢ × ٢ لدراسة تأثير الاتزان الملحى فى العلف على اداء الدجاج البياض المحلى من سلالة الجميزة تحت ظروف الجو الحار. استخدم فى هذه التجربة عدد ١٦٠ دجاجة بياضة و ٨٠ ديك من سلالة الجميزة عمر ٤٥ أسبوع تم توزيعها عشوائيا الى ١٦ معاملة غذائية. حيث استخدم أربع مستويات من الاتزان الملحى ١٧٥ ، ٢٠٠ ، ٢٢٥ ، ٢٥٠مللى مكافئ/كجم عليقة مع مستويين من الصوديوم (١٦, ، ١٨, %) و مستويين من البوتاسيوم (٨٠, ، ٩٠,%) تم ضبط الاتزان الملحى فى العلف باستخدام املاح كلوريد الصوديوم ، بيكربونات الصوديوم، كلوريد البوتاسيوم و كلوريد الامونيوم. كل معاملة احتوت على ١٠ دجاجات و٥ ديوك تم تسكينها و تغذيتها فى اقفاص فردية و انتهت التجربة عند عمر ٥٣ أسبوع.

اوضحت النتائج ان زيادة الاتزان الملحى فى العلف من ١٧٥ الى ٢٢٥ مللى مكافئ/ كجم علف ادى الى زيادة معنوية فى نسبة انتاج البيض و وزن البيضة و كتلة البيض والوزن المكتسب للجسم و كذلك تحسين الغذاء المستهلك و معدل التحويل الغذائى .علاوة على التحسن المعنوى فى جودة القشرة و وزن الصفار ووحدات هو.

جميع الصفات الطبيعية للسائل المنوى تحسنت معنويا مع زيادة الاتزان الملحى فى العلف من ١٧٥ الى ٢٢٥مللى مكافئ/ كجم علف. كما أدى زيادة الاتزان الملحى فى العلف من ١٧٥ الى ٢٢٥مللى مكافئ / كجم علف الى زيادة معنوية لمستوى كل من الكالسيوم و الفوسفور والبوتاسيوم و الماغنسيوم مع انخفاض معنوى لمستوى الكلور فى الدم لكل من الجنسين. ايضا تحسنت معنويا بعض المقاييس الفسيولوجية الاخرى مثل عدد كرات الدم الحمراء ومستوى كل من الهيموجلوبين و الهيماتوكريت بينما عدد كرات الدم البيضاء أنخفض معنويا و ذلك بزيادة مستوى الأتزان الملحى فى العلف من ١٧٥- ٢٢٥ مللى مكافئ/ كجم علف فى الجنسين. كما حدث أرتفاع فى قيم رقم الحموضة للدم بزيادة الأتزان الملحى فى العلف من ١٧٥- ٢٥٠ مللى مكافئ/ كجم علف فى كلا الجنسين و لكن بزيادة الاتزان الملحى فى العلف من ٢٢٥ الى ٢٥٠مللى مكافئ/ كجم علف لم يكن له تأثير أو كان له تأثير سلبى على المقاييس الانتاجية و الفسيولوجية السابقة.

يستخلص من نتائج التجربة ان المستوى الأمثل من الاتزان الملحى فى العلف هو ٢٢٥ مللى مكافئ/ كجم علف مع مستوى الصوديوم ١٦, ومستوى البوتاسيوم ٩٠, % لسلالة الجميزة خلال الفترة الأخيرة لأنتاج البيض تحت الظروف المناخية الحارة لتحسين الأداء ومقاييس انتاج البيض و جودة القشرة و المحتوى الداخلى للبيضة و كذلك بعض الصفات الطبيعية للسائل المنوى و الصفات الفسيولوجية التى تم دراستها.