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The Effects of Dietary Electrolyte Balance on Performance of Laying Hens Exposed to Heat - Stress Environment in Late Laying Period

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Abstract: This study was conducted to determine the effects of different dietary electrolyte balance on performance and eggshell quality of laying hens in heat stress condition. four diets were formulated using different inclusions of NaCl, $NaHCO_3$, $KHCO_3$ and NH_4Cl to give the dietary electrolyte (DEB) as 0, 120, 240 and 360 mEq/kg, and fed to laying hens from 55 weeks to 65 weeks of age exposed to heat - stress environment. Egg production, feed intake, water consumption, egg mass and feed conversion ratio were not significantly affected by the diets of various DEB ($P>0.05$). Among egg parameters shell weight/surface area, shell weight, shell thickness and egg specific gravity were significantly affected by DEB ($P<0.01$). In conclusion, increasing dietary electrolyte balance to 360 mEq/kg in laying hens rations under heat stress condition in late period of production can improve egg quality.

Key words: Laying hens, electrolyte balance, potassium, bicarbonate, heat stress

Introduction

Electrolytes are compounds which are dissolved and dissociated into positively and negatively ions in a suitable medium. This term, commonly used in animal nutrition primarily refers to Na, K and Cl (Hooge, 1995). There is a critical balance among the Na, K and Cl in poultry and such balance at optimum level, ensure the recovery of egg productivity, feed efficiency and egg quality (Hughes, 1988).

Some studies focused on the relationship between the dietary electrolyte balance (DEB) and eggshell quality (Mongin, 1968; Sauveur and Mongin, 1978, El-Hadi and Sykes, 1982). The formation of the eggshell in poultry is affected by the acid-base balance in blood is a restrictive factor for the accumulation of CO_3 in egg shell (Mehner and Hartfiel, 1983). Mongin (1968) was noted that the first restrictive factor of the egg shell formation was the Ca and the second factor was the carbonate ions so the breakage, which was observed in egg shell in hot weathers had been caused by a certain decrease in blood CO_2 level depending on the increase respiration speed. Decline in laying performance and eggshell quality are the primary responses of laying hens subjected to acute heat stress. Egg production rate decreases and egg weight increases as age advances (Al Bustany and Elwinger, 1987; Summers and Leeson, 1983). Egg quality and composition also change in accordance with level of production and age of layer. As age advances, proportion of yolk increases, whereas proportions of albumen and shell thickness decrease (Akbar *et al*., 1983; Fletcher *et al*., 1983). Despite no difference in feed conversion ratio, hen laying eggs with light shell weight (Abdullah *et al*., 1994). Both shell thickness and shell stiffness decrease as age advances (Carnarius *et al*., 1996; De Ketelaere *et al*., 2002). Strength or weakness of eggshell is more directly related to carbonic anhydrase activity (Balnave *et al*., 1992). Alteration of acid- base balance by using of dietary electrolyte (Balnave and Muhereeza, 1997; Davison and Wideman, 1992; Grizzle *et al*., 1992) is current approaches for improving laying performance and egg quality. This can be achieved by a careful balancing of Na+ K+ - Cl- levels using sodium bicarbonate ($NaHCO_3$), Potassium bicarbonate ($KHCO_3$) and ammonium chloride(NH_4Cl) in the diet. There were no effect on egg shell weight or surface was obtained when electrolyte balance evaluated by Na+ K+- Cl- was comprised between 160- 360 mEq/kg in thermoneutral condition (Sauveur and Mongin, 1978). On the contrary, no significant alteration an egg shell quality when electrolyte balance was lower than 330 mEq/kg or higher than 620 mEq/kg, but reduction of the rate of lay and feed intake (Hamilton and Thompson, 1980).

There were no research about dietary electrolyte balance in laying hens diets exposed to heat- stress in late laying period.

This research was carried out to determine the effects of different dietary electrolyte balance (DEB) on laying performance and egg shell quality under heat stress in late laying period.

Materials and Methods

Hens, and management: Two hundred and fifty six laying hens from a commercial strain (Hy-Line W36 Company, Urmia, Iran) 55 weeks old hens were randomly allocated to four dietary treatments (DEB0, DEB120, DEB240, DEB360) in a completely randomized design. All birds used in the experiment were reared in caged with freely

Table 1: Composition[1] of laying hen diets (as fed basis)

	Treatment[2]			
	DEB0	DEB120	DEB240	DEB360
Ingredient composition(kg/t)				
Corn grain, ground	410.4	410.4	410.4	410.4
Wheat grain, ground	200	200	200	200
Soybean meal(440 g/kg Cp)	212.5	212.5	212.5	212.5
Vegetable oil	42.3	42.3	42.3	42.3
Oyster shell	95.4	95.4	95.4	95.4
Dicalcium phosphate	13.4	13.4	13.4	13.4
Salt	2.8	2.8	2.8	2.8
Vitamin premix[3]	2.5	2.5	2.5	2.5
Mineral premix[4]	2.5	2.5	2.5	2.5
DL- Methionine 990 g/kg	1.5	1.5	1.5	1.5
L-Lysine monohydrochloride	0.3	0.3	0.3	0.3
Inert	7.7	10.9	8.1	0
NH_4CL	8.7	3.6	0.9	0
$KHCO_3$	0	0	0	3.4
$NaHCO_3$	0	1.9	7.4	13
Chemical composition[5] (g/kg)				
Metabolizable energy(kcal/kg)	2860	2860	2860	2860
Crude protein	152.5	152.5	152.5	152.5
Calcium	40	40	40	40
Avail. phosphorus	3.7	3.7	3.7	3.7
Potassium	6.4	6.4	6.4	7.9
Chloride	8.1	4.6	2.7	2.1
Sodium	1.5	2	3.5	5
Lysine	7.6	7.6	7.6	7.6
Methionine+ cystine	6.4	6.4	6.4	6.4
Troptophan	2.1	2.1		

[1]Dry matter content 900 g/kg. [2]DEB0 (dietary electrolyte balance=0), DEB120 (dietary electrolyte balance = 120), DEB240 (dietary electrolyte balance = 240), DEB360 (dietary electrolyte balance=360). [3]Premix supplied per kg of diet: 9000 IU vitamin A, 1.78 mg vitamin B_1, 6.6 mg vitamin B_2, 30 mg niacin, 10 mg pantothenic acid, 3 mg vitamin B_6, 0.15 mg biotin, 1500 mg choline, 0.015 mg vitamin B_{12}, 2000 IU vitamin D, 18 IU vitamin E, 2 mg vitamin K_3. [4]Premix supplied per kg of diet: 10 mg Cu, 0.99 mg I, 50 mg Fe, 100 mg Mn. 0.08 mg Se, 100 mg Zn. [5]All values were calculated from NRC values (1994).

access to feed and water and with constant 14.5 hour lighting daily. They exposed to heat stress (30-34°C) for 8 hour from 08 to 16. Heaters were turned on at 0800h and off at 1600h. The experiment was carried out between the September 23th and December 6th (10 week). During this time, the interior temperature and relative Humidity rate was recorded twice a day. Average temperature in heat stress period with a maximum 34°C and a minimum of 30°C. Relative air humidity was 70% throughout the experiment.

Treatment and experimental protocol: Hens housed in cages were randomly assigned to four equal main groups (n=64). A practical layer diet was provided during the experiment. All diets were in the meal form and based on corn and soybean meal. The diets were formulated to be isonitrogenous (15.25%) and isocaloric (2860 Kcal/kg) According the NRC (1994) as fed basis. Treatment groups were formed according to dietary electrolyte balance (DEB). DEB was calculated in mEq according to mongin's formula: DEB= $[Na^+] + [K^+] - [Cl^-]$. Sodium, Potassium and Chloride were added to diets as NaCl, $NaHCO_3$, KH_4Cl (Table 1). Respective amounts of dietary electrolytes were first blended thoroughly with small amount of dicalcium phosphate then was mixed with a larger amount of the basal diet until the total amount of the respective diets were homogeneously mixed.

Chemical analysis and measurements of hens performance and eggshell quality: Prior feeding, laboratory assays were conducted in each diets for sodium, potassium and chloride. The sodium and potassium were determined by Flame spectro-photometer. The Chloride in feed was determined by titration (Lacroix *et al*., 1970). Assay these determined values, NaCl, $NaHCo_3$, $KHCO_3$, NH_4CL. Quantities were adjusted to provide the wanted DEB according to assay groups. Analyses of the drinking water revealed very low quantities of sodium, potassium and chloride. Therefore, the intake of these elements via drinking water was not considered in the calculations.

The birds were weighted at the commencement (55 wk of age) and the end (65 wk of age) of the trial. Water consumption and feed intakes of hens were recorded weekly. Egg production and egg weight were determined daily by collecting and weighing all the colleted eggs. Eggshell weight and shell thickness were determined by

Table 2: Effects of electrolyte balance on laying performance

Treatments DEB(mEq/kg)	Egg production (%)	Feed intake (g/hen/day)	Egg weight (g/egg)	Egg mass (g/hen/day)	FCR (g feed/g egg)
0	75.9[a]	100.5[a]	61.2[a]	46.6[a]	2.2[a]
120	77.8[a]	106[a]	60.8[a]	47.2[a]	2.29[a]
240	75.8[a]	98.4[a]	60.9[a]	46.1[a]	2.14[a]
360	73.6[a]	104.7[a]	60.8[a]	44.8[a]	2.40[a]

[a]Means within each column with same superscripts are not significantly different

Table 3: Effects of electrolyte balance on eggshell quality

Treatments DEB(mEq/kg)	Specific gravity	Eggshell weight (g)	Egg shell thickness (mm)	Egg shell ash (%)	Shell weight/ surface area (mg/cm^2)
0	1.069[b]	5.46[ab]	.320[b]	91.4[a]	74.3[ab]
120	1.063[b]	5.20[b]	.321[ab]	90.9[a]	71.6[b]
240	1.071[b]	5.5[a]	.336[ab]	91.9[a]	74.4[a]
360	1.08[a]	5.6[a]	.340[a]	91.4[a]	77[a]

[a-b]Means within each column with different superscripts are significantly different.

randomly collecting 4 eggs from each replicate. After the eggs were broken the shells were washed and dried in room temperature for the determination of shell weight. Shell thickness was measured at the two ends and one from middle using a micro meter (Measure, 24 21/1 type). These measurements were pooled. Feed conversion ratio, FCR, was calculated as gram feed consumption per day per hen divided by gram egg mass per day per hen.

Statistics: The collected data was recorded on a weekly basis and statistically analyzed by ANOVA using GLM (General Linear Model) in a windows- based statistical package program, SAS (1985). The difference between the mean of groups were separated by Duncan's Multiple Rang Test. Significant- level used in the group comparison was set at($p<0.05$).

Results

The results of experiment indicated that DEB levels did not significantly ($p<0.05$) affect egg production (Table 2). Adding Ammonium Chloride into layer diets to decrease dietary electrolyte balance (DEB) to 0, 120 did not effect the egg production. The overall egg production percent between dietary treatments: 75.93, 77.81, 75.79, 73.37%, respectively. Modification of dietary electrolyte balance during this period did not significantly ($p>0.05$) affected feed intake, water consumption, egg weight, egg mass and FCR. Average feed intake from 55 to 65 weeks of age range from 98.35 to 106 gram per hen per day. Average egg weight or egg mass was not significantly ($p>0.05$) affected by electrolyte balance. No significant differences in FCR values between the dietary treatments were observed. The corresponding FCR values were 2.2, 2.29, 2.14, 2.40 respectively.

The results of experiment concerning the effects of electrolyte balance on egg shell quality, shell weight /surface area, eggshell weight ,egg specific gravity and eggshell thickness ($p<0.01$) (Table 3).

Shell weight/surface area were reduce in groups 1,2 but increased in groups 3,4. Were statistically significant for experimental period ($p<0.01$). Eggshell weight and egg specific gravity in group 3 and group 4 increased significantly ($p<0.01$) with increasing dietary electrolyte balance .eggshell thickness increased with increasing dietary electrolyte balance.

Discussion

The present study was undertaken to investigate the effects of different dietary electrolyte balance (DEB) on laying performance and eggshell quality of laying hens. Shell weight/surface area, egg shell percent and egg specific gravity are markedly increased in the group 4(DEB= 360 mEq/kg) and group 3 (DEB = 240mEq/kg). Our findings agreed with the obtained by (Gezen *et al*., 2005), reported a moderate DEB (256 MEq/kg) can improve eggshell quality. Hughes (1988) also reported positive results by increasing DEB using at 70 wk of age. Chen and Balnave (2001) reported an optimal activity of carbonic anhydrase that plays an important role in eggshell formation in slightly alkaline medium. Moreover an excessive Chloride intake limited calcium transports to shell gland lumen (2001). Consequently, our finding's show that high DEB positively affected the eggshell quality, are consistent with these observations. Using young hens (32 wk of age), Hughes (1988) observed curvilinear increase in shell thickness as DEB increase from about 150 mEq/kg. some researchers (Deaton, 1983; Odom, 1989), reported that high temperature have negative effect on eggshell thickness in poultry and use dietary electrolyte balance have positive effect. It is agree with our results.

In contrast (Nizamettin *et al*., 2005) Suggested that there was no need for the supplementation of sodium bicarbonate and or potassium carbonate into practical laying hens diets during peak production. Sauveur and Mongin (1978) reported no effect of DEB over the rang 160-360 mEq/kg on shell weight/surface area. Similarly, Hamilton and Thompson (1980) reported a lack of response to DEB in terms of shell quality in hens of 68 weeks of age. they only found that the rate of lay and feed intake significantly depressed by 330 and 620 mEq/kg which were found to be extreme DEB values and not commonly practiced with the commercial diets.

Conclusion: Increasing DEB to 360 mEq/kg in heat stress can improve eggshell quality of laying hens in late laying period. Consequently, during establishments of layer hen diets, minimum requirements for each mineral given by NRC should be provided in a first attempt, then after the dietary electrolyte balance should be adjusted especially under heat stress in late laying period.

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