EFFECT OF DIETARY SUPPLEMENTATION OF SODIUM AND POTASSIUM ON EGG QUALITY CHARACTERISTICS IN LAYERS*

P. Shamsudeen[1], S.T. Selvan[2] and K. Viswanathan[3]
Department of Poultry Science
Veterinary College and Research Institute
Namakkal – 637 001

ABSTRACT

The effect of different levels of dietary sodium (Na) and potassium (K) supplementation on egg characteristics during summer month was evaluated in commercial layers. One hundred and fifty layers were randomly assigned into ten groups of fifteen birds each for the five treatment groups with 2 replicates in each. Hens were reared in cages and fed continuously for 15 days, one of the following 5 treatment diets viz., standard layer diet control (with 0.15% Na, 0.67% K), diet containing two excessive levels of sodium (0.28 and 0.45%) or two excessive levels of potassium (0.95 and 1.22%). The excess sodium and potassium levels were obtained by adding sodium acetate and potassium acetate, respectively. Egg quality characteristics were studied on days 5-8 and 12-15 using 12-eggs/ treatment/day. The results revealed that the eggshell thickness was significantly increased in all treatment groups than control. The potassium supplemented groups and highest sodium supplemented groups had highest eggshell thickness followed by higher sodium supplemented group, compared to control. The other parameters studied viz., egg weight, shape index, albumen index and yolk index did not differ significantly from the control group.

Key Words: sodium, potassium, layer, shell thickness, egg quality characteristics

INTRODUCTION

The poultry industry in tropical countries has been experiencing problem of poor egg shell quality which leads to breakage and loss of eggs during handling, transport and marketing, in addition to short self life of eggs and poor hatchability of breeder eggs. The problem is higher during summer months even though the feed is provided with adequate calcium and other minerals and the change in electrolyte balance has been attributed as the cause of this problem. Sodium supplementation as sodium bicarbonate was reported to increase the eggshell secretion (Frank and Burger, 1965). Sodium was supplemented in some other forms but its supplementation in acetate form and its relationship with egg quality characteristics especially shell thickness has received little attention. Similarly, relationship of excess potassium with shell thickness has also received little attention. In this study, we presume that the level of sodium or potassium in relation to chloride is important for shell formation

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[1]Assistant Professor, VUTRC, 306-Veerappanchatram, Sathy road, Erode –04, T.N and the corresponding author, e-mail: shams_phd @ rediffmail.com
[2]Associate Professor, LRS, Kattupakkam, Chennai
[3]Dean, VCRI, Namakkal, T.N

especially during summer, rather than the form of sodium or potassium. Hence, a study was formulated to study the effect of dietary supplementation of sodium and potassium in acetate form with chloride at normal level on egg quality characteristics of laying hens.

MATERIALS AND METHODS

One hundred and fifty layers were randomly assigned into ten groups of fifteen birds each for the five experimental groups with two replicates in each. The layers were reared in conventional cages with 3 layers in each cage and all the management practices were followed uniformly to all the groups with *ad libitum* feeding and watering. Normal requirement of sodium, chloride and potassium in layer diet was 0.15%, 0.15% and 0.65% respectively and the control diet (T_1) was prepared to provide this requirements. Five experimental layer diets (Table 1) were prepared for the study and were as follows.

1. Diet containing 0.15% sodium and 0.67% potassium (T_{1} - Control).
2. Diet containing 0.28 percent sodium and 0.65 percent potassium (T_2).
3. Diet containing 0.42 percent sodium and 0.63 percent potassium (T_3)
4. Diet containing 0.15 percent sodium and 0.95 percent potassium (T_4)
5. Diet containing 0.17 percent sodium and 1.22 percent potassium (T_5)

The sodium levels were obtained by adding sodium acetate in hydrated form with three waters of hydration and the potassium levels were obtained by adding potassium acetate in an anhydrous form. When the hen day egg production was approximately 70 per cent, the experimental diets were given continuously for 15 days and the following egg quality characteristics were studied on days 5-8 and 12-15 using 12 eggs / treatment/ day.

1. Egg weight

Egg weight (g) was recorded by an egg weighing balance with an accuracy of 0.01g. The mean of egg was calculated.

2. Shell thickness

Shell thickness (mm) was measured at 3 places viz., equatorial region, narrow and broad ends by using a screw gauge with 0.01 mm accuracy.

3. Shape index

The length and width of the eggs were measured in millimeter by using a dial caliper with 0.05 mm accuracy. The shape index was calculated as follows.

$$\text{Shape index} = \frac{\text{Greatest width of egg}}{\text{Greatest length of egg}} \times 100$$

4. Albumen index

The eggs were broken and the width of thick albumen was measured in two places using a dial caliper with 0.05 mm accuracy and their mean width was arrived. The height of thick albumen was measured in two places by using an Ames tripod micrometer with 0.01 mm accuracy and their mean height was arrived and Albumen index was calculated by using the formula,

$$\text{Albumen index} = \frac{\text{Greatest height of the albumen}}{\text{Greatest width of the albumen}}$$

5. Yolk index

The width of yolk at two places was measured by using a dial caliper with 0.05 mm accuracy and their mean width was arrived. The height of the yolk was measured in two places by using an Ames tripod micrometer with 0.01 mm accuracy and their mean height was arrived. The yolk index was calculated by using the formula.

$$\text{Yolk index} = \frac{\text{Average height of the yolk}}{\text{Average width of the yolk}}$$

All the data collected during the experiment were subjected to standard statistical analysis as per Snedecor and Cochran (1980). Completely Randomized Design was used as statistical design and P- value less than 0.05 was considered significant. All the results were expressed as mean ± SE.

RESULTS AND DISCUSSION

The mean values of egg quality characteristics as influenced by dietary sodium and potassium are presented in Table 2. The results revealed no significant difference between the treatment groups in egg quality parameters studied viz. egg weight, shape index, albumen index, yolk index except the shell thickness which differed significantly (P<0.01) among different treatment groups.

Egg weight

The dietary supplementation of sodium and potassium did not significantly influence egg weight. This was in congruency with the findings of Hall and Helbacka (1959), Vogt *et al.* (1971), Vogt and Harnisch (1978), Austic and Keshavarz (1988) who observed no significant difference in egg weight due to supplementation of dietary sodium or potassium in diet. Similarly, Ronald *et al*. (1990), Keshavarz and McCormick (1991) Dikicioglu *et al.* (1991) observed no significant difference in egg weight between the groups of birds fed on diet with different levels of excess sodium. On the contrary, Latshaw and Turner (1991) observed a significant decrease in egg weight after 28 days of feeding with sodium aluminosilicate. Vogt (1974) and Sauveur and Mongin (1978) observed reduced egg weight due to increased sodium, whereas, Christmas and Harms (1982) reported heavier eggs from hens receiving 0.14 per cent sodium with low chloride.

In concurrence with this study, Sauveur and Mongin (1978) observed no significant difference in mean egg weight from birds receiving 0.7 and 1.22 per cent dietary potassium, but Ibanez *et al.* (1980; 1981) noticed a significant increase in egg weight at a level of 8000 mg per kg dietary potassium than at the levels of 4000 and 6000 mg per kg dietary potassium.

Shell thickness

A highly significant difference (P<0.01) was observed in shell thickness of eggs between treatment groups. Eggs laid in 0.42 per cent sodium group and potassium supplemented groups (at both levels) had significantly higher shell thickness followed by 0.28 per cent sodium group than control. Though numerical differences existed between 0.42 per cent dietary sodium groups and dietary potassium groups the difference were not significant. The control group registered the least shell thickness.

Many authors with inconsistent results reported the effect of supplementation of Na or K on eggshell quality. Keshavarz and McCormick (1991) reported increased shell thickness with dietary sodium but Vogt and Harnisch (1983) observed decreased shell thickness with increased sodium and chloride in the feed. However, Hall and Helbacka (1959), Padhmanaban *et al.* (1980), Austic (1984), Jackson *et al.* (1987), Keshavarz and McCormick (1991) observed no significant difference in shell thickness. Many authors reported the effect of potassium upon shell thickness and Leach (1974) observed that potassium supplementation in feed influenced shell thickness. However, Ibanez *et al.* (1981), Austic (1984) reported on the contrary that dietary potassium did not influence eggshell strength.

Several authors attributed different reasons for the increase in shell thickness due to increase in Na level in the feed. Many research workers suggested increase in the proportion of sodium relative to chloride caused the increase in shell thickness (Austic and Keshavarz, 1988;Amin *et al.*, 1970; Latshaw and Turner, 1991), while Cohen *et al.* (1972) attributed that mild alkalosis produced by sodium salts was the cause for increase in shell thickness. Similar opinion was also made by Frank and Burger (1965) whereas Scott *et al.* (1971) reported that the level of calcium, phosphorous and sodium and their relation to phosphorous metabolism were responsible for calcium deposition on the shell.

We presume that season of their experimental period might be the reason for this inconsistency of the result of previous studies. We conducted our studies during summer month when the daytime environmental temperatures were about 38 – 42^0 C with RH of 60-65%. Since the eggshell is mainly made up of Calcium Carbonate ($CaCO_3$), the availability of both calcium (Ca^{++}) and carbonate (CO_3^-) ions in the uterine mucosa is equally important for shell formation in layers. At extreme temperature, birds increase their respiratory rate in an attempt to increase the rate of evaporative cooling and such panting increase loss of bicarbonate (HCO_3^-) and subsequent carbon dioxide loss which leads to degree of alkalosis (Leeson and Summers, 2002). Even though the availability of Ca^{++} ions is sufficient during summer, low availability of CO_3^- leads to impairment in the formation of $CaCO_3$ and subsequently causes thin shell eggs. Cohen and Hurwitz (1974) stated that the addition of Na, without increasing Cl level in diet increase plasma HCO_3^- while addition of Cl without increasing Na decrease plasma HCO_3^-. This increase in HCO_3^- might be helpful to compensate the lost HCO_3^- during extreme temperature and this might be the reason for the increase in shell thickness in Na supplemented groups.

We are in opinion that dietary electrolyte balance can dramatically influence the process of shell formation and increase of either Na or K, without increasing Cl can increase the shell thickness during summer. Mongin (1989) suggested that electrolyte balance of feed could be accommodated by consideration of Na+K – Cl in the diet. Even though Leeson and Summers (2002) suggested that an optimum dietary electrolyte balance (Na+K / Cl) of poultry diet is about 250 mEq/Kg diet for normal physiological functions, we opined that an increase in electrolyte balance of poultry diet to about 300 mEq/Kg during summer using either Na or K would be beneficial for restoring HCO_3^- concentration and subsequent shell formation. In the present study, the electrolyte balance of T_3 was 298.6 mEq/Kg diet where there was maximum shell thickness and increasing electrolyte balance beyond 300 mEq/Kg by using K in diet (T_4 and T_5) did not further increase shell thickness, though it was comparable to T_3 statistically. T_2 with electrolyte balance of 242.8 mEq/Kg showed lesser shell thickness than T_3, T_4 and T_5 even though it was better than control group with electrolyte balance of 191.4-mEq/Kg diets.

Hence, it may reasonably suggested that an electrolyte balance of about 300 mEq/Kg feed using either Na or K without increasing Cl level using forms of Na or K salts other than KCl or NaCl might be beneficial to improve shell thickness in layers during summer months. However, the level of Cl should be kept around 0.15% of the feed and wet dropping should be taken into consideration while increasing Na or K in layer feed.

Shape index

Shape index was not significantly influenced by the dietary treatments of sodium or potassium. The values ranged from 75.823 to 76.793. The highest value of shape index was observed in 0.28 percent sodium group (T_2) and the lowest in 0.42 per cent sodium group (T_3). The shape index values for T_4 and T_5 were 76.451 and 76.202 respectively and were comparable with the values observed in control group (76.284).

Albumen index

In this experiment the values ranged from 0.097 to 0.111 with lowest index in the control group and highest value in the group fed 0.28 per cent sodium (0.111) followed by 0.95 per cent potassium group (0.100) and 0.42 per cent sodium and 1.22 per cent potassium with albumen index values of 0.098 and 0.099 respectively. Statistical analysis revealed no significant difference between the treatment groups. Similar reports were made by Austic (1984) who inferred that the excessive level of sodium did not affect the albumen quality. Similar conclusions were also drawn by Dikicioglu *et al.* (1991) in their study without or with 0.75 per cent sodium bicarbonate or sodium acetate or 1 per cent sodium sulphate or sodium phosphate.

Ibanez and Gonzalez (1975) also found no difference in albumen index due to potassium supplementation at 6 or 10 g per kg diet. Similar conclusion was also drawn by Austic (1984) who observed that the albumen height was not affected with 0.89 per cent dietary potassium.

Yolk index

The results of present study revealed that the dietary sodium or potassium supplementation did not influence the yolk index value and the mean value of yolk index ranged from 0.401 to 0.407. Similar to the observation made in this study, Ibanez and Gonzalez (1975) also observed that yolk quality was not affected with diets containing 6 to 10 g of potassium per kg diet. However, Dikicioglu *et al.* (1991) observed sodium salts affected the yolk index during some period.

Based on the present study, it may reasonably be concluded that the supplementation of sodium or potassium without supplementation of chloride is important for eggshell quality rather than the form of sodium or potassium and dietary supplementation of sodium or potassium as acetate may increase the shell thickness of egg in layers during summer months. The dietary supplementation of sodium or potassium may not influence other egg quality characteristics such as egg weight, shape index, albumen index and yolk index.

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Table 1

Ingredient composition and nutrient composition of experimental diets (%)

Ingredients	T_1	T_2	T_3	T_4	T_5
Maize	35.00	36.50	37.25	36.50	37.25
Bajra	18.00	17.20	17.20	17.20	17.20
Deoiled rice bran	6.00	4.50	2.20	4.50	2.20
Deoiled Groundnut cake (S.E.)	13.50	14.05	14.25	14.05	14.25
Soya bean meal	2.50	3.00	3.00	3.00	3.00
Sunflower oil cake	10.00	9.00	9.60	9.00	9.60
Fish meal	6.00	6.00	6.00	6.00	6.00
Calcite	3.50	3.50	3.50	3.50	3.50
Shell grit	3.50	3.50	3.50	3.50	3.50
Mineral Mixture[1]	2.00	2.00	2.00	2.00	2.00
Vit.AB_2D_3K (g) [2]	10.00	10.00	10.00	10.00	10.00
Sodium acetate	-	0.75	1.50	-	-
Potassium acetate	-	-	-	0.75	1.50
Nutrient Composition (on per cent DM basis)					
Crude protein	17.20	17.20	17.19	17.20	17.19
ME (kcal/kg)	2520	2520	2518	2520	2518
Calcium	3.73	3.73	3.73	3.73	3.73
Available Phosphorous	0.41	0.41	0.41	0.41	0.41
Chloride	0.16	0.16	0.16	0.16	0.16
Sodium	0.15	0.28	0.42	0.15	0.17
Potassium	0.67	0.65	0.63	0.95	1.22
Dietary Electrolyte Balance*(mEq/ Kg diet)	191.4	242.8	298.6	319.6	340.9

1 Mineral mixture at the added level per kg feed supplied calcium 6.4 g, phosphorus 1.2g, manganese 55 mg, iodine 2 mg, zinc 52 mg, copper 2 mg, iron 20 mg.

2 Vitamin AB2D3K at the level added per kg feed supplied Vit A 8,250 IU, B2 5 mg, D3 1200 IU, Vit K 1 mg

* Dietary electrolyte balance was calculated as per method given in the book *Nutrition of the chicken* (Page No.364), 4th Edn by Leeson and Summers (2002).

Table 2

Egg quality characteristics as influenced by dietary sodium and potassium (Mean+ SE)

Mean values within the same column bearing a superscript in common do not differ significantly (P<0.05)

* Number of observations in each treatment - 96 eggs