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Primary Audience: Nutritionists, Poultry Scientists

SUMMARY

Sodium and Cl are low-cost nutrients with great influence on feed conversion ratio (FCR), eggshell quality, and excreta moisture. Actual values of dietary requirements of these minerals for commercial laying hens are not well defined. These requirements were reevaluated in a factorial experiment using corn-soybean meal basal diets. No significant influence of Na and Cl levels was observed on egg production (%), egg weight (g), or feed intake (g/d), but levels of these minerals had variable effects on FCR, eggshell quality, and excreta moisture. The optimum requirement of Na changed according to the variable evaluated and level of Cl used.

Key words: chloride, layer, requirement, sodium

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DESCRIPTION OF PROBLEM

Sodium and Cl are essential for all animals. To provide the requirements of these minerals in poultry diets, NaCl is commonly used, which contains approximately 40% Na and 60% Cl. In most of the laying hen requirement tables, only Na is listed. Levels of NaCl used in commercial diets for laying hens vary from 0.15 to 0.50% [1]. Variations are associated with feedstuffs used but must provide the requirements of 0.15% of Na and 0.13% of Cl that have been recommended for laying hens [2]. However, recently a new requirement of 0.225% Na and 0.200% Cl for Leghorn layers has been proposed [3]. High dietary intakes of Na or K will cause large osmotic changes within the intestinal lumen of birds, increasing the water content of the excreta [4]. High-moisture excreta provide a more favorable environment for fly larvae development.

The proportion of Na and Cl, together with K are important to maintain acid-base balance. The equilibrium among these elements is necessary to obtain good growth, adequate bone development, good eggshell quality, and better use of amino acids [5, 6]. Because of the importance of these minerals in avian metabolism and the controversy about optimum requirements, the objective of this experiment was to determine the requirements of Na and Cl for commercial laying hens.

MATERIAL AND METHODS

The experiment was conducted for 84 d (four periods of 21 d) and included 512 31-wk-old

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TABLE 1. Composition and calculated nutrient content of the basal diet

Ingredient	%
Yellow corn	58.89
Soybean meal (45% CP)	27.06
Vegetable oil	3.13
Limestone	8.05
Dicalcium phosphate	2.03
DL-Methionine 99%	0.14
Vitamin premix[A]	0.10
Trace mineral mix[B]	0.10
BHT	0.01
Variables[C]	0.50
Total	100.00
Calculated analysis	
ME kcal/kg	2,880
Crude protein, %	17.42
Calcium, %	3.70
Nonphytate P, %	0.48
Lysine, %	0.90
TSAA, %	0.70
Potassium, %	0.69

[A]Vitamin premix provided per kilogram of product: 4,000 IU vitamin A; 900 IU vitamin D_3; 2,500 mg vitamin E; 234 mg vitamin K_3; 99 mg thiamin; 1,920 mg riboflavin; 249 mg pyridoxine; 3,250 mg vitamin B_{12}; 3,325 mg pantothenic acid, 4,900 mg niacin, 1,470 mg antioxidant.
[B]Trace mineral mix provided per kilogram of product: Mn ($MnSO_4 \cdot H_20$) 28,600 mg; Zn ($ZnSO_4 \cdot 7H_20$) 24,300 mg; Fe ($FeSO_4 \cdot 7H_20$) 25,000 mg; I ($Ca(IO_3)_2 \cdot H_20$) 276 mg; Cu ($CuSO_4 \cdot 5H_20$) 3,010 mg; Co 50 mg; Se 76 mg; 1.000 vehicle Quantidade Sufficiente Para (QSP).
[C]KCl fixed (0.02%).

Lohmann laying hens in wire-floored cages. Treatments were randomly distributed in a four-by-four factorial arrangement (Na by Cl levels) with four replicates of eight birds in each treatment. Treatments consisted of a basal diet formulated to attain all nutritional requirements for laying hens as recommended by NRC (1994), except for Na and Cl and with 0.69% K (Table 1). The feed ingredients used to provide Na and Cl levels were NaCl, $NaHCO_3$, and KCl. The levels studied were 0.15, 0.18, 0.21, and 0.24% Na and 0.14, 0.17, 0.20, and 0.23% Cl. The average environmental maximum and minimum temperatures during the experimental period were 32 and 21°C, respectively.

Eggs were collected every day, and feed consumption was determined at the end of each period. Eggs collected in the last 4 d of each period were identified per treatment and weighed, and the specific density was determined by immersion in a series of saline solutions of different densities. The solution densities were determined with a hydrometer. A sample of three eggs per experimental unit was taken in each one of the four experimental periods. These eggs were broken, and eggshells were weighed after washing and 48 h drying at room temperature.

Excreta were collected in plastic bags that had been placed under each cage for 12 h on the last day of each period. Once the sample was collected, it was immediately dried at 55°C in a ventilated oven for 72 h. The average values from all periods were used for statistical analyses. Data were analyzed by ANOVA and response surface regression analysis [7].

RESULTS AND DISCUSSION

Sodium and Cl had no effect ($P > 0.05$) on egg production (%), eggs weight (g), or feed intake (g/d). Increasing Cl levels in the diet resulted in a quadratic effect ($P < 0.05$) on FCR (g feed/g egg), and the best FCR was estimated at 0.175% Cl (Table 2, Figure 1). Cl levels had a cubic effect ($P < 0.05$) on feed conversion (kg feed/dozen eggs) (Figure 2). For Na levels, FCR decreased linearly ($P < 0.05$). There was an interaction ($P < 0.05$) between Na and Cl levels on eggshell percentage and eggshell specific density (Figures 3 and 4). The levels of Cl influenced

TABLE 2. Regression equations for performance parameters of Leghorn laying hens fed diets with different levels of sodium and chloride

Parameter	Regression equation	R^2	CV%
FCR* (g:g)	$Y = 2.2678 - 5.0246\ Cl + 14.3571\ Cl^2 - 0.3712\ Na$	0.42	2.71
FC* (kg/dozen)	$Y = 4.16614 - 45.7001\ Cl + 242.382\ Cl^2 - 418.400\ Cl^3$	0.56	2.70
Eggshell* (%)	$Y = 12.8065 - 9.7011\ Cl - 28.2588\ Na + 49.2942\ Na^2 + 43.9605\ Na \times Cl$	0.28	1.77
Specific density*	$Y = 1.1049 - 0.0497\ Cl - 0.1544\ Na + 0.2811\ Na^2 + 0.2082\ Na \times Cl$	0.41	0.09
Excreta moisture* (%)	$Y = 44.0881 + 405.045\ Cl - 1{,}045.80\ Cl^2$	0.55	3.82

*$P < 0.05$.

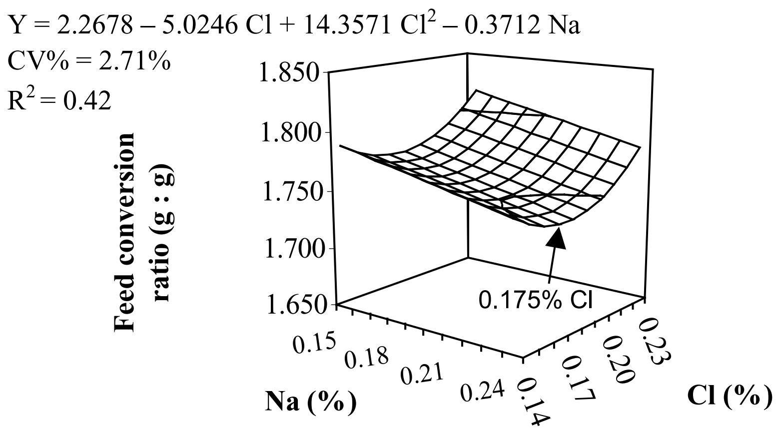

FIGURE 1. Effect of dietary Na and Cl levels on feed conversion ratio (g:g) of Leghorn laying hens.

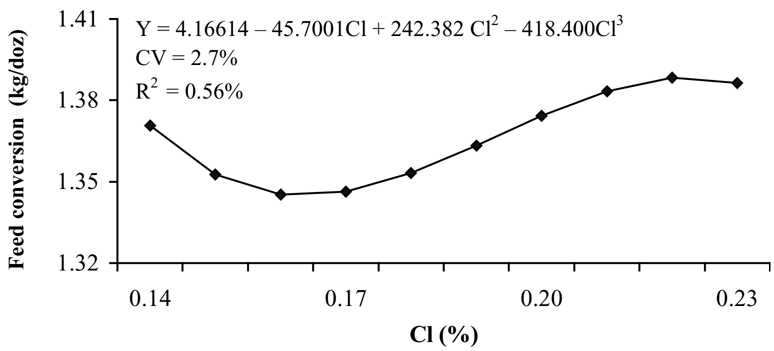

FIGURE 2. Effect of dietary Cl levels on feed conversion (kg/doz.) of Leghorn laying hens.

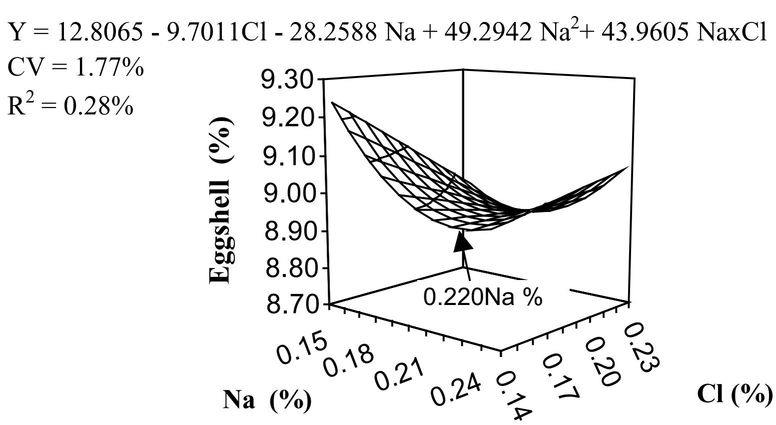

FIGURE 3. Effect of dietary Na and Cl levels on eggshell percentage of Leghorn laying hens.

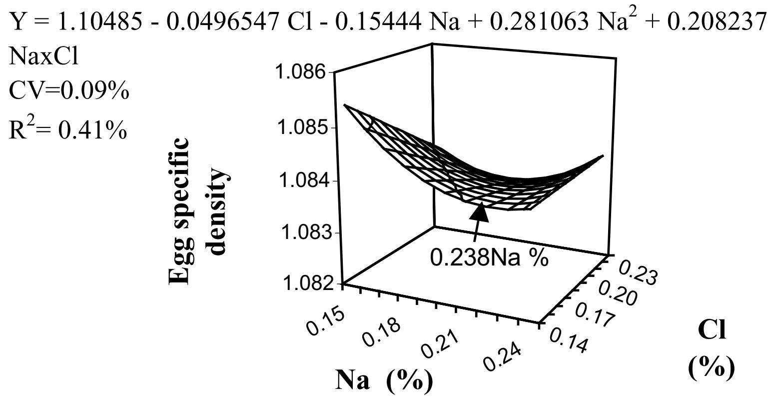

FIGURE 4. Effect of dietary Na and Cl levels on egg specific density of Leghorn laying hens.

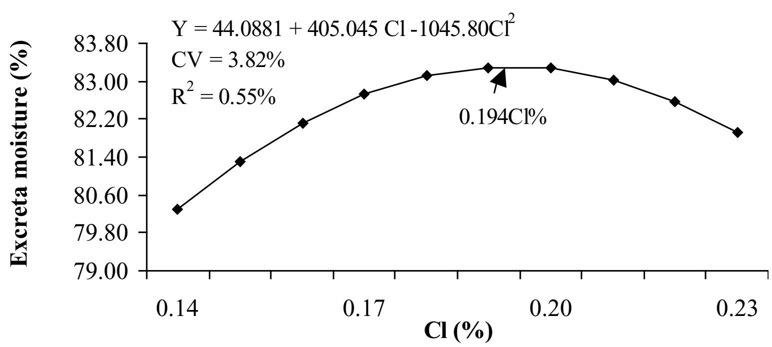

FIGURE 5. Effect of dietary Cl levels on excreta moisture percentage of Leghorn laying hens.

($P < 0.05$) both variables linearly, and Na levels had a quadratic effect on ($P < 0.05$) the eggshell percentage and specific density. Detrimental effects of excessive dietary chloride on eggshell percentage have been reported previously [8, 9].

Chloride levels had a quadratic effect on the moisture of the excreta (Figure 5) with a maximum point at 0.194% Cl; however, sodium levels had no significant effect on excreta moisture in the experiment reported herein. High dietary sodium has been reported to increase excreta moisture [1], but other researchers report that under some conditions this effect is not significant [10]. The increase in moisture should be relative to osmotic disturbances in the intestinal tract and is not due to increased urine production [11]. The best FCR was estimated at 0.175% Cl; however, when this dietary Cl level was associated with a low level of Na, hens produced high-quality eggshells. In the same way, when high levels of Na were associated with higher or lower Cl levels, a reduction in eggshell quality was observed. Diets with high levels of Na from addition of $NaHCO_3$ have been associated with improvement in eggshell quality as measured by specific density [12].

The combination of a lower Na level with a higher Cl level resulted in the worst FCR. It has been recommended that the ratio of Na:Cl should be 1.2:1 to 2.0:1 [13]. One option to satisfy the requirements of these minerals is to maintain low Cl (0.175%) and high Na levels (0.24%). In this case, the cost of the diet could be higher, because the nutritionist needs to use $NaHCO_3$. Alternatively, it could be recommended to use high Cl (0.23%) and high Na levels (0.24%), thus allowing the nutritionist to use NaCl, and consequently the price of the diets will be lower, but the FCR would not be optimal.

CONCLUSIONS AND APPLICATIONS

1. Under the conditions of this experiment for best FCR, the requirements of Cl should be 0.175% for any Na levels. However, for good eggshell quality, the best level should be 0.15% Na for low (0.14%) or high (0.23%) levels of Cl.
2. Nutritionists should balance the levels of Na according to the level of Cl in the diet to obtain good eggshell quality and to minimize the moisture of the excreta.

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