

The Effects of Dietary Levels of Chloride and Bicarbonate on Egg Production and Shell Quality (41103)¹

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Abstract. Groups of individually caged Single Comb White Leghorn layers in their seventh month of lay (Trial 1) and pullets entering their first production cycle (Trial 2) were fed a corn-soy diet with four levels of NaCl and four levels of NaHCO₃ to maintain a constant level of added sodium of 0.11% and levels of added chloride varying from 0.02 and 0.18%. Analyses for total chloride in the various diets showed a range from 0.08 to 0.23. No significant differences due to treatment were observed in egg shell deformation or shell thickness. In Trial 2, hen-day egg production of the groups fed the lowest level of chloride (0.08%) was significantly lower than production at any of the higher chloride levels. It appears that 0.08% chloride was not adequate for egg production but 0.14% was adequate.

According to the National Research Council report (1), laying hens require 0.15% Na and 0.08% Cl, a ratio of sodium to chloride of about 2:1. However, common salt which is the usual dietary source of these elements contains them in a ratio of approximately 2:3. This means that laying hens usually receive about three times as much chloride as they require.

It has been suggested that the need to dispose of excess chloride ion might interfere with the processes of egg shell formation, and several investigators observed greater shell thickness or strength if part of the dietary sodium was provided as bicarbonate rather than chloride (2-5). However, there are several other reports showing no such beneficial effect of bicarbonate (6-9). Of the investigators cited, only Vogt, Hamilton, and Thompson (4, 9) undertook a multistage variation of the chloride content of the diet.

The report of Sauveur and Mongin (10) supports the NRC chloride requirement of 0.08%. They fed diets containing 0.08 and 0.14% total chloride (0.02 and 0.08% added), and in diets with adequate sodium levels, the 0.08% chloride was adequate for

egg production. Diets with 0.14% chloride were not consistently better. Sullivan and Njoku (11) reported that 0.05% of dietary chloride was not adequate for egg production but 0.11% was adequate.

Materials and Methods. Two trials were conducted at two different periods of the year. The first trial, of 12 weeks duration, was started in mid-April, 1979, and involved Single Comb White Leghorn (SCWL) hens already in production for 7 months. The birds were individually caged in a well-ventilated laying house with a positive ventilation system and windows. A 14-h light period was provided daily. These birds were reared in floor pens and each bird housed weighed at least 1000 g at 20 weeks of age. There were six birds per diet.

The test diets formulated were corn-soy based, these two ingredients making up 90% of the total weight of each diet (Table I). The levels of NaCl and NaHCO₃ were calculated to maintain a constant level of sodium with varying levels of chloride.

Water and feed were provided *ad libitum*. Measurements commenced after the birds had been on the diets for 10 days. Daily egg production and monthly feed consumption records were kept. Eggs for shell deformation were collected on the last 2 days of each week in order to have a reasonable number from each treatment. The method described by Schoorl and Boersma (12)

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TABLE I. COMPOSITION OF DIETS A, B, C, AND D

	Percentage
Yellow corn	69
Soybean meal (44% protein)	21
Dicalcium phosphate	1
Limestone	7.75
NaCl + NaHCO ₃ + corn ^a	0.40
DL-methionine	0.06
Vitamin-trace mineral mix ^b	0.79
Total	100.00

^a In diets A to D the levels of NaCl were 0.035, 0.07, 0.15, and 0.30 and of NaHCO₃ 0.35, 0.30, 0.20, and 0.00%. The respective levels of added chloride were 0.02, 0.04, 0.09, and 0.18%. Added sodium approximated 0.11 to 0.12% in all diets.

^b Supplied per kg of diet: 21.6 mg MnO, 71.8 mg ZnCO₃, 3200 IU vitamin A, 520 ICU vitamin D, 1.0 IU vitamin E, 0.0033 mg vitamin B₁₂, 0.8 mg riboflavin.

with the Marius apparatus was used for this determination and basically consisted of applying a 500-g weight on the large end of a vertically standing egg and noting the extent of bending or deflection caused. This gave an indication of the strength of the egg shell and hence, the higher the deformation (or bending) the weaker the shell. Shell thickness determination was done on all eggs collected during the last week of the experiment. Eggs were broken out and a paper thickness gauge was used to take three measurements along the equatorial region of the shells with their intact membranes.

Trial 2 was done between October 1979 and March 1980, and consisted of pullets entering their first production cycle. There were 12 birds per diet and shell thickness measurements were done at the end of each month rather than at the end of the entire experimental period. The diets fed and the procedure followed in this trial were the same as those described in the first trial. Determinations for chloride in each diet were done by spectrophotometry and by potassium permanganate oxidation followed by precipitation with silver nitrate and titration with thiocyanate.

All the data except those for feed consumption or feed conversion were analyzed using the procedures described by Winer

(13) for one-way analysis of variance of the shell thickness measurements and for the repeated measures method in analyzing all the other data collected.

Results and Discussion. Table II presents the data on chloride content of the diets, hen-day egg production, shell deformation, and shell thickness. There were no significant differences in shell deformation or shell thickness in either experiment. In experiment 1 there might appear to be a trend, even though the differences were not significant, but the trend is the reverse of the expected result. Group A with the lowest chloride level showed the largest deformation. Certainly under the conditions of these experiments lowering dietary chloride and providing sodium as NaHCO₃ did not improve shell quality. This result agrees with several earlier reports (6-9). In the two experiments the birds were at different stages of the production cycle. In neither test were they exposed to extreme hot weather, even though the first test extended from April to July. They were not subjected to a high level of dietary phosphate, as some layers are. Presumably differences in level of dietary phosphate would influence the ionic balance.

In experiment 2 the hen-day egg production was significantly less for diet A than for any other diet and diets B, C, and D did not differ significantly among themselves. In experiment 1, the trend among diets A, B, and C was very similar to the trend in experiment 2, but because of greater variability within groups there were no significant differences in experiment 1. Diet A contained 0.08% of chloride, the required level according to the National Research Council report. These results indicate that the requirement of chloride for egg production was more than 0.08% but not more than 0.10 to 0.14%. All of the references cited by the National Research Council report were based on experiments with young chicks. Apparently the estimated requirement figures given for growing chickens and laying and breeding hens were all based on the chick experiments.

Diet A contained approximately 0.02% of chloride added as sodium chloride, so the

TABLE II. EFFECT OF DIETARY CHLORIDE ON EGG PRODUCTION AND SHELL DEFORMATION

Diet	Chloride in diet		Hen-day egg production		Shell deformation		Shell thickness	
	Titration (%)	Spectro. (%)	Expt 1 (%)	Expt 2 (%)	Expt 1 ($\times 0.001$ mm)	Expt 2 ($\times 0.001$ mm)	Expt 1 (mm)	Expt 2 (mm)
A	0.08	0.085	61.7 ^a	71.9 ^b	17.6 ^c	14.0 ^c	0.395 ^a	0.462 ^a
B	0.14	0.100	68.3 ^a	78.6 ^a	16.9 ^c	14.5 ^a	0.402 ^a	0.452 ^a
C	0.18	0.140	74.2 ^a	82.1 ^a	14.9 ^c	14.5 ^a	0.413 ^a	0.458 ^a
D	0.22	0.230	56.0 ^c	78.4 ^a	15.0 ^c	15.0 ^a	0.387 ^b	0.460 ^a

^{a,b} Means within the same column having different superscript letters are significantly different ($P < 0.05$).

other ingredients of the diet must have supplied approximately 0.06% chloride.

The levels of added and total chloride in diet A correspond almost exactly with those in the low chloride diet of Sauveur and Mongin (10). Whereas they found this level to be adequate for egg production, the present study found it to be inadequate. They emphasized the importance of relationships among sodium, potassium, and chloride, but such relationships do not explain the disagreement. The diet used in these studies contained calculated levels of 0.18% sodium and 0.63% potassium compared with 0.17% sodium and 0.7% potassium in one set of diets used by Sauveur and Mongin.

In these studies, feed consumption per hen per day was in the expected range. Intakes of diets A, B, C, and D were, respectively, 101, 104, 117, and 102 g in experiment 1 and 107, 107, 111, and 104 g in experiment 2.

In the past accurate information on chloride requirement of chickens was not important because the use of common salt to meet the sodium requirement always provided an excess of chloride. If other sources of sodium are to be used, attention must be given to the chloride requirement. It appears that the laying hens' requirement may be higher than the NRC value.

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