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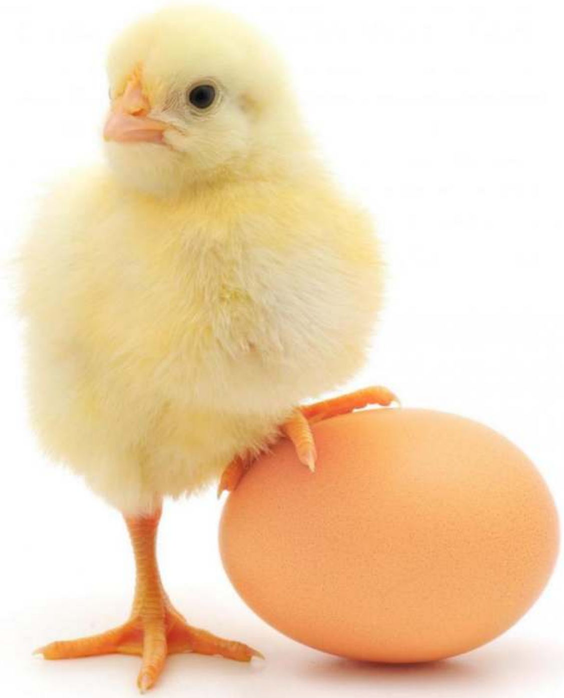

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ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
Mob: +92 300 3008585, Fax: +92 41 8815544
E-mail: editorijps@gmail.com

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Nutritional Requirement of Calcium in White Laying Hens from 46 to 62 Wk of Age

William Narváez-Solarte[1], Horácio Santiago Rostagno[2], Paulo Rubens Soares[2],
Luis F. Uribe-Velasquez[1] and Marcelo A. Silva[3]
[1]Depto de Salud Animal, Universidad de Caldas, Colombia
[2]Depto de Zootecnia, Universidade Federal de Viçosa, MG, Brasil
[3]Agroceres Animal Nutrition, Brazil

Abstract: A total of 240 Lohmann Selected Leghorn hens were fed 5 experimental diets in this experiment to determine dietary Ca requirement. Limestone was added to the basal diet containing 2800 kcal of ME/kg and 16.5% CP to produce 2.60, 3.00, 3.40, 3.80, and 4.20% Ca contents. This experiment lasted from 46 to 62 week of age. Increasing dietary Ca from 0.28 to 0.42% had a quadratic effect on egg production, egg mass, feed intake, feed conversion, and egg shell weight. With increasing dietary Ca bone strength linearly increased. Based on quadratic regression, dietary Ca requirements for maximum egg production and egg mass, and the best feed conversion were 3.52, 3.54, and 3.62%, respectively. Dietary Ca requirement for white laying hens from 46 to 62 weeks of age was 3.56% in the diet or 4.0 g Ca per hen daily with the average ambient temperature of 21.65°C.

Key words: Calcium, laying hens, egg shell

Introduction

Because calcium is one of the most important compositions of egg shell, it can significant affect performance and egg shell quality of laying hens. Inadequate Ca significantly decreased egg production, egg weight, egg specific gravity, feed consumption, and bone density and strength (Roland *et al.*, 1996). On the other hand excess Ca significantly reduced egg weight, egg production, and feed consumption (Harms and Waldroup, 1971), and reduced the profits. A number of studies have been conducted to investigate Ca requirement for laying hens. However, the results for Ca requirement ranging from 3.25 to 5.57 g hen per d are inconsistent among researchers (Roush *et al.*, 1986, Frost and Roland, 1991, Keshavarz and Nakajima, 1993; Roland and Bryant, 1994; NRC, 1994, Roland *et al.*, 1996; Ahmad *et al.*, 2003). Ca requirement recommended by the commercial management guides is from 3.9 to 4.2 g Ca per hen daily (Anonymous, 1999a, b). Hens cannot maintain optimal shell quality for even a single day without dietary Ca (Roland, 1986), because hen's ability to store Ca for future shell formation is limited (Lennards and Roland, 1981). There are many factors including strains, other nutrients such as phosphorus and dietary energy, age of birds, and temperature, which can affect Ca requirement. Because new strains of commercial Leghorns had higher egg yield than old strain (Wu *et al.,* 2005a), new strains might need more Ca to meet high egg yield. Hen's calcium requirement increases with age (Roland, 1986). However, little research has been conducted dietary Ca requirement in current commercial strain of Lohmann hens from 46 to 62 wk of age. Ca intake is calculated based on dietary Ca content and feed intake. Feed intake significantly decreased with increasing dietary energy or fat (Grobas *et al.*, 1999a,b; Harms *et al.*, 2000; Wu *et al.*, 2005b). Because protein ingredient prices have increased for several years, high dietary energy or fat level is often used to decrease feed intake to improve the profits. If Ca requirements determined from old strains from 21 to 36 wk of age are used to formulate the diets containing high dietary energy or fat level for current commercial strains from 46 to 62 wk of age, hens may easily become deficient in dietary Ca. Therefore, it is necessary to know more about dietary Ca requirement to optimize the performance and profits in current strain of commercial Leghorns. The objective of this study is to determine the calcium requirements for commercial Leghorn from 46 to 62 wk of age.

Materials and Methods

The present experiment was conducted in the Section of Poultry Production of the Departament of Zootechia of the Agrarian Center of the Federal University of Viçosa. MG, Brazil. 240 Lohmann Selected Leghorn hens were used from 46 to 62 wks of age. During the initial and growth phases the birds were fed following the recommendations of the Lohmann management guide (1996). After 17 wk of age, the birds were transferred from the growth house to the production house (60 x 10m) covered with ceramic roofing tiles. Two birds were placed in one cage (25 x 40 x 45 cm^3). All birds consumed the same diet until the 45 week of age. All birds were received stimulation of increased light according to the recommendations of the Lohmann management guide (1996). From 27 wk, chicken house

Table 1: Average of temperature during the trial (ºC)

Period	Minimum	Maximum
1- 4 week	13.80	28.60
5-8 week	13.82	27.60
9-12 week	18.17	28.74
13-16 week	16.86	25.61
Mean	15.66	27.63

Table 2: Composition of basal diet (46 to 62 wk of age)

Ingredient	Amount (%)
Corn	65.131
Soybean meal	17.936
Dicalcium phosphate	1.371
DL-methionine	0.019
Limestone	5.790
Salt	0.261
Corn gluten	4.544
Inert	4.722
Vitamin premix[1]	0.100
Mineral premix[2]	0.050
Chloride of choline	0.040
Zinc Bacitracin	0.025
B.H.T.[3]	0.010
Calculated analysis	
Crude protein (%)	16.50
M.E (kcal/kg)	2800
Calcium (%)	2.60
Available phosphorus (%)	0.350
Methionine (%)	0.320
Methionine+cystine (%)	0.610
Lysine (%)	0.710
Threonine (%)	0.635
Tryptophan (%)	0.185

[1]Rovimix® (Roche) - Composition/kg.: Vit.A.12.000.000 U.I.; Vit D_3. 3.600.000 U.I.; Vit. E. 3.500 U.I.; Vit. B1. 2.500 mg; Vit. B_2. 8.000 mg; Vit. B_6. 3.000 mg; Pantothenic acid. 12.000 mg; Biotine. 200 mg.; Vit. K. 3.000 mg.; Folic acid. 3.500 mg.; Nicotinic acid. 40.000 mg; Vit. B_{12}. 20.000 mcg. [2]Roligomix® (Roche) - Composition/kg.: Mn,160 g; Fe, 100 g; Zn, 100 g; Cu, 20 g; Co, 2 g. [3]Butil-Hidroxi-Tolueno (Antioxidant).

had 16 hours 30 minutes of light a day. Hens were randomly distributed to 5 treatments (6 replicates/treatment and 8 hens/replicate) by body weight and egg production before the experiment. The inner house temperature was recorded during the experimental period (Table 1). The average ambient temperature was 21.65ºC.

From 46 wk of age hens were fed 5 experimental diets for 16 weeks. Limestone was added to the basal diet containing 2800 kcal of ME/kg and 16.5% CP (Table 2) to produce 2.60, 3.00, 3.40, 3.80, and 4.20% Ca contents. The nutritional requirements except calcium in the experiment diets were according to recommendations of Rostagno *et al.* (2000) and NRC (1994), and nutrient compositions except Ca were kept the same. The proximal analysis of the diets was conducted to confirm dietary Ca content in Laboratory of Animal Nutrition of the Department of Zootechnia of Federal University of Viçosa, Brazil, according to the methods of Silva (1990). The mashed diets were supplied twice (7:00 and 17:00 hours) daily to guarantee hens have enough diets during the whole experimental period. Water was provided for *ad libitum* consumption. Egg production (%), egg weight (g), feed consumption (g/per hen day), and egg shell weight (g) were determined every four weeks. Egg production was recorded daily. Eggs were collected at the last four days of each four weeks and were used to determine average of egg weight and average shell weight. Feed consumption (g per bird day) was determined by the difference between the amount of offered diets and the leftovers in the end of each four weeks. Tibias from both legs were removed in the end of experiment as described by Orban *et al.* (1993). Bone breaking strength of wet tibias was measured using an Instron Universal Testing System (Model 1011)[1], with a probe (15mm dia) and speed of 200 mm/min.

Data for each response criterion were analyzed in ANOVA using the SAEG (System for Statistical Analyses and Genetics, 1996). Once differences among treatments were detected by one-way ANOVA, linear and quadratic effects were tested by contrast statements. Estimates of calcium requirements for performance were estimated by subjecting treatment means to quadratic regression model by using maximum or minimum asymptote.

Results and Discussion

Increasing dietary Ca had a quadratic effect on egg production and egg mass (Table 3). As dietary Ca level increased from 2.6 to 3.4%, egg production increased from 77.6 to 83.1%, resulting in a 5.5% increase. However, further increase of dietary Ca from 3.4% to 4.2 had no improvement of egg production. As dietary Ca increased from 2.6 to 3.8%, egg mass increased from 49.5 to 54.4 g per hen daily. Increasing Ca from 3.8 to 4.2% had no effect on egg mass. These results are in agreement with those of Roland *et al.* (1996), who reported that increasing dietary Ca level linearly increased egg production. Increasing dietary Ca had no effect on egg weight (Table 3). No response of egg weight to increasing Ca is consistent with other reported research (Harms and Waldroup, 1971; Zapata and Gernat, 1995).

Increasing dietary Ca had a quadratic effect on feed consumption (Table 3). Hens fed the diet containing 2.6% dietary Ca level had more feed consumption than hens fed the other diets. This suggested that hens fed

[1]Model 1011, Instron Corp, Canton, MA, USA

Table 3: Effect of calcium level on egg production, egg weight, egg mass, feed consumption, feed conversion, egg shell weight, and bone strength in leghorn laying hens from 46 to 62 weeks of age

Ca %	Egg production (%)	Egg weight (g)	Egg mass (g/hen per d)	Feed consumption (g/h per d)	Feed conversion (g feed/g egg)	Egg shell weight (g) (kg/cm^2)	Bone strength
2.60	77.59	63.87	49.54	115.55	2.367	6.86	8.27
3.00	81.03	64.05	51.91	113.43	2.206	6.86	10.42
3.40	83.07	64.00	53.17	113.61	2.161	6.97	12.20
3.80	82.37	66.07	54.41	112.30	2.073	7.14	12.20
4.20	80.06	63.86	51.10	112.14	2.215	7.03	12.52
C. V. (%)	5.14	2.00	5.56	1.66	5.33	2.45	8.57
Probability	Q*	NS	Q*	Q**	Q**	Q**	L*

Q means quadratic effect; L means linear effect. *P<0.05; * * (P<0.01)

Table 4: Nutritional calcium requirements estimated by quadratic regression model for white laying hens

Model	Equation of quadratic regression	Point of Maximum	Ca requirement (%)	R^2	SSD
Egg Production (%)	$Y=3.916+44.867X-6.367X^2$	82.95	3.52	1.0	0.544
Egg Mass (g/h per d)	$Y=-9.868+35.958X-5.081X^2$	53.75	3.54	0.88	9.755
Feed Conversion (g feed /g egg)	$Y=5.393-1.814X+0.251X^2$	2.11	3.62	0.91	0.024

diet with deficient Ca level might over-consume feed to compensate Ca deficiency. This is in agreement with that of Ahmad *et al.* (2003), who reported hens fed Ca deficient diets over-consumed the diets. Increasing dietary Ca had a quadratic effect on feed conversion (Table 3). As dietary Ca level increased from 2.6 to 3.8%, feed conversion improved from 2.37 to 2.07. No improvement in feed conversion can be found as dietary Ca increased from 3.8 to 4.2%.

As dietary Ca level increased from 2.6 to 4.2%, there was a quadratic response of egg shell weight to dietary Ca level (Table 3). Hens fed the diet containing 2.6% Ca had the lowest egg shell weight (6.86 g), while hens fed the diet containing 3.8% had the highest egg shell weight (7.16 g). Increased egg shell weight with increasing dietary Ca level agrees with those of Roland *et al.* (1996), who reported that increasing dietary Ca level improved egg shell quality. Increasing dietary Ca level resulted in a linear increase in bone strength. As dietary Ca increased from 2.8 to 4.2%, bone strength increased from 8.27 to 12.52 kg-f/cm^2. This result was similar to that of Roland *et al.* (1996), who reported that increasing dietary Ca level linearly increased bone strength. Because hens must use Ca from bones to produce eggs, hens can use dietary Ca to save Ca from bones when hens had adequate Ca intake (Farmer, 1986).

Quadratic model was used to predict dietary Ca requirements by taking maximum or minimum asymptote. Ca requirement determined by quadratic model for maximum egg production and egg mass were 3.52 and 3.54%, respectively (Table 4). The requirement of Ca for the best feed conversion was 3.62%. The average of Ca requirements for maximum egg production and egg mass, and the best feed conversion was 3.56%. Because average feed intake between hens fed 3.4% dietary Ca level and hens fed 3.8% dietary Ca level was 113 g per hen daily, dietary Ca requirement of white laying hens from 46 to 62 wk of age was 4.02 g per hen daily. This value is close to that of Roland *et al.* (1996), who reported that the requirement of dietary Ca ranged from 3.6 to 4.2 g per hen daily at 32 wk of age. The results of this experiment along with others (Roland, 1986; Frost and Roland, 1991; Clunies *et al.*, 1992; Keshavarz and Nakajima, 1993; Roland and Bryant, 1994; Roland *et al.*, 1996; Ahmad *et al.*, 2003) indicated that the NRC (1994) Ca requirement for laying hens (3.25 g per hen daily) is inadequate for maximum performance.

In conclusion, increasing dietary Ca significantly improved performance of laying hens. Dietary Ca requirement for white laying hens from 46 to 62 weeks of age was 3.56% in the diet or 4.02 g Ca per hen daily with the average ambient temperature of 21.65 ºC.

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