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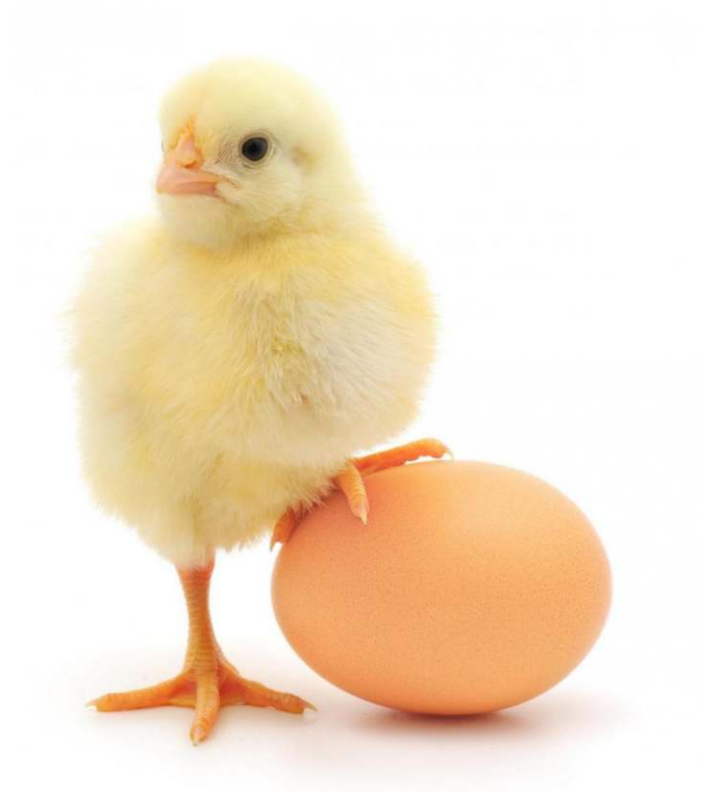

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Calcium Requirements of Bovanes Hens

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Abstract: Calcium requirements of laying hens have been widely studied yet keep challenging nutritionists as a result of new genetic make-ups of commercial strains, farm management techniques, environmental concerns, and economics considerations. The present research was conducted to determine the calcium requirement of "Bovines" hens that represent about 17% of US layer industry. Increasing dietary level of calcium from 2.5 to 5.0% in hens' diets in increments of 0.5% had a significant positive linear effect on egg production and egg specific gravity. Increasing dietary calcium level from 2.5 to 5.0% increased egg production from 75.3 to 82.4% and egg specific gravity from 1.078 to 1.083 units. Calcium level had no effect on feed consumption or egg weight. "Bovines" hens required 5.57 g calcium/h/d for a maximum egg specific gravity index of 1.083 units (high shell quality). The decision to feed this level of calcium to achieve maximum shell quality however depends upon the nature and cost-benefits analysis of the layer operation.

Key words: Calcium requirement, Bovines hens, egg production, egg specific gravity

Introduction

The calcium requirement of commercial leghorns is a widely studied problem yet it keeps challenging the poultry nutritionist with the advent of new genetic make-ups, commercial strains, farm management, environmental concerns, economic realities of layer production, and its effect on eggshell quality of aging hens. The significance of calcium requirements in layer production can be determined by the fact that eggshell contains about 94% calcium carbonate that is equivalent to two grams of calcium. Poor eggshell quality causes substantial economic losses to the commercial egg producer with an estimated annual loss of around $478 million (Roland, 1988). There are a number of factors involved in eggshell formation and its subsequent quality. The macro factors include, but are not limited to, the level and source of calcium in the diet. Less than optimum calcium can cause demineralization of bone, low serum calcium level and subsequently low egg production with higher thin-shelled eggs and egg breakage. Excess dietary calcium on the other hand may cause reduced egg weight, egg production, and extra feed consumption (Harms and Waldroup, 1971).

In the literature there is a wide difference of opinion (Table 1) regarding calcium requirement for optimum performance, varying from 3.25 to 5.17 g/h/d. Realizing this variation, National Research Council (NRC, 1994) reduced the calcium requirement for commercial leghorn from 3.75 g/h/d to 3.25 g/h/d. The commercial hens' management guides recommend a minimum daily intake of 3.9 to 4.20 g/h/d for optimum performance (Anonymous, 1999a, b). Bovines hens that represent more than 17% of US commercial White Leghorns and are second to only Hy-line hens have no confirmed published reports on the optimum calcium requirements. The present study was undertaken to establish the optimum calcium requirement of Bovines hens for optimum profits.

Table 1: Published reports on calcium requirement of laying hens

Year	g/h/d	Reference
1986	4.73	Roush *et al.*
1991	4.53	Frost and Roland, Sr.
1993	5.17	Keshavarz and Nakajima
1994	4.35	Roland and Bryant
1994	3.25	NRC
1996	4.20	Roland *et al.*

Materials and Methods

A complete randomized block design, with six calcium levels of 2.50 to 5.0% with a 0.5% increment was used to determine the optimum calcium requirement. The experimental diets (Table 2) otherwise were similar in regards to other nutrients. A total of 960, 57 wk old Bovines hens were randomly assigned to the six dietary treatments. Each dietary treatment was composed of eight replicates of 20 hens housed four hens per cage (40.6 cm x 45.7) in five adjacent cages. Replicates were equally distributed into upper and lower level cages to minimize cage level effect. Feed and water were provided for *ad libitum* consumption. A photoperiod of 16h light: 8h dark was provided. An average daily temperature of 20 ^{o}C was maintained (23.3 ^{o}C during the day and 15.6 ^{o}C during the night). Response criteria were feed consumption, egg production, egg weight, and egg specific gravity. Egg weight and egg specific

Table 2: Ingredient and nutrient composition of experimental diets

Ingredient (%)	1	2	3	4	5	6
Corn*	56.52	59.01	61.50	63.99	65.50	65.50
SBOM (48%)*	25.63	25.34	25.13	24.92	24.79	24.79
Limestone	11.61	10.32	9.03	7.74	6.45	5.16
Dicalcium phosphate	1.64	0.63	1.62	1.61	1.61	1.61
Poultry oil	3.49	2.52	1.55	0.58	----	----
Salt	0.45	0.45	0.45	0.45	0.51	0.45
Vitamin premix[1]	0.25	0.25	0.25	0.25	0.25	0.25
Mineral premix[2]	0.25	0.25	0.25	0.25	0.25	0.25
DL-methionine	0.16	0.19	0.18	0.17	0.17	0.17
Sand	----	----	----	----	0.50	0.50
Calculated analysis (%)						
Protein	17.13	17.24	17.35	17.47	17.53	17.53
ME kcal/lb	1282	1282	1282	1282	1282	1282
Calcium	5.00	4.50	4.00	3.50	3.00	2.50
Total phosphorus	0.61	0.61	0.61	0.62	0.62	0.62
Available phosphorus	0.40	0.40	0.40	0.40	0.40	0.40
Salt	0.20	0.20	0.20	0.20	0.20	0.20
DL-Methionine	0.49	0.48	0.48	0.48	0.48	0.48
TSAA	0.76	0.76	0.76	0.76	0.76	0.76
L-Lysine	0.92	0.92	0.92	0.92	0.92	0.92
Tryptophan	0.21	0.21	0.21	0.21	0.21	0.21
Glycine	0.91	0.91	0.92	0.92	0.92	0.92
Histidine	0.49	0.49	0.49	0.49	0.49	0.49
Isoleucine	0.86	0.86	0.86	0.86	0.86	0.86
Phe	0.93	0.94	0.94	0.95	0.95	0.95
Leucine	1.44	1.46	1.47	1.49	1.50	1.50
Threonine	0.64	0.64	0.64	0.65	0.65	0.65

*Amino acid analysis of corn and soybean meal was determined by chemical analysis. [1]provided per kilogram of the diet: vitamin A, 8000 IU; cholecalciferol, 2200 ICU; vitamin E, 8 IU; vitamin B_{12}, 0.02 mg; riboflavin, 5.5 mg; d-calcium pantothenate, 13 mg; niacin, 36 mg; choline, 500 mg; folic acid, 0.5 mg; thiamin, 1 mg; pyridoxine, 2.2 mg; biotin, 0.05 mg; menadione sodium bisulfite complex, 2 mg. [2]provided per kilogram of the diet: manganese, 65 mg; iodine, 1 mg; iron, 55 mg; copper, 6 mg; zinc, 55 mg; selenium, 0.3 mg.

gravity were done on a weekly basis on all the eggs laid on two consecutive days. Egg specific gravity was determined using saline solutions varying in specific gravity from 1.060 to 1.100 in 0.005 unit increments (Strong, 1989). Data collected from all the response criteria were subjected to ANOVA using GLM Procedure of SAS (SAS Institute, 1989).

Results and Discussion

Dietary calcium level had a significant effect on egg production (Table 3). Egg production linearly increased with incrementing calcium level. This linear effect was observed as early as second week of the experiment. There was a 7% average production difference (75.3 vs 82.3%) between the lowest (2.5%) and highest (5.0%) calcium intake level. This increase in production is consistent with the published report (Roland *et al*., 1996) where incrementing calcium level produced higher egg production in Hy-line W36 hens; however, not to this magnitude.

Egg weight was not significantly different among the experimental diets (Table 4). Average egg weight was similar between the lowest and highest fed dietary calcium level (64.10 vs 64.16 g). This lack of response in egg weight due to various calcium intake levels is consistent with other reported research (Zapata and Gernat, 1995; Harms and Waldroup, 1971).

Dietary calcium level had no significant effect on feed consumption (Table 5). Average feed consumption for the six experimental diets ranged between 111 to 114 g/h/d. Hens fed calcium deficient diets generally over consume to alleviate this deficiency. Although there was no increase in feed consumption *per se* due to calcium deficiency, the significant egg production drop suggests that hens fed calcium deficient diets over consumed to compensate.

Specific g ravity improved linearly with increasing dietary calcium level and this improvement was significant (Table 6). Hens fed the diet containing 5% calcium produced eggs with an average of 1.0832 egg specific gravity compared to 1.0785 from hens fed the diet with

Table 3: Effect of incremental calcium level change on egg production

Calcium level (%)	Weekly egg production (%)								
	1	2	3	4	5	6	7	8	Avg
	NS	**L	**L	NS	NS	NS	**	**	**L
5.00	84.4	82.8	83.1	81.1	81.3	80.3	82.7	82.7	82.3
4.50	80.0	82.5	81.5	80.0	79.4	77.5	75.8	75.8	79.1
4.00	82.1	80.1	81.0	82.5	81.9	80.9	83.2	83.0	81.8
3.50	81.4	79.6	79.4	78.5	78.4	80.6	81.5	81.5	80.1
3.00	80.5	76.7	78.9	82.0	81.1	80.2	81.8	81.6	80.4
2.50	78.7	70.9	71.6	74.4	77.4	76.1	76.6	76.6	75.3
SEM	0.52	2.33	2.16	2.16	2.14	2.19	1.85	1.85	1.60

L: Linear response, NS: Not significant at P > 0.05, **: P < 0.01

Table 4: Effect of incremental calcium level change on egg weight

Calcium level (%)	Weekly egg weight (gm)								
	1	2	3	4	5	6	7	8	Avg
	NS	**Q	**Q	NS	NS	NS	NS	NS	NS
5.00	64.17	63.96	64.03	64.36	64.12	64.28	63.85	64.54	64.16
4.50	63.74	65.11	64.90	64.02	65.09	64.32	64.95	65.21	64.67
4.00	65.13	65.19	65.03	65.11	65.11	65.16	64.94	65.22	65.11
3.50	64.12	64.05	64.58	64.64	64.62	64.46	64.35	64.89	64.46
3.00	64.26	64.02	64.82	64.21	64.89	64.12	64.89	64.90	64.51
2.50	63.92	63.72	63.83	64.18	64.69	63.87	64.09	64.48	64.10
SEM	0.27	0.17	0.19	0.23	0.22	0.20	0.24	0.18	0.17

L: Linear response, Q: Quadratic response, NS: Not significant at P > 0.05, **: P < 0.01

Table 5: Effect of incremental calcium level change on feed consumption

Calcium level (%)	Weekly feed consumption (gm)								
	1	2	3	4	5	6	7	8	Avg
	**	L	Q	NS	NS	NS	NS	NS	NS
5.00	112.9	110.9	111.5	111.7	112.3	110.0	110.7	111.3	111.4
4.50	111.1	110.5	112.3	111.2	115.0	10.8	107.5	109.5	110.7
4.00	112.2	112.4	114.2	117.0	117.8	113.3	113.6	113.9	114.3
3.50	108.5	107.8	115.0	116.2	116.0	115.4	116.4	116.2	113.9
3.00	104.9	108.6	112.2	113.9	115.3	111.7	112.5	114.1	111.7
2.50	102.6	103.2	109.1	112.8	116.0	112.6	113.4	113.2	110.4
SEM	0.65	0.68	0.57	0.66	0.61	0.76	0.91	0.57	0.56

L = Linear response, Q = Quadratic response, NS = Not significant at P > 0.05, ** = P < 0.01

Table 6: Effect of incremental calcium level change on egg specific gravity

Calcium level (%)	Bi-weekly egg specific gravity				
	2	4	6	8	Avg
	L ***	L ***	L ***	L ***	L ***
5.00	1.0843	1.0814	1.0829	1.0833	1.0832
4.50	1.0824	1.0812	1.0814	1.0827	1.0818
4.00	1.0819	1.0805	1.0823	1.0826	1.0817
3.50	1.0814	1.0806	1.0816	1.0826	1.0815
3.00	1.0795	1.0801	1.0796	1.0815	1.0802
2.50	1.0767	1.0793	1.0791	1.0802	1.0785
SEM	0.00	0.00	0.00	0.00	0.00

L = Linear response, *** = P < 0.001,

2.5% calcium. Improvement in egg specific gravity due to increasing calcium intake agrees with those of Roland *et al.* (1996) who found linear increase in egg specific gravity of Hy-line W36 hens when fed diets containing 2.5 to 5.0% calcium level. The Bovines hens in this study obtained maximum eggshell quality at 5.59 g calcium/h/d. This is 72% more than recommended by NRC (1994), which is 3.25 g/h/d. Determining appropriate calcium level for optimum eggshell quality is a continuous challenge particularly with the aging birds and as shown in Table 1 there are conflicting reports in this regard. Some of the variations in these studies could be attributed to the design of the study, strain of hens used, and age of the birds fed experimental diets. Another reason of variation in calcium requirement might be due to the variation in individual bird's feed consumption, absorption capacity, and egg size. Therefore, it is difficult to specify a minimum calcium level that will optimize shell quality in all hens (Roland and Bryant, 1994). The calcium quantity recommendation is also related to the pressure that eggs receive at a particular location. In a modern inline complex-maintaining undergrades of 3% or below may require less calcium than hens located on contract farms. Hens genetically selected for feed efficiency (optimal 28.1 kg case weight) and housed in inline complex may only require 3.6 g/h/d compared to 3.85 g/h/d housed in contract farms. However, hens selected for egg mass (23.2 kg case weight) could require a calcium intake of 4.0 g/h/d when housed in inline complex and 4.25 g/h/d or more in contract farms (Roland and Bryant, 2000). Because the beneficial effect of calcium on shell quality decreases as the calcium level approaches the requirement, the level required for maximum profits should be determined based upon the amount of under grades and market egg prices.

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