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EFFECT OF DIETARY CALCIUM LEVEL ON THE PRODUCTIVE AND REPRODUCTIVE PERFORMANCE OF GIMMIZAH AND MAMOURAH LAYING HENS

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ABSTRACT

The present study was undertaken to evaluate the effects of feeding four levels of dietary calcium on productivity, egg quality and reproductive performance of Gimmizah and Mamourah laying hens. A total number of 280, 18-week-old birds of two Egyptian breeds (120 pullets and 20 cockerels of each breed) were used. Pullets of each breed were randomly divided into four equal experimental groups; of 3 replications of 10 birds each, kept individually in laying battery cages set up in an open-sided laying house, exposed to a daily photoperiod of 16 hr, and managed similarly. Thus, four isocaloric (2700 kcal ME/kg)-isonitrogenous (16% CP) experimental diets, containing graded calcium (Ca) levels [3.0% (served as a control), 3.25, 3.50 and 3.75%] were formulated and given to the experimental birds from 18 to 46 weeks of age. At 25 weeks of age and onwards, the hens were artificially inseminated twice a week using freshly-collected undiluted semen from cockerels of the same age and breed, which had been fed the control diet (3.0% Ca). The criteria of response were change in body weight, productive performance (daily feed and Ca intakes, egg production rate, egg weight, daily egg mass and feed conversion ratio), some egg quality traits (egg components and certain measurements of egg quality), reproductive performance (egg fertility, hatchability, embryonic mortality and hatch weight of chicks) and certain blood parameters (plasma levels of glucose, total lipids, cholesterol, albumin, total calcium and inorganic P as well as activities of plasma alkaline phosphatase, alanine aminotransferase and aspartate aminotransferase). Ash, Ca and P contents of tibia bone and eggshell were also determined. In both Gimmizah and Mamourah laying hens, all criteria measured were not significantly affected by the dietary Ca level; but as it is expected, the daily Ca intake was significantly increased with increasing dietary Ca level from 3.0 to 3.75%. On the other hand, significant breed differences were observed in egg production rate, egg weight, percentages of egg yolk and albumen, eggshell thickness and egg yolk index, but were not detected in the other measurements, regardless of dietary Ca level. Gimmizah hens achieved higher means of egg production rate, percent egg yolk, eggshell thickness and yolk index compared with those of Mamourah hens while means of egg weight and percent albumen were in favor of Mamourah hens; however, the other measurements were not affected. The effects of dietary Ca level and hen breed, however, were not interrelated. Under the conditions of this study, daily Ca intake for Gimmizah and Mamourah laying hens of about 2.78 g/hen was sufficient to produce a satisfactory egg production, egg quality, and egg fertility and hatchability.

Keywords: Dietary calcium, Egyptian laying hens, productive and reproductive performance

INTRODUCTION

Because of the fact that dietary calcium is cheaper than almost all other nutrients, together with its key role in eggshell formation, high dietary levels of calcium are often used in laying rations. It is well documented that an excess of dietary calcium interferes with the availability of other minerals, such as phosphorus, magnesium, manganese and zinc (National Research Council; NRC, 1994). The same publication (NRC, 1994) recommended proper calcium to nonphytate phosphorus ratio of 12:1 in laying hen diets. However, Keshavarz (1986) concluded that dietary Ca to P ratio is not as crucial in the laying hens as in the growing chicks. In addition, because of a lack of a significant interaction between the effects of dietary Ca and P levels on productive performance of laying hens, Chandramoni *et al.* (1998) concluded that dietary Ca: P ratio is not of great importance for laying hens.

The impact of excessive levels of dietary calcium on productive performance of laying hens is controversial. Scott *et al.* (1971) found that egg production and feed intake were significantly decreased when dietary calcium level was increased to 5%. Damron and Harms (1980) reported that egg production was significantly higher with 3.5% than with either 2.5 or 6% calcium in the ration, whereas feed intake was significantly reduced when dietary calcium level was increased from 2.5 to 6%. On the other hand, other investigators did not observe adverse effects on egg production or feed intake with high calcium levels in laying hen diets (Holcombe *et al.*, 1977; Reichmann and Connor, 1977; Taher *et al.*, 1984; Keshavarz, 1986; Roland *et al.*, 1996).

The NRC (1994) stated that most of calcium in the diet of the growing bird is used for bone formation, whereas in the mature laying fowl most dietary calcium is used for eggshell formation. In this regard, it has been reported that when calcium level in the laying hen diets reaches 3.56% or higher, most of eggshell calcium is derived directly from the small intestine (Hurwitz and Bar, 1969), but when dietary calcium level is restricted to be 1.95%, then 30 to 40% of calcium needed for eggshell formation is supplied by the skeleton, particularly the medullary bone, and on calcium-free diets, the skeleton is the obvious principal source (Mueller *et al.*, 1969). Rapid development of the medullary bone begins in the female birds at about two weeks prior to the onset of egg laying (Hurwitz, 1987). Proper development of the medullary bone in pullets is critical because it serves as a calcium "buffer" during eggshell formation (Hurwitz, 1987 and 1989). When immature 19-week-old pullets were fed diets containing 3.5% calcium, Leeson *et al.* (1986) observed normal pullet development, skeletal integrity, and kidney histology. Also, Keshavarz (1987) indicated that feeding a diet containing 3.5% calcium from as early as 14 weeks of age had no adverse effect on skeletal integrity, apparent renal function, or subsequent reproductive performance.

Since demand for calcium and phosphorus increases as maturing pullets begin to develop medullary bone, and because this rate of skeletal growth depends upon the timing of sexual maturity, different genotypes (breeds or strains) of chickens may respond differently to feeding different calcium levels starting at the pre-laying period. Therefore, the present study was conducted to evaluate the effects of feeding four levels of dietary calcium on productivity, egg quality and reproductive performance of Gimmizah and Mamourah laying hens, from 18 to 46 weeks of age.

MATERIALS AND METHODS

The present study was accomplished at El-Serw Poultry Research Station, Animal Production Research Institute, Ministry of Agriculture, Egypt. A total number of 280, 18-week-old birds of two Egyptian strains (120 pullets and 20 cockerels of each of Gimmizah and Mamourah chickens) were used in this study. Pullets of each breed were randomly divided into four equal experimental groups of 3 replications of 10 birds each, and kept individually in laying battery cages set up in an open-sided laying house, exposed to a daily photoperiod of 16 hours and managed similarly. All groups of pullets were fed their respective experimental diets containing four graded dietary Ca levels (3.0, 3.25, 3.50 and 3.75%), while cockerels of both breeds were fed the lowest level of dietary calcium (3.0%; which served as a control), from 18 up to 46 weeks of age. Four isoenergetic (about 2700 kcal ME/kg)-isonitrogenous (about 16% CP) experimental diets containing the above mentioned dietary calcium levels were formulated and offered in mash form. Birds had free access to feed and water throughout the experimental period. Composition and chemical analysis of the experimental diets are shown in Table 1.

All pullets were weighed at the start of study (18 weeks of age), again at the beginning of egg production (22 weeks of age), and at the end of the experimental period (46 weeks of age). Body weight change (BWC) was calculated from 18 to 46 weeks of age. Individual daily records of egg production and egg weight were maintained on a 28-day period basis, for the whole experimental period. Feed intake, calcium intake and feed conversion ratio (grams of feed consumed: g egg produced) were determined on a replicate group basis. The productive performance of Gimmizah and Mamourah laying hens were evaluated in terms of daily feed intake (DFI), daily calcium intake (DCaI), hen-day egg production rate (EPR), daily egg mass (DEM), egg weight (EW) and feed conversion ratio (FCR) for the entire experimental period. At 25 weeks of age and onwards, hens were artificially inseminated twice a week using freshly-collected undiluted semen from cockerels of the same age and breed, which had been fed the control diet.

When the birds were 33 weeks of age, two-hundred freshly collected eggs (25 per treatment, collected and examined at two consecutive days) were broken out and used for egg quality measurements. These included egg weight, percentages of egg components (Keshavarz and Nakajima, 1995), egg shape index, egg shell thickness, egg specific gravity (Harms *et al.*, 1990) shell weight per unit surface area (Carter, 1975), Haugh units (Haugh, 1937), yolk index and yolk color score (by means of the Roche yolk color fan). Shell thickness, as an average of two measures at corresponding positions on the equator of the egg shell, was determined by a special micrometer.

For evaluating the reproductive performance, 3 sets of hatching eggs were performed when the birds were 36, 37 and 38 weeks of age. The settable eggs were collected for five consecutive days in each set. Eggs of each treatment within each set were considered as a replication when these data were subjected to statistical analysis. The eggs were examined two weeks after setting them into the incubator.

Table 1: Composition and chemical analyses of experimental diets containing different levels of calcium

Ingredients (%)	Dietary calcium level (%)			
	Control (3.0)	3.25	3.50	3.75
Yellow corn, ground	63.99	63.97	64.47	64.50
Soybean meal, 44% CP	22.20	22.60	22.90	23.30
Wheat bran	5.09	4.07	2.60	1.50
Dicalcium phosphate	0.82	0.76	0.80	0.81
Ground limestone	7.20	7.90	8.53	9.19
Common salt	0.30	0.30	0.30	0.30
Vit.+Min. Premix	0.30	0.30	0.30	0.30
Dl-Methionine	0.10	0.10	0.10	0.10
Total	100	100	100	100
Calculated analyses; As fed basis (NRC, 1994):				
Metabolizable energy; kcal/kg	2708	2704	2708	2704
Crude protein; %	16.06	16.08	16.02	16.03
Crude fiber, %	3.52	3.44	3.31	3.22
Ether extract; %	2.76	2.73	2.71	2.68
Calcium; %	3.00	3.25	3.50	3.75
Total P; %	0.53	0.51	0.51	0.50
Nonphytate P; %	0.25	0.25	0.25	0.25
Ca: nonphytate P; %	12	13	14	15
Lysine; %	0.80	0.80	0.80	0.80
Methionine; %	0.36	0.36	0.36	0.36
Methionine+Cystine; %	0.64	0.64	0.64	0.64
Determined analyses; DM basis (AOAC, 1984):				
Dry matter (DM); %	89.66	89.75	90.00	90.15
Crude protein (CP); %	17.80	17.85	17.76	17.79
Ether extract (EE); %	2.97	3.01	3.05	2.99
Crude fiber (CF); %	3.85	3.77	3.66	3.60
Ash; %	6.77	6.82	6.85	6.92
Nitrogen free extract (NFE); %	68.61	68.55	68.68	68.70
Ca; %	3.41	3.69	3.93	4.22
Total P; %	0.61	0.58	0.56	0.57

: Each three kilograms contains: Vit. A, 10,000,000 IU; Vit. D_3, 2,000,000 ICU; Vit. E, 10,000 mg; Vit. K_3, 1,000 mg; Vit. B_1, 1,000 mg; Vit. B_2, 5,000 mg; Vit. B_6, 1,500 mg; Vit. B_{12}, 10 mg; Biotin, 50 mg; Choline chloride, 250,000 mg; Pantothenic acid, 10,000 mg; Nicotinic acid, 30,000 mg; Folic acid, 1,000 mg; Mn, 60 g; Zn, 50 g; Fe, 30 g; Cu, 4 g; I, 0.3 g; Se, 0.1 g and Co, 0.1 g.

Data on the fertile and infertile eggs and the eggs with dead embryos were recorded. Egg fertility and hatchability (% of fertile and total eggs), and embryonic mortality were calculated. Weight of healthy hatched chicks was also recorded.

At the end of experiment (46 weeks of age), four hens per treatment were slaughtered within one to two hours of oviposition in order to take some measurements on blood parameters. During slaughtering, blood samples were individually collected in heparinized tubes, and then plasma samples were separated by the centrifugation at 4000 r.p.m. for 15 minutes and stored at –20° C until analysis. Also, the left tibia of each slaughtered hen was removed and cleaned of adhering flesh, dried at 100 °C for 24 hrs, crushed and defatted using the Soxhlet extraction apparatus, and dried again prior to ashing at 600 °C overnight. At the same time, 4 eggshells per treatment, from eggs produced by these hens, were oven-dried and ground prior to ashing at 600 °C for 48 hrs in a muffle furnace. Egg shell and tibia bone contents of ash, Ca and P were determined according to the methods of Association of Official Analytical Chemists (AOAC, 1984). The experimental diets were also analyzed for dry matter (DM), crude protein (CP), ether extract (EE), crude fiber (CF), ash, calcium and total P by using the official methods (AOAC, 1984). Blood plasma levels of glucose (Trinder, 1969), total lipids (Frings and Dunn, 1970), total cholesterol (Allain *et al.*, 1974), albumin (Doumas *et al.*, 1971), Ca (Moorehead and Biggs, 1974) and inorganic P (Goldenberg and Fernandez, 1966) and activities of plasma alkaline phosphatase (Kind and King, 1954), and aspartate aminotransferase and alanine aminotransferase (Reitman and Frankel, 1957) were determined, using commercial kits.

A completely randomized design in a 4×2 factorial arrangement of treatments, four dietary calcium levels (3.0, 3.25, 3.50 and 3.75%) and two breeds of chickens (Gimmizah and Mamourah), was used. The statistical processing of data was performed using the Statgraphics Program (Statistical Graphics Corporation, 1991) based on a multifactor analysis of variance, with $P \leq 0.05$ considered to be significant. For each parameter, significant differences among means were separated by using LSD-multiple range test of Quattro Program (Borland International, Inc., 1990).

RESULTS AND DISCUSSION

It was observed that all interactions between dietary calcium level and genotype for all criteria investigated were not statistically significant (Tables 2 to 6), suggesting that both breeds responded similarly to dietary Ca level.

Laying hen performance

Data on laying performance of Gimmizah and Mamourah hens fed different dietary Ca levels, from 18 to 46 weeks of age, are presented in Table 2. As was expected, increasing dietary Ca level from 3.0 to 3.75% was associated with significant increases ($P \leq 0.01$) in daily Ca intake compared with those of their control counterparts, regardless of the type of breed; however, no significant differences were observed in live body weights, BWC, DFI, EPR, EW, DEM or FCR. On the other hand, EW of Mamourah pullets was significantly higher ($P \leq 0.01$) than that of Gimmizah hens, and conversely, the latter surpassed the former in EPR, independent of dietary Ca level. Looking through these data, one can observe that pullets fed the lowest dietary Ca level (*i.e.* the control diet), which had the lowest daily Ca intake, achieved the best means of EW, DEM and FCR compared with those of the higher dietary Ca levels, regardless of the breed of chickens. This observation may be an indication that Ca requirement for these two Egyptian breeds of chickens during the laying period is as low as 3.0%; but further studies are needed to reevaluate the optimal dietary levels of Ca and P in a wide range of both elements for the local laying hens. In agreement with the present results, Summers *et al.* (1976) found that feed intake, egg production and egg size were not significantly affected by dietary calcium levels varying from 2.5 to 4.0%, during a 140-day feeding trial. Also, in an experiment over a 7-week period with laying hens, Atteh and Leeson (1983) reported that dietary calcium level (from 3.0 to 4.2%) had no significant effect on feed consumption, egg production or egg weight. Similar results also obtained by Scheideler and Sell (1986) who observed no effects of feeding three levels of dietary calcium (3.0, 3.5 or 4.0%) on the production traits of two strains of Single Comb White Leghorn hens, throughout a 336-day experiment.

In partial agreement with the present results, Atteh and Leeson (1985a) fed laying hens experimental diets containing three levels of calcium (3.0, 3.6 or 4.2%) from 33 to 40 weeks of age and found that dietary treatments had no significant effect on egg production or egg weight while feed consumption significantly decreased only when dietary calcium level was increased from 3.0 to 4.2%. On the other hand, Frost and Roland (1991) found that increasing dietary calcium levels from 2.75 to 3.75% or 4.25% did not significantly affect egg production or body weight but significantly increased feed consumption of DeKalb XL pullets during peak production. In addition, Roland *et al.* (1996) found that increasing calcium level in commercial Leghorns diets from 2.5 to 5.0% (with increments of 0.5%) resulted in a significant increase in feed consumption and egg production and had no adverse effect on either body weight or egg weight, from 20 to 32 weeks of age. Moreover, Ahmad *et al.* (2003) found that egg production of Bovans hens was linearly increased with increasing dietary calcium level from 2.5 to 5.0%, but feed consumption and egg weight were not significantly affected by dietary calcium levels, from 55 to 63 weeks of age. Inconsistent responses of laying hens to dietary calcium levels may be related to age and genotype of hens, stage of egg production, dietary level of available phosphorus and vitamin D_3, duration of experiment and/or other factors.

Egg quality and components

Data on egg components and egg quality traits (measured at 33 weeks of age) of Gimmizah and Mamourah laying hens fed different dietary Ca levels are illustrated in Table 3. Apart from the effect of breed of hens, statistical analysis of these data revealed that neither egg components nor egg quality traits were significantly affected by dietary calcium level. The observation that means of egg quality traits and egg components of Gimmizah and Mamourah laying hens, measured herein, were approximately similar whatever was the level of dietary calcium, may suggest that the range of dietary calcium levels used in the present study was too narrow to exert any beneficial or detrimental effects on these traits.

Table (2): Effects of feeding four graded levels of dietary calcium on the productive performance of two local breeds of chickens from 18 to 46 weeks of age

Main effects	Live body weights			18-46 BWC[1] (g)	DFI[2] (g/hen)	DCal[3] (g/hen)	DEM[4] (g)	EPR[5] (%)	EW[6] (g)	FCR[7] (g:g)
	18-wk	22-wk	46-wk							
Ca level (A)										
1 (3.00%)	1308	1503	1772	458	92.77	2.78^d	28.99	60.14	48.42	3.319
2 (3.25%)	1312	1494	1745	434	94.30	3.06^c	28.63	60.25	47.61	3.485
3 (3.50%)	1307	1501	1692	394	93.13	3.26^b	27.85	58.98	47.31	3.584
4 (3.75%)	1306	1490	1731	421	93.89	3.52^a	26.88	56.93	47.41	3.667
Sig. level[8]	NS	NS	NS	NS	NS	**	NS	NS	NS	NS
Pooled SEM[9]	18.2	17.6	28.7	26.5	0.95	0.03	0.84	1.78	0.46	0.129
Breed (B)										
1 (Gimmizah)	1314	1505	1721	412	93.72	3.16	28.42	60.84^a	46.73^b	3.455
2 (Mamourah)	1303	1489	1779	441	93.32	3.15	27.76	57.32^b	48.65^a	3.573
Sig. level[8]	NS	NS	NS	NS	NS	NS	NS	*	**	NS
Pooled SEM[9]	12.8	12.5	20.3	18.8	0.67	0.02	0.60	1.26	0.32	0.091
AB Interaction										
1 (1x1)	1315	1512	1743	425	94.32	2.83	29.96	63.76	47.10	3.203
2 (1x2)	1316	1501	1758	448	94.33	3.07	29.61	63.21	46.82	3.305
3 (2x1)	1312	1507	1678	384	93.70	3.28	28.09	60.23	46.65	3.511
4 (2x2)	1313	1501	1703	390	92.54	3.47	26.01	56.15	46.37	3.800
5 (3x1)	1301	1495	1801	491	91.23	2.74	28.03	56.53	49.74	3.436
6 (3x2)	1308	1487	1732	420	94.27	3.06	27.65	57.30	48.41	3.666
7 (4x1)	1302	1494	1705	405	92.55	3.24	27.62	57.74	47.97	3.657
8 (4x2)	1300	1479	1759	451	95.25	3.57	27.75	57.71	48.46	3.534
Sig. level[8]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pooled SEM[9]	25.7	25.0	40.6	37.5	1.35	0.04	1.55	2.51	0.64	0.182

[1-7]: Refer to means of body weight change, daily feed and calcium intakes, daily egg mass, hen-day egg production rate, egg weight and feed conversion ratio, respectively; [8]: Significance level; [9]: Pooled SEM refers to standard error of the means.
NS = not significant; *= significant at $P<0.05$; **=significant at $P<0.01$.
[a-d]: Means within the same column, and main effect for each criterion, bearing different superscripts differ significantly ($P \leq 0.05$).

Table (3): Effects of feeding four graded levels of dietary calcium on egg components and some egg quality traits (measured at 33 weeks of age) for two local breeds of chickens

Main effects	Egg weight (g)	Egg components (%)			Egg quality traits						
		Shell	Yolk	Albumen	ESI[1] (%)	ESG[2]	EST[3] (mm)	SWUSA[4] (mg/cm^2)	HU[5]	YI[6] (%)	YCS[7]
Ca level (A)											
1 (3.00%)	49.13	11.42	30.49	58.08	80.18	1.095	.359	90.25	75.91	41.40	5.40
2 (3.25%)	48.22	11.36	30.34	58.29	81.01	1.094	.357	89.36	76.81	41.75	5.32
3 (3.50%)	48.94	11.60	30.34	58.06	80.98	1.096	.360	91.58	76.41	42.03	5.32
4 (3.75%)	49.29	11.51	30.16	58.34	80.39	1.095	.360	91.03	78.46	40.82	5.22
Sig. level[8]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pooled SEM[9]	0.51	0.15	0.33	0.37	0.43	.0008	.004	1.15	0.98	0.43	0.07
Breed (B)											
1 (Gimmizah)	48.28^b	11.59	31.00^a	57.42^b	80.31	1.095	.365^a	91.12	76.81	42.13^a	5.38
2 (Mamourah)	49.51^a	11.36	29.67^b	58.97^a	80.98	1.094	.353^b	89.98	76.99	40.87^b	5.25
Sig. level[8]	*	NS	**	**	NS	NS	**	NS	NS	**	NS
Pooled SEM[9]	0.36	0.10	0.23	0.26	0.31	.0006	.003	0.81	0.69	0.30	0.05
AB Interaction											
1 (1x1)	47.35	11.68	31.30	57.01	79.40	1.096	.366	91.41	76.29	42.38	5.56
2 (1x2)	50.91	11.16	29.68	59.16	80.97	1.093	.352	89.08	75.53	40.43	5.24
3 (2x1)	48.00	11.59	31.07	57.34	79.89	1.096	.366	91.01	76.54	42.98	5.40
4 (2x2)	48.44	11.14	29.61	59.25	82.13	1.093	.348	87.70	77.08	40.53	5.24
5 (3x1)	48.73	11.50	30.87	57.63	80.88	1.095	.366	90.68	77.10	42.74	5.28
6 (3x2)	49.15	11.70	29.81	58.49	81.07	1.096	.355	92.48	75.72	41.32	5.36
7 (4x1)	49.04	11.57	30.75	57.68	81.07	1.095	.364	91.40	77.29	40.43	5.28.
8 (4x2)	49.55	11.45	29.56	58.99	79.72	1.095	.356	90.66	79.64	41.21	5.16
Sig. level[8]	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pooled SEM[9]	0.72	0.21	0.47	0.53	0.61	.0012	.005	1.63	1.38	0.61	0.09

[1-7]: Denote to egg shape index, egg specific gravity, egg shell thickness, shell weight per unit surface area, Haugh units, yolk index and yolk color score, respectively.
[8]: Significance level; [9]: Pooled SEM refers to standard error of the means.
NS = not significant; *= significant at $P<0.05$; **= significant at $P<0.01$.
[a-b]: Means in the same column, and main effect for each criterion, bearing different superscripts differ significantly ($P\leq0.05$).

However, significant breed differences were observed in egg weight, percentages of egg yolk and albumen, eggshell thickness and yolk index, regardless of dietary calcium level. Egg weight and percent albumen were significantly higher for Mamourah hens than those of Gimmizah ones; conversely, Gimmizah surpassed Mamourah hens in percent egg yolk, eggshell thickness and yolk index. These breed differences are primarily in close relation to egg weight. However, due to the fact that feed and Ca intake were the same for both breeds of hens (Table 2), and because eggshell quality is a combination of shell deposition and egg size, the superior eggshell thickness achieved by Gimmizah hens may be attributed to their smaller egg size.

As regards the effects of dietary Ca level on egg quality, the present results are in harmony with those reported by Keshavarz (1996) who observed no significant differences in eggshell quality (measured as shell thickness, shell weight, percent shell and SWUSA) or albumen quality (determined as albumen height and Haugh unit) when laying hens were fed two levels of dietary calcium (2.8 and 3.8%). On the contrary, Frost *et al.* (1991) found that increasing dietary Ca level from 2.75 to 4.25% caused a significant linear increase in egg specific gravity. Also, Roland *et al.* (1996) and Ahmad *et al.* (2003) found that increasing dietary Ca level from 2.5 to 5.0% (with increments of 0.5%) significantly increased egg specific gravity and had no adverse effect on egg weight. Lim *et al.* (2003) compared two Ca levels (3.0 and 4.0%) in laying hen diets and found that low Ca decreased egg specific gravity, eggshell strength and shell thickness of ISA-Brown layers from 21 to 41 weeks of age, and increased Haugh units in the second 10-week period. According to the literature, it was observed that the improvement in eggshell quality associated with increasing calcium level in laying hen diets may be linear up to a certain level, depending upon the range between the highest and the lowest dietary calcium levels (Frost *et al.*, 1991; Roland *et al.*, 1996 and Ahmad *et al.*, 2003). Other multi-factors such as dietary phosphorus level (Gordon and Roland, 1998), and availability and source of dietary Ca and P (Coon *et al.*, 2002) can also affect the quality of this egg component when laying hens are fed diets varying in calcium contents. In addition, age and strain of laying hens, plane of nutrition (*i.e. ad libitum* versus restricted feeding), feeding program (*i.e.* single stage versus phase feeding) and the duration of study (short- or long term experiment), may also be contributing factors in that respect.

Egg fertility and hatchability

Fertility and hatchability of eggs are the major parameters evaluating the reproductive performance of chickens and other poultry species. Data on egg fertility and hatchability of Gimmizah and Mamourah laying hens fed different dietary Ca levels are shown in Table 4. Statistical analysis of these data detected no significant differences in egg fertility, hatchability, embryonic mortality or hatch weight of chicks due to dietary Ca level or to the genotype of hens. Inasmuch as these measurements fell within the normal range, suggesting no adverse effect of the dietary calcium level that were used in the present study on the reproductive performance of Gimmizah and Mamourah laying hens.

Table (4): Effects of feeding four graded levels of dietary calcium on the reproductive performance of two local breeds of chickens, measured between 36 and 38 weeks of age

Main effects	Egg fertility (%)	Hatchability of fertile eggs (%)	Hatchability of total eggs (%)	Embryonic mortality (%)	Chick weight at hatch (g)
Ca level (A)					
1 (3.00%)	94.97	82.41	78.22	17.59	39.10
2 (3.25%)	93.85	85.61	80.40	14.39	39.02
3 (3.50%)	92.51	82.52	76.37	17.48	38.65
4 (3.75%)	93.60	84.11	78.68	15.89	38.93
Sig. level[1]	NS	NS	NS	NS	NS
Pooled SEM[2]	1.34	1.36	1.73	1.36	0.28
Breed (B)					
1 (Gimmizah)	94.08	83.66	78.67	16.34	38.82
2 (Mamourah)	93.39	83.66	78.16	16.34	39.02
Sig. level[1]	NS	NS	NS	NS	NS
Pooled SEM[2]	0.95	0.96	1.22	0.96	0.20
AB Interaction					
1 (1x1)	96.41	78.71	75.90	21.29	38.70
2 (1x2)	93.54	86.11	80.54	13.89	39.49
3 (2x1)	94.23	89.49	84.33	10.51	39.27
4 (2x2)	93.47	81.73	76.47	18.27	38.76
5 (3x1)	93.73	82.83	77.65	17.17	38.58
6 (3x2)	91.31	82.20	75.10	17.80	38.72
7 (4x1)	91.96	83.60	76.81	16.40	38.74
8 (4x2)	95.24	84.61	80.54	15.39	39.11
Sig. level[1]	NS	NS	NS	NS	NS
Pooled SEM[2]	1.90	1.93	2.44	1.93	0.39

[1]: Significance level; NS = not significant; *= significant at $P<0.05$.
[2]: Pooled SEM refers to standard error of the means.

In line with the present result, Mehring (1965) reported that increasing dietary Ca level (from 3.0 to 6.0%) had no adverse effect on percent hatchability of eggs in broiler-type laying hens. Similar results were obtained for turkey hens by Jensen *et al* (1964) who found no effect on hatchability of turkey hen eggs when dietary calcium level was increased from 1.75 to 6.25%. In addition, normal hatchability was obtained in broiler breeders fed diets containing 2.5 to 6.0% calcium (Wilson *et al.*, 1980). Also, it should be that dietary calcium levels for breeder hens reared in floor pens can be somewhat lower than those of caged laying hens. On the other hand, it has been reviewed that calcium levels in breeder diets affect embryonic development primarily through eggshell quality (Wilson, 1997). In this connection, McDaniel *et al.* (1979) reported that eggshell quality, expressed as egg specific gravity, is one of the best determinants of calcium adequacy for breeder hens; and concluded that eggs should have a specific gravity of 1.080 or greater for optimal hatchability. In the present study, means of ESG ranged between 1.093 and 1.096, and the achieved scores of hatchability (%

of fertile eggs) were 78.71 and 89.49% which fell within the normal acceptable levels, regardless of other factors affecting hatchability of eggs.

Blood Parameters

Data of some blood plasma constituents and activities of plasma ALP, ALT and AST enzymes of 46-week-old Gimmizah and Mamourah laying hens. fed diets containing different Ca levels are presented in Table 5. Analysis of variance of these data showed that dietary Ca levels, used in the present study, produced no differences in plasma levels of glucose, total lipids, total cholesterol, albumin, total Ca or inorganic P, or in activities of ALP, ALT and AST in blood plasma of Gimmizah and Mamourah laying hens. Also no breed differences were observed in the aforementioned blood plasma parameters.

In line with the present results, Bolden and Jensen (1985) reported that plasma Ca was not affected by dietary Ca level. Also, Keshavarz (1986) found that dietary calcium level did not have a significant effect on plasma levels of calcium and phosphorus. On the contrary, Reichmann and Connor (1977) reported that increasing dietary Ca significantly increased plasma Ca and inorganic P but significantly decreased plasma alkaline phosphatase in laying hens. Roland *et al.* (1996) found that increasing dietary Ca in laying hen diets resulted in a significant linear increase in plasma ionic Ca and a significant linear decrease in plasma P. In general, irrespective of the effect of dietary treatments and hen breed, mean values of blood parameters of laying hens, obtained in the current study, fell within the normal physiological range and agree with those reported by Freeman (1984) and Campbell (2004).

Tibia bone and eggshell components

Data on ash, Ca and P contents of tibia bone and eggshell of 46-week-old Gimmizah and Mamourah laying hens, fed experimental diets containing different Ca levels, are shown in Table 6. Statistical analysis of these data revealed that ash, calcium and phosphorus contents of tibia bone and eggshell were not significantly affected by either dietary Ca level or hen breed. The insignificant effect of dietary treatments on eggshell and bone ash, Ca and P of both breeds of laying hens would suggest that these minerals were normally metabolized for shell formation and maintenance of bone integrity.

The current results, however, are in harmony with those of Atteh and Leeson (1985a) who found no significant effect of increasing dietary calcium level on bone and eggshell ash or their mineral contents of calcium and phosphorus. The results reported herein are also in line with the findings of Hopkins *et al.* (1989), who found that neither tibial bone ash nor its contents of Ca and P of ISA Brown laying hens was affected by dietary calcium level, from 20 to 80 weeks of age. Similar results were reported by Keshavarz and Nakajima (1993) and Keshavarz (1996), who found that tibia ash and tibia Ca were not influenced by increasing dietary Ca level in laying hen diets. However, significant increases in bone ash and calcium (Atteh and Leeson, 1983 and Frost and Roland, 1991) or in bone ash alone (Atteh and Leeson, 1985b) were observed with increasing dietary calcium level in laying hen diets.

Table (5): Effects of feeding four graded levels of dietary calcium on blood plasma parameters of two local breeds of chickens, measured at 46 weeks of age

Main effects	GLOC[1] mg/dL	TL[2] g/L	CHOL[3] mg/dL	ALB[4] g/dL	Ca[5] mg/dL	P[6] mg/dL	ALP[7] U/L	ALT[8] U/L	AST[9] U/L
Ca level (A)									
1 (3.250 %)	231	20.38	128	2.53	27.84	6.42	278	27.88	151
2 (3.575 %)	217	21.56	149	2.61	27.50	6.71	270	27.50	161
3 (3.900 %)	239	21.44	133	2.05	27.64	6.67	250	29.50	164
4 (4.226 %)	239	21.56	123	2.22	27.07	6.47	220	30.88	158
Sig. level[10]	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pooled SEM[11]	6.89	0.69	6.87	0.16	0.51	0.23	22.1	1.68	9.80
Breed (B)									
1 (Gimmizah)	233	21.80	128	2.39	27.55	6.58	248	28.75	159
2 (Mamourah)	230	20.68	139	2.32	27.48	6.56	261	29.13	158
Sig. level[10]	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pooled SEM[11]	4.87	0.49	4.86	0.11	0.36	0.17	15.6	1.19	6.93
AB Interaction									
1 (1x1)	231	21.84	126	2.76	27.10	6.79	288	28.25	168
2 (1x2)	230	18.91	130	2.30	28.36	6.35	292	27.50	148
3 (2x1)	216	22.75	143	2.29	26.75	6.50	207	25.75	156
4 (2x2)	218	20.38	156	2.93	27.71	6.60	258	29.25	161
5 (3x1)	252	21.22	129	2.14	27.90	6.63	253	31.50	154
6 (3x2)	227	21.66	136	1.97	27.32	6.49	263	27.50	155
7 (4x1)	234	21.38	114	2.37	27.39	6.45	233	29.50	160
8 (4x2)	243	21.75	133	2.07	27.58	6.75	242	32.25	168
Sig. level[10]	NS	NS	NS	NS	NS	NS	NS	NS	NS
Pooled SEM[11]	9.74	0.98	9.71	0.23	0.73	0.33	31.3	2.37	13.9

[1-9]: Refer to means of concentrations of glucose, *total lipids*, *total cholesterol*, *albumin*, total calcium and inorganic phosphorus, and activities of *alkaline phosphatase*, alanine aminotransferase and aspartate aminotransferase in blood plasma, respectively; [10]: Significance level.
[11]: Pooled SEM refers to standard error of the means; NS = not significant.

Table (6): Effects of feeding four graded levels of dietary calcium on ash, calcium and phosphorus contents of tibia bone and egg shell of two local breeds of chickens, measured at 46 weeks of age

Main effects	Tibia bone			Egg shell		
	Ash (%)[3]	Ca (%)[4]	P (%)[4]	Ash (%)[5]	Ca (%)[5]	P (%)[5]
Ca level (A)						
1 (3.00%)	55.40	34.36	17.11	48.53	37.85	0.085
2 (3.25%)	56.09	34.42	17.26	49.07	38.18	0.094
3 (3.50%)	54.82	34.23	16.80	48.71	38.86	0.092
4 (3.75%)	56.00	34.17	17.53	48.17	37.91	0.090
Sig. level[1]	NS	NS	NS	NS	NS	NS
Pooled SEM[2]	0.45	0.27	0.31	0.46	0.52	0.004
Breed (B)						
1 (Gimmizah)	55.31	34.17	17.23	48.82	38.01	0.087
2 (Mamourah)	55.84	34.42	17.12	48.42	38.39	0.093
Sig. level[1]	NS	NS	NS	NS	NS	NS
Pooled SEM[2]	0.32	0.19	0.22	0.33	0.37	0.003
AB Interaction						
1 (1x1)	55.86	34.87	17.68	48.57	37.90	0.094
2 (1x2)	55.79	34.11	17.36	48.17	38.29	0.086
3 (2x1)	56.68	34.48	16.88	48.58	38.40	0.096
4 (2x2)	55.03	34.21	16.54	48.36	38.95	0.094
5 (3x1)	56.31	33.97	16.83	49.56	38.46	0.093
6 (3x2)	55.00	34.62	16.85	48.89	37.41	0.083
7 (4x1)	55.31	33.87	18.17	47.77	37.42	0.087
8 (4x2)	54.60	34.24	17.09	49.05	38.77	0.084
Sig. level[1]	NS	NS	NS	NS	NS	NS
Pooled SEM[2]	0.63	0.38	0.44	0.66	0.74	0.006

[1]: Significance level; NS = not significant.
[2]: Pooled SEM refers to standard error of the means.
[3]: On dry, fat-free basis; [4]: % of bone ash.
[5]: % of dry shell weight.

Conclusion

Under the conditions of this study, daily Ca intake for Gimmizah and Mamourah laying hens of about 2.78 g/hen was sufficient to produce a satisfactory egg production, egg quality, and egg fertility and hatchability.

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تأثير مستوى الكالسيوم في الغذاء على المظاهر الإنتاجية والتناسلية لدجاج الجميزة والمعمورة المحلي أثناء فترة إنتاج البيض

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تم إجراء هذه الدراسة بهدف تقييم تأثير تغذية دجاج الجميزة والمعمورة على علائق تحتوي على أربعة مستويات من الكالسيوم على كفاءتها الإنتاجية والتناسلية وجودة البيض الناتج. كان عدد الطيور الكلية المستخدمة ٢٨٠طائرا عمر١٨أسبوعا (١٢٠دجاجة+٢٠ديكا من كل سلالة)-حيث تم تقسيم دجاج كل سلالة عشوائيا إلى ٤مجموعات تجريبية متساوية بكل منها ٣مكررات متساوية وتحتوي كل مكررة على١٠دجاجات وتم تسكين الطيور في بطاريات ذات أقفاص ومعالف فردية مقامة في عنبر مفتوح وتعرضت جميع الطيور إلى ١٦ساعة إضاءة يوميا ونفس ظروف الرعاية. وبالتالي تم تكوين أربعة علائق تجريبية متساوية في محتوياتها من الطاقة القابلة للتمثيل (٢٧٠٠كيلوكالوري/كجم)و البروتين الخام (١٦%) وتحتوي على مستويات متدرجة من الكالسيوم (٣% أو ٣,٢٥% أو ٣,٥٠% أو٣,٧٥%) وتم تغذية المجموعات المختلفة من الدجاج على العلائق لتجريبية الخاصة بها طوال فترة التجربة (من ١٨ إلى ٤٦أسبوعا من العمر). وتم التلقيح الصناعي للدجاج بالسائل المنوي غير المخفف عقب جمعه من الديوك مباشرة مرتان أسبوعيا بدءا من الأسبوع الخامس والعشرين من العمر وحتى نهاية التجربة. وتضمنت القياسات: التغير في وزن الجسم والمظاهر الإنتاجية (المأكول اليومي من الغذاء والكالسيوم ومعدل انتاج البيض ووزن البيضة وكتلة البيض اليومية ومعامل التحويل الغذائي) وبعض صفات جودة البيض (نسب مكونات البيضة وبعض مقاييس جودة القشرة والجودة الداخلية للبيض) والمظاهر التناسلية (نسب الخصوبة والفقس والنفوق الجنيني للبيض وكذلك وزن الكتاكيت عند الفقس) وبعض معايير بلازما الدم (تركيز كل من الجلوكوز والدهون الكلية والكوليستيرول والالبيومين والكالسيوم والفوسفور غير العضوي وكذلك نشاط إنزيمات الفوسفاتيز القلوي والانين أمينوترانسفيريز وأسبرتيت أمينوترانسفيريز في البلازما).كما تم تقدير محتويات عظمة الساق وقشرة البيضة من الرماد وعنصري الكالسيوم والفوسفور.

ويمكن تلخيص النتائج المتحصل عليها للفترة التجريبية الكلية فيما يلي: لم يكن لمستوى الكالسيوم في الغذاء تأثيرا معنويا على كل الصفات المقاسة في كلا السلالتين إلا انه كما هو متوقع ازداد المأكول اليومي من الكالسيوم معنويا مع زيادة مستوى كالسيوم الغذاء من ٣% الى ٣,٧٥%- بغض النظر عن سلالة الدجاج. من ناحية أخرى--كانت هناك فروقا معنوية بين سلالتي الدجاج في معدل إنتاج البيض ووزن البيضة والنسب المئوية للصفار والبياض في البيض وسمك قشرة البيضة ومعامل الصفار بينما لم تتأثر باقي القياسات--بصرف النظر عن تأثير مستوى الكالسيوم في الغذاء. تفوقت سلالة الجميزة على سلالة المعمورة في معدل إنتاج البيض والوزن النسبي للصفار وسمك القشرة ومعامل الصفار بينما تفوقت سلالة المعمورة على سلالة الجميزة في وزن البيضة والوزن النسبي للبياض. لم يكن للتداخل بين مستوى الكالسيوم في الغذاء وسلالة الدجاج تأثيرا معنويا على كل الصفات المدروسة.

وبناءا على نتائج هذه الدراسة يمكن التوصية بأن دجاج الجميزة والمعمورة المصري البياض يكفيه قدر يومي من كالسيوم الغذاء في حدود ٢,٧٨جرام/دجاجة لكي تعطي انتاجا مقبولا كما ونوعا من بيض المائدة وبيض التفريخ.