INCUBATION CONDITIONS AND JAPANESE QUAIL EGG CHARACTERISTICS AS INFLUENCED BY DIFFERENT LEVELS OF DIETARY CALCIUM

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Abstract

Five groups of 120 Japanese quails were used to study dietary calcium (Ca) levels on slected egg parameters, eggshell thickness, egg-shell porosity and egg weight loss during incubation. egg production, egg wight, feed consumption and feed efficiency were not significantly affected by Ca levels. Shell thickness, specific gravity , shape index, yolk and albumen heights were significantly affected . Loss of egg weight was significantly affected with increasing Ca level in the first three days of incubation than during other stages of incubation. No significant effect of dietary Ca on hatchability of fertile eggs was found. Pore numbers and shell thickness were significantly ($P<0.05$) affected in different eggshell regions for Late dead (LD) and hatched (H) eggshell types. Pore numbers decreased significantly with increasing Ca levels for the different eggshell types . Negative ($p < 0.05$) correlation between shell thickness and pore concentration was recorded in LD type allover the egg regions. Negative correlation ($P < 0.05$) was also recorded in H type among the equator and small end egg regions.

INTRODUCTION

Eggshell is a major respiratory component of the developing embryo (Rahn *et al.* 1979). Most of the researches in the past have emphasized the importance of the physical eggshell qualities (Reichmann and Connor1977, Ousterhout 1980). Little attention has been given to the functional eggshell qualities, especially in the quail , which have a gas diffuse across the pores of the shell and determined by pore number , pore radius and shell thickness (Pore length) (Paganelli 1980, Rahn et al. 1981). A sufficiently high total number of pores in relation to shell thickness is required to reach the proper total pore area for normal developmet and hatching (Rahn *et al* . 1979). In order to hatch , an egg for a wide range of avian species , must lose 12 to 15 % of its weight primarily as water during incubation and maintain proper vital gas exchange (Beebles 1986). It is well known that the percentage of weight loss is an important factor in egg hatchability (Christensen and McCorkle 1982). Furthermore , decreased eggshell porosity has been associated with embryonic mortality and adversely affects hatchability (Beebles and Brake 1985). However , increased egg specific gravity is associated with increased pore length and decreased pore number (Tullet 1978).

The point of view of Tortuero and Centeno (1973), is that we could not establish comparative models for utilizing calcium (Ca) in poultry nutrition or as a factor affecting eggshell. The publications reflect a lack of ağreement and could be due to different variations.

The effect of various Ca levels on egg weight and egg production for quail has been studied (Vohra *et al* . 1979, Keshavarz 1986). Also , considerable work has been presented regarding the effectiveness of dietary Ca supplements on chicken eggshell quality (Atteh and leeson 1983, Keshavarz 1986) and for quail (Vohra *et al.* 1979).

This study was undertaken to investigate the effect of different levels of dietary Ca on the performance and some egg quality characterisitics in the Japanese quail . Special emphasis was given to the influence of these levels on regional pore concentration, pore length with the incidence of embryos on development and hatchability as well as studying the egg weight loss during incubation.

MATERIALS AND METHODS

This study was carried out at the Poultry Experimental Station , Faculty of Agriculture , Kafr El-Sheikh. A total of 120 laying Japanese quails (10 weeks of age) with an average egg production of 60 percent were randomly assigned to batteries with feed and tap water offered *ad libitum.* Two replicas of 12 birds (8 females and 4 males) were used in each of five treatments for the experimental period of 8 weeks . The composition of basal diet (control), which contains 2.67 % Ca, as recommended by Woodard *et al.* 1973, is shown in Table 1. Three increased Ca diets were formulated by replacing parts of inert sand with limestone, thus resulting in diets calculated to contain 3.16 , 3.66 and 4.15 % Ca. The low Ca diet was formulated to contain 2.17 % Ca.

Throughout the experiment , feed consumption (g / bird / day) and feed efficiency (kg foody / kg eggs) were calculated biweekly for eight weeks period. Daily egg production , egg weight and mortality were recorded for every treatment. Ninety egg samples were taken weekly after one month of the experiment for four times to determine the egg quality. Egg weight to the nearest 0.01 g on Mettler Balance and specific gravity were determined within 5 hours of collection. The maximum width and length of each egg were measured to the nearest 0.01 mm with calipers and their shape indices calculated using the formula : maximum width/maxiumum length . These eggs subsequently were broken out to determine the shell thickness at the equator to 0.01 mm accuracy with a micrometer. The equatorial region was chosen because variability in shell thickness tends to be least at the equator (Romanoff and Romanoff 1949). Also, albumen and yolk heights in millimeters and shell weight were recorded.

Additionally , 928 hatched eggs during four subsequnent weeks were incubated in Egyptian-made forced draft-type incubator, once a week and was operated at 99.5^{O}F dry bulb and 87^{O}F wet bulb . Hatchability and embryonic mortality were determined by macroscopic examination of hatchery residue. Then they were classified as infertile, ED (0-3 days) and LD (4.18 days), and H eggs. A total of 240 eggs from the four hatches (60 eggs each) from the different eggshell types were obtained to determine regional shell thickness and pore concentration. Egg contents, including the chorioallantoic membrane, were removed leaveing the inner and outer membranes and shell intact. Methylene blue (0.5 g of 89% dye /1 liter 70 % ethanol) was applied to the shell interior and allowed to diffuse through the shell , so that the pores could be visualized externally (Beebles and Brake 1985). Pores were counted using a dissecting microscope at 2.5x power and expressed as pore number / 0.25 Cm^2 within each eggshell region , large end (LE), equator (EQ) and small end (SE). Two areas were counted and averaged to determine the mean pore concentration for each region. Shell thickness without membrane was measured for each re-

Table 1. Compositon of experimental diets.

Ingredients	Diets %				
	1	2	3	4	5
Ground yellow corn	58.50	58.50	58.50	58.50	58.50
Soybean meal	16.50	16.50	16.50	16.50	16.50
Layer concentrate	10.00	10.00	10.00	10.00	10.00
Wheat bran	4.20	4.20	4.20	4.20	4.20
Bone meal	2.00	2.00	2.00	2.00	2.00
Limestone	4.00	4.00	4.00	4.00	4.00
Sand	4.50	4.50	4.50	4.50	4.50
NaCl	0.20	0.20	0.20	0.20	0.20
Vitamin[1] - trace min[2]. premix	0.10	0.10	0.10	0.10	0.10
Calculated analysis					
crude protein , %	18.09	18.09	18.09	18.09	18.09
Metabolizable energy, Kcal / Kg	2615	2615	2615	2615	2615
Calcium , %	2.67	3.16	3.66	4.15	2.17
Total phosphorus , %	0.75	0.75	0.75	0.75	0.75

Phizer premix 1-Each gram contains 2000 IU vit. A , 2000 IU vit. E.

2. Each kilogram contains 45 gm zinc , 40 g copper , 0.3 g iodine, 0.1 g selenium and 30 g iron.

gion. Shell thickness, regional pore concentrations among the various embryonic types were statistically compared.

For measurements of evaporative egg weight loss, all eggs were numbered consecutively and weighed to the nearest 0.01 g . before setting in the incubator (0 day) , and again on days 3, 7, 14 and 16 of incubation. Rate of egg weight loss was measured as mentioned by El-Turky *et al.* (1981). as follows:

$$\% \text{ Rate of egg weight loss} = \left(1 - \frac{\text{weight of incubated eggs}}{\text{weight of fresh eggs}}\right) X\ 100$$

The data were subjected to the analysis of variance and correlation coefficients for shell thickness and pore numbers determination according to Snedecor and Cochran (1967). Significant differences were determined by the multiple range test of Duncan (1955).

RESULTS AND DISCUSSION

As shown in Table 2 , Ca level in the diet had no statisticaly significant effect on egg weight, egg production, feed consumption and feed effeciency for the subsequnent experimental periods up to eight weeks. It can be observed that such slight increase in egg weight is shown numerically with increasing Ca level to 3.16 and 3.66%, but decreased for 4.17% Ca level and also for those which received the low level of Ca (2.17 %). This result partly agrees with those reported by Atteh and Leeson (1983) , and Keshavarz (1986), who revealed that there were no significant differences in egg weight according to alternate treatments. Increasing Ca in the diet resulted in a slight numerical increase in egg production with increasing Ca levels. The difference however, was not statistically significant. This resrult is in agreement with studies conducted by Ousterhout (1980) and Atteh and Leeson (1993) . They disagreed with the report of Reichman and Connor (1977), who stated that insufficient dietary Ca depressed egg production. Vohra *et al.* (1979) showed that calcium deprivation causes a drastically reduced production in coturnix.

Feed consumption and feed efficiency were not significantly influenced by dietary Ca level . Also, the feed efficiency data closely followed the rate of egg production. These results are in agreement with Ousterhout (1980) and Atteh and Lee-

Table 2. The influence of calcium levels on the production traits of Japanese quail.

Treatment (Calcium %)	Experimental peroid (week)	Production trait			
		Egg weight (g) $\bar{X} \pm$ S.D	Egg production % $\bar{X} \pm$ S.D	Feed consumption (g/bird /day) $\bar{X} \pm$ S.D	Feed consumption (g/bird /day) $\bar{X} \pm$ S.D
2.67	2	11.18 ± 0.23	66.07 ± 5.05	28.80 ± 0.01	3.90 ± 0.37
3.16		11.53 ± 0.20	65.79 ± 2.12	27.79 ± 0.04	3.66 ± 0.38
3.66		11.56 ± 0.23	66.97 ± 1.27	29.82 ± 0.04	3.85 ± 0.13
4.15		11.11 ± 0.11	67.86 ± 5.05	27.78 ± 0.04	3.68 ± 0.35
2.17		11.16 ± 0.10	65.18 ± 6.31	29.84 ± 0.08	4.10 ± 0.66
2.67	4	11.13 ± 0.52	67.61 ± 0.36	27.75 ± 0.07	3.96 ± 0.22
3.16		11.29 ± 0.35	7.86 ± 2.52	27.77 ± 0.00	3.62 ± 0.05
3.66		11.43 ± 0.19	69.05 ± 6.73	27.76 ± 0.06	3.52 ± 0.34
4.15		10.77 ± 0.16	69.65 ± 2.52	28.81 ± 0.01	3.84 ± 0.01
2.17		10.85 ± 0.09	66.33 ± 1.44	27.73 ± 0.04	3.55 ± 0.44
2.07	6	10.90 ± 0.15	67.35 ± 2.89	27.77 ± 0.04	3.78 ± 0.18
3.16		11.38 ± 0.42	68.57 ± 1.26	28.80 ± 0.01	3.68 ± 0.27
3.66		11.44 ± 0.05	70.27 ± 1.72	28.82 ± 0.01	3.89 ± 0.11
4.15		11.10 ± 0.12	71.43 ± 0.00	29.82 ± 0.03	3.96 ± 0.06
2.17		10.72 ± 0.40	66.33 ± 7.22	27.76 ± 0.06	3.90 ± 0.66
2.67	8	11.11 ± 0.15	69.39 ± 2.89	27.77 ± 0.08	3.60 ± 0.54
3.16		11.38 ± 0.32	69.65 ± 2.52	28.80 ± 0.04	3.63 ± 0.45
3.66		11.24 ± 0.12	71.43 ± 0.00	28.83 ± 0.00	3.83 ± 0.06
4.15		10.83 ± 0.04	70.54 ± 1.27	29.85 ± 0.02	3.91 ± 0.07
2.17		10.90 ± 0.43	67.35 ± 0.00	27.76 ± 0.04	3.78 ± 0.59

son (1983) . On the other hand , some researchers have observed that feeding the highest or lowest levels of Ca resulted in a significant influence of feed consumption or feed efficiency (Lennards and Roland 1981 and Keshavarz 1986). No mortality was recorded allover the experimental period.

The data in Table 3 indicate that Ca levels significantly ($P \leq 0.01$) affect shell thickness. This result is in agreement with the data reported by Ousterhout (1980) and keshevarz (1986) , who poined out that eggshell thickness as estimated by all methods was increased with the concentration of Ca in the diet . Vohra *et al.* (1979) reported that dietary deprivation of Ca in Japanese quail resulted in reduced shell thickness . On the other hand, Tyler (1945) found no differences in shell thickness in 6.0 or 3.0 % Ca diets. Table 3 shows also that there were highly significant differences in egg specific gravity with increasing of dietary Ca levels. The present report is in agreement with Reichmann and Connor (1977), who reported that, as dietary Ca is increased, egg specific gravity is improved.

Considering the albumen height as measurement of interior quality , it could be noted that increasing the dietary Ca improved significantly the quality in the interior of the egg. Imai *et al.* (1986), reported that albumin height is more suitable than Haugh unit for expressing interior quality in the quail.

Highly significant differences were also noticed in shape index with increasing Ca level as shown in Table 3 . This trend was nearly the same as found in specific gravity and shell thickness . These results were confirmed with the findings of Essary *et al.* (1977), who noticed a relationship between the length , width ratio and shell thickness, and Yannakopoulos and Tserveni Gousi (1986) who also found a relationship between egg shape and specific graveity.

There were significant differences ($p < 0.01$) in quail egg weight loss percentage during the first three days of incubation between Ca treatemetns (Table 4) . High percentage of weight loss (2.50 %) with the lowest level of Ca was found. Similarly, such numerical increase of egg weight loss during different periods of incubation (7,14 and 16 days) was noticed with low Ca level . Accordingly , the high percentage of loss (13.83 %) recorded on the 16th day could be due to the Ca decrease (2.17%) . Also, some slight decrease of quail egg weight loss was noticed with increasing levels of Ca . The embryo must change from diffusive gas exchange (eggshell) to water convection (pulmonary) gas exchange, thus, losing sinificant amount of water and emerge from the eggshell (Rahn 1984). This process includes

Table 3. The influence of calcium levels on quality characteristics of Japanese quail eggs.

Treatment (Calcium %)	Shell thickness (mm)	Sbell wieght (g)	Albument height (mm)	Yolk height (mm)	Shape Index	Specific gravity
2.67	214 ± 019^{d}	0.95 ± 0.1^{a}	420 ± 0.09^{c}	9.38 ± 0.24^{a}	65.01 ± 2.50^{c}	1.0767 ± 0.21^{b}
3.16	221 ± 0.42^{c}	0.96 ± 0.11^{a}	4.33 ± 0.04^{b}	9.25 ± 0.54^{a}	65.48 ± 2.54^{c}	1.0767 ± 0.54^{a}
3.66	227 ± 0.41^{b}	0.98 ± 0.13^{a}	4.36 ± 0.06^{b}	8.80 ± 0.52^{a}	70.36 ± 1.11^{b}	1.0778 ± 0.01^{ab}
4.15	244 ± 0.43^{a}	1.011 ± 0.00^{a}	4.64 ± 0.09^{a}	10.22 ± 0.54^{a}	79.78 ± 2.43^{a}	1.0800 ± 0.01^{a}
2.17	192 ± 0.41^{e}	0.88 ± 0.04^{a}	4.14 ± 0.08^{c}	9.23 ± 0.52^{a}	63.39 ± 2.42^{c}	1.0760 ± 0.01^{b}

* Means in the same column , having identical letters are not significant at the 0.05 level.

Table 4. Percentage of egg weight loss during incubation as influenced by dietary calcium levels.

Treatment (Calcium %)	No of egge	Day of incubation			
		3	7	14	15
		$\bar{X} \pm$ S.D	$\bar{X} \pm$ S.D	$\bar{X} \pm$ S.D	$\bar{X} \pm$ S.D
2.76	155	2.26 ± 0.42^{ab}	4.00 ± 1.10^{a}	9.93 ± 1.99^{a}	11.50 ± 1.98^{a}
3.16	172	2.01 ± 037^{bc}	4.07 ± 1.05^{a}	10.40 ± 2.83^{a}	11.75 ± 2.35^{a}
3.66	174	1.74 ± 0.18^{cd}	3.47 ± 1.30^{a}	96.93 ± 2.70^{a}	11.50 ± 1.87^{a}
4.15	229	1.69 ± 0.29^{d}	3.30 ± 1.13^{a}	9.70 ± 2.00^{a}	11.252 ± 1.68^{a}
2.17	198	2.50 ± 0.18^{a}	4.65 ± 1.59^{a}	12.22 ± 2.09^{a}	13.83 ± 2.79^{a}

* Means in the same column , having identical letters are not significant at the 0.05 level

12% loss of the initial egg weight as water vapour prior to internal pipping, achieving plateau metabolism prior to internal pipping (Tazawa 1980). Carey (1980), reported that eggs have a requisite loss of 15 % of their initial mass as water vapour . The 15 % loss must occur because the relative water content of eggs at the end of incubation must be the same as when the egg was laid. Increasing embryonic mortality may have bean due to decrease in shell conduct (water vapour loss) Christensen (1978). Christensen and McCorkle (1982) indicated that eggs with embryos dying late in incubation have decreased conduct rate.

A significant ($P \leq 0.05$) reduction in percent hatchability of total eggs due to Ca deficency (2.17 %) was observed (Table 5) . Also , early dead embryos percentage was significantly ($P \leq 0.05$) affected by the same level of Ca. This increase of early dead embryos may be the cause of diminishing the hatchability percentage. Accordingly , we can assume some relationship between the increment of egg weight loss percentage (Table 4) and the same trend of early dead embryos percentage (Table 5) as a result of Ca decrease . As with dietary Ca levels , no significant response in fertility, late dead embryos and hatchability of fertile eggs were noticed (Table 5) . From this table also we can observe numerical diminish of early dead embryos percentage with both Ca levels (3.16 and 3.66 %) but not with the highest Ca percentage (4.15 %) . In agreement with our result, Menge *et al.* (1977) reported that reduction($P< 0.05$) in the percrntage embryonic mortality was observed with eggs from hens fed 3.34 % Ca. Atkinson *et al.* (1967) observed no effect of Ca level on fertility . Also, our results support the previous finding of Mehring (1965), who showed that high dietary Ca level had not been found to affect hatchability of chicken eggs. Hatchability of fertile chicken eggs was not significantly affected by dietary Ca level (Wilson *et al.* 1980). Moreover, Nelson *et al* . (1964), reported that there was little or no differernce in fertility , early deaths and late deaths between Ca treatments for coturnix quail , also the hatchability was variable.

As a trend , there was significant increase of eggshell thickness ($P \leq 0.01$) with increasing Ca levels in different eggshell types (ED , LD and H) except form infertile type (Table 6) . The same table also reveals that pore numbers for all eggshell types differ significantly ($P < 0.01$) , and generally diminish with increasing Ca level . The highest shell porosity was recorded numerically in hatched egg type compared to other eggshell types. Several publications have been reported concerning the relationship betweeen Ca levels and shell thickness and its role in developing embryos and hatchability. For Example Reichman and Connor (1977), Keshavarz (1986) have reported that increasing the Ca levels significantly increased eggshell thickness, as shown in this study . The present report is in agreement with different reports . Tyler (1945) reported that an increased level of dietary Ca feed decreased shell porosity. Nestor *et al.* (1972) have found that supplemented Ca did increase the amount of shell and reduced shell porosity. Beebles and Brake (1985) have shown that eggshells form eggs containing ED embryos possesess lower porsoity and thicker shells than eggs from LD or hatched eggs.

On the other hand , Titus *et al.* (1937) reported that dietary Ca levels of 1.2,3.5 and 5.4 percent did not influence porosity of eggshell . Paganelli (1980) has shown that little attention has been given to the functional eggshell qualities determined by the number and geometry of the individual pores, but Simkiss (1980) concluded that the importance of eggshell porosity to the embryo may be overemphasized. Egg hatchability and embryonic growth have been clearly shown to be dependent upon the porosity (Burton and Tullett 1983) and they added that the decrease in shell porosity may affect the ability of the embryo to breath especially towards the end of incubation period.

Significantly higher concentrations of pores at the large end than in other regions have been found in H and LD types (Table 7) . This result is partly in agreement with Beebles and Brake (1985) who reported that only H eggshells exhibited an increase in pore concenration at the LE relative to other eggshell regions. Higher concentrations of pores at the LE than in other regions have been found to occur in eggshell of turkey (Christensen 1983) and the importance of LE porosity to embryonic respiration has been recognized (Visschedijk 1968).

Both same types (LD and H) showing significant differences ($P > 0.01$) in shell thickness between the egg regions, and the greatest shell thickness were recorded at the SE (Table 7). The same table also shows no significant differences of shell thickness and pore concentration among the egg regions of infertile and ED types.

We can observe from this study that , the number of shell pores in the quail is less than the pore numbers in chicken and turkey. Since the quial is considered relatively semidomesticated, we are likely to observe a less number of pores to fit the wild life circumstances. The size of the egg could also influence the number of pores in equal units of area in the light of spectulations by Tullett (1978).

A compilation of data over the different eggshell types in different egg regions LE, EQ and SE showed a negative correlation between shell thickness and pore concentration in all traits (Table 8) . Also negative ($P < 0.05$) correlation betweem

Table 5. Embryonic development and hachability of Japanese quail as influenced by dietary calcuim levels.

Treatment (Calcium %)	Fertility % $\bar{X} \pm$ S.D.	Early dead embryos (ED) % $\bar{X} \pm$ S.D.	Late dead embryos (LD) % $\bar{X} \pm$ S.D.	Hatchability %	
				Total eggs set $\bar{X} \pm$ S.D.	Fertile eggs $\bar{X} \pm$ S.D.
2.67	74.00 ± 3.75^{a}	17.65 ± 3.01^{b}	14.82 ± 4.83^{a}	49.79 ± 4.12^{a}	67.53 ± 7.81^{a}
3.16	71.85 ± 2.80^{a}	16.64 ± 4.60^{b}	16.73 ± 3.89^{a}	47.92 ± 5.21^{a}	66.81 ± 8.07^{a}
3.66	73.16 ± 2.99^{a}	15.20 ± 6.07^{b}	16.52 ± 2.13^{a}	49.87 ± 3.50^{a}	68.28 ± 6.15^{a}
4.15	75.54 ± 1.45^{a}	20.83 ± 2.12^{ab}	16.17 ± 1.60^{a}	47.60 ± 1.50^{a}	63.00 ± 1.72^{a}
2.17	73.51 ± 4.21^{a}	25.16 ± 3.15^{a}	19.58 ± 4.25^{a}	40.46 ± 1.60^{b}	55.26 ± 5.29^{a}

* Means in the same column, having identical letters are not significant at the 0.05 level.

Table 6. eggshell thickness (mm) and eggshell pore concentration (number/0.25 cm^2) in different eggshell types for Japanese quail as influenced by dietray calcium levels.

Treatment (Calcium%)	Infetiule		Early dead		Late dead		Hatched	
	Shell thickness X ± S.D.	pore thickness X ± S.D.	Shell thickness X ± S.D.	pore concentration X ± S.D.	Shell thickness X ± S.D.	pore concentration X ± S.D.	Shell thickness X ± S.D.	pore concentration X ± S.D.
2.76	0.218 ± 3.75^{a}	11.9 ± 203^{cd}	0.218 ± 0.02^{a}	9.3 ± 1.27^{b}	0.209 ± 2.02^{c}	7.2 ± 0.87^{ab}	0.212 ± 0.02^{cd}	$10.2 \pm L12^{a}$
3.16	0.206 ± 0.02^{a}	11.5 ± 3.14^{bc}	0.225 ± 0.01^{a}	8.7 ± 1.49^{b}	0.221 ± 0.01^{b}	7.1 ± 1.04^{ab}	0.217 ± 0.01^{bc}	9.5 ± 0.82^{a}
3.66	0.214 ± 0.01^{a}	7.9 ± 1.27^{b}	0.232 ± 0.01^{b}	86 ± 0.67^{c}	0.226 ± 0.02^{ab}	7.6 ± 1.33^{a}	0.228 ± 0.02^{ab}	9.0 ± 1.41^{a}
4.15	0.222 ± 0.02^{a}	84 ± 1.17^{b}	0.247 ± 0.02^{a}	63 ± 1.00^{c}	0.235 ± 0.02^{a}	6.2 ± 1.03^{b}	0.240 ± 0.02^{a}	84 ± 0.88^{b}
2.17	0.213 ± 0.02^{a}	83 ± 1.42^{b}	0.208 ± 0.01^{d}	10.9 ± 1.27^{a}	0.201 ± 0.02^{c}	7.6 ± 1.00^{a}	0.210 ± 0.02^{d}	7.21 ± 0.72^{c}

* Means in the same column having identical letters are not significant at the 0.05 level.

Table 7. eggshell thickness (mm) and eggshell pore concentration (number /0.25 cm^2) in different egg regions for different eggshell types for Japanese quail.

Egg region	Infertile		Early dead		Late dead		Hatched	
	Shell thickness	Pore concentration	Shell thickness	Pore concentration	Shell thickness	Pore concentration	Shell thickness	Pore concentration
	$\bar{X} \pm$ S.D.	$\bar{X} \pm$ S.D.	$\bar{X} \pm$ S.D.	$\bar{X} \pm$ S.D.	$\bar{X} \pm$ S.D.	$\bar{X} \pm$ S.D.	$\bar{X} \pm$ S.D.	X ± S.D.
Large end	0.210 ± 0.01^{a}	9.2 ± 0.96^{a}	0.224 ± 0.02^{a}	8.5 ± 1.67^{a}	0.211 ± 0.02^{b}	7.8 ± L22^{a}	0.211 ± 0.02^{b}	9.4 ± 1.75^{a}
Equator	0.216 ± 0.02^{a}	10.1 ± 3.30^{a}	0.223 ± 0.02^{a}	9.00 ± 1.91^{a}	0.214 ± 0.02^{b}	6.8 ± 0.99^{b}	0.220 ± 0.03^{ab}	8.6 ± 1.34^{b}
Small end	0.219 ± 0.01^{a}	9.2 ± 2.71^{a}	0.232 ± 0.02^{a}	8.18 ± 2.46^{a}	0.231 ± 0.02^{a}	6.8 ± 0.99^{b}	0.227 ± 0.01^{b}	8.5 ± 1.51^{b}

* Means in same coulumn , having identical letters are not significant at the 0.05 level.

Table 8. Correlation coefficients between egg shell thickness and eggshell pore numbers in different egg regions for different eggshell types.

Egg region		Shell thickness (mm) / pore concetation (number /0. 25 cm^2)			
		Infertile	Early dead	Late dead	hatched
Large end	(r)	-0.607 **	-0.368	-0.411 *	-0.402
	(b)	-59.480	-30.728	-26.901	-35.175
Equator	(r)	-0.246	-0.350	-0.445 *	-0.450 *
	(b)	-40.590	-33.425	-22.05	-20.10
Small end	(r)	-0.265	-0.243	-0.433 *	-0.502 *
	(b)	-71.815	-29.889	-21.384	-57.70

* Significant ($P < 0.05$) ; signifieant** ($P < 0.01$)

r Correlation coefficient.

b Slope

shell thickness and pore concentration was recorded in LD type allover the egg regions (r=-0.441, - 0.445 and - 0.433), respectively. Negative correlations (P< 0.05) were also recorded in H type among the EQ and SE egg regions (r = - 0.450 and - 0.502) , respectively (Table 8) . The importance of the relation between shell thickness and pore numbers has been investigated. Wangensteen *et al.* (1970/ 71) reported that the resistance of the calcite shell to diffusion is the function of the length and number of pores, and alteration of this relation will affect gas diffusion. Total functional pore area is inversely proportional to shell thickness (Ar *et al.* 1974). Tullett (1978) reported that inverse relationship between shell thickness and column density exists and pore number is inversely related to shell thickness. . Rhan *et al.* (1981), showed that a sufficiently high total number of pores in relation to shell thickness is required to reach the proper total pore area for normal development and hatching.

More experiments are needed to evaluate the role of the pigment on quail eggshells in masking the pores and its role in the permeability and developing embryos.

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ظروف التفريخ وصفات بيض السمان اليابانى ومدى تأثرها بالمستويات المختلفة من الكالسيوم فى العلف

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استخدم فى هذه الدراسة عدد ١٢٠ سمانه يابانى بياضة حيث قسم هذا العدد الى خمسة مجاميع مختلفة كل مجموعة تحتوى على ٢٤ سمانه وتم تغذية هذه المجاميع على خمسة مستويات مختلفة من الكالسيوم فى العلف . ولقد استمرت التجربة لمدة ٨ اسابيع بغرض دراسة تأثير رفع مستوى الكالسيوم اوخفضه فى العلف على انتاجية السمان البياض وبعض مقاييس جودة البيض والفاقد فى وزن البيض خلال بعض فترات التفريخ وكذلك سُمك القشرة ومساميتها فى أجزاء البيض الثلاثة في المراحل الجنينية المختلفة وعلاقتها بنسبة الفقس .

ويمكن تلخيص أهم نتائج البحث فيما يلى :

١ . لم يتأثر كل من انتاج البيض ووزنه واستهلاك العلف والكفاءة الغذائية جوهرياً بمستويات الكالسيوم المختلفة فى العلف .

٢ . كان هناك تأثير جوهرى على سمك القشرة ، الكثافة النوعية ، معامل البيض ، وارتفاع كل من الصفار والبياض.

٣. كان لزيادة مستويات الكالسيوم تأثير معنوى على الفاقد فى وزن البيض خلال الثلاثة ايام الأولى من التفريخ بالمقارنة بالمراحل المختلفة منه.

٤ . لم يكن لمستويات الكالسيوم المختلفة تأثير جوهرى على نسبة الفقس للبيض المخصب .

٥. اوضحت النتائج تأثر كل من سمك القشرة وعدد المسام معنوياً فى مناطق البيض المختلفة لكل من قشرة البيض ذى الأجنة الميتة فى المراحل المتأخرة وقشرة بيض الكتاكيت الفاقسة.

٦ . لوحظ انخفاض جوهرى فى عدد المسام بزيادة مستويات الكالسيوم في كل من حالات التفريخ المختلفة (الغير مخصب ، الأجنة النافقة مبكراً ، الأجنة النافقة مؤخراً والفاقس)

٧. كان هناك ارتباط سلبى بين كل من سمك القشرة وعدد المسام فى قشرة بيض الأجنة النافقة مؤخراً فى جميع اجزاء البيض المختلفة ، كما لوحظ كذلك وجود ارتباط سلبى فى قشرة بيض الكتاكيت الفاقسة بين سمك القشرة وعدد المسام فى كل من الطرف الضيق والاوسط من البيض.