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ANALYZING OF QUAIL EGGS HATCHABILITY, QUALITY, EMBRYONIC MORTALITY AND MALPOSITIONS IN RELATION TO THEIR SHELL COLORS

Ayman E. Taha

Department of Animal Husbandry and Animal Wealth Development, Faculty of Veterinary Medicine, Alexandria University, Behira, Rashid, 22758 Edfina, Egypt

*Email: Ayman_soma2007@yahoo.com

ORIGINAL ARTICLE

ABSTRACT: *A total 2400 hatching eggs were obtained from Japanese quails breeders ranged from 100 to 150 days of age used to analyze the effect of shell color on fertility, hatchability, embryonic mortality and malposition as well as internal and external egg quality. Results revealed that shell color had significant effect on fertility and scientific hatchability while it doesn't affect commercial hatchability percentage. Moreover, there were significant effects for shell colors on early and late embryonic mortalities but not for mid embryonic mortalities. In addition, egg shell color represented some differences for embryonic malposition. Results also showed that egg shell color had significant effect on egg weight, length, width, volume, haugh unit, shell thickness and egg weight loss. But doesn't affect shape index, yolk index, yolk percentage, albumen percentage, shell weight and shell percentage. We recommended that spotted and white shelled eggs should be excluded from hatching procedures and used for another purpose because they recorded the lowest scientific and commercial hatchability percentages, highest early embryonic mortalities, the lowest egg volume and shell thickness as well as the highest values for egg weight loss during egg storage.*

Keywords: *Quail egg colors, fertility, hatchability, embryonic mortality and malposition, egg quality*

INTRODUCTION

Japanese quail lays eggs with colorful and patterned shells which make the eggshell color difficult to classify. Quail eggs are graded as white, sandy-spotted, little-spotted, high-spotted and/or medium-spotted (Okumus and Durmus, 1998), while eggshell color of the wild quail is white, flesh-tint, light brown or speckled blue and/or brown. Moreover, these differences in egg color have been proposed as a means of identifying hens (Mizutani, 2003). Also, (Sezer and Tekelioglu, 2009) concluded that quail eggshell color varies from white to blue and green. Additionally, quail eggs have brown or reddish-brown patterned areas on a light background. This colorful quail eggs provides more opportunities to study a wide variety of questions, such as the metabolism of pigment deposition and its relationship to overall bird physiology, egg quality and sexual behaviors.

Hulet et al. (1985) documented that fertility was not significantly affected by shell color. However, eggs with blue or tan colored shells tended to have a significantly lower hatchability in Pheasant. McDaniel et al. (1979) and Bennett (1992) concluded that thinner eggshells are associated with lowering in hatchability percentage, while thick-shelled eggs showed an increased hatchability as a result of greater fertility and lower intermediate and late embryonic mortalities (Roque and Soares, 1995). There are variations of the normal embryonic positions that are considered to not be detrimental to successful hatching. However, there are many positions that are associated with difficulty in hatching or are found in increased incidence in cases of poor hatchability (Wilson et al., 2003). It should be noted that there were significant correlations between shell color and shell strength, thickness, and shell weight. While there were no distinct correlations between shell color and egg weight, albumen weight, yolk weight, haugh unit, yolk color of the Yangzhou chicken (Yang et al., 2009), in addition, they demonstrated that some egg quality traits such as shell strength, shell thickness, shell weight and shell ultra-structure could be assessed through the shell color.

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The objectives of this study were to investigate the effect of eggshell color on fertility, hatchability, embryonic mortality and malposition as well as egg quality traits.

MATERIALS AND METHODS

This study was carried out on 2400 hatching eggs obtained from Japanese quails breeders ranged from 100 to 150 days of age at the Department of Animal Husbandry and Animal Wealth Development, Faculty of Veterinary Medicine, Alexandria University, Egypt.

Eggs

Collected daily from battery cages that contain quail breeders each cage contains 2 males and 6 females with sex ratio (1: 3). Eggs then arranged into five different color groups based up on pigment found on the surface of egg shell (Figure 1). Group (I) Brown pigmentation, group (II) grayish white egg shell pigmented with various sizes of black pigments (Black stained); group (III) non-pigmented egg shell (white), group (IV) small black pin dots on grayish brown shell (Spotted) and group (V) slightly blue pigments

(I) (II) (III) (IV) (V)

Fig. 1 - different shell color groups of Japanese quail eggs

Management of eggs

Eggs were collected and stored for seven days in the storage room at 18oC and 75% relative humidity. Cracked eggs, thin shells, dirty eggs and abnormal in size or shape, were eliminated. Eggs were fumigated using formaldehyde gas (Mixing of 40 ml formalin 40% and 20 g Potassium permanganate, KMNO4)/three cubic meters of cabinet area for about 20 minutes then the gas expelled). Eggs were set vertically with broad end up in the setting trays according to their color groups. Incubation temperature was 37.5°C and relative humidity was 65% which kept all over the period of optimum hatchability. Eggs were turned automatically six times daily from second day of setting until the 14^{th} day of incubation with turning angle was ±45 degree from vertical position. Eggs were transferred to Hatcher at 14^{th} day of incubation were there was no turning occur. On hatching day the hatched chicks were removed to rearing house while non-hatched eggs were broken and examined for fertility, hatchability and mortality percentages.

Studied traits

Fertility percentage (No. of fertile eggs/Total number of eggs set)*100, scientific hatchability percentage (No. of hatched eggs/Total number of fertile eggs)*100, commercial hatchability percentage (No. of hatched eggs/Total number of eggs set)*100, embryonic mortalities (early embryonic mortality from zero to seven days of incubation, mid embryonic mortality from eight to 14^{th} days of incubation and late embryonic mortality from 15^{th} to 17^{th} days of incubation), embryonic malposition (head toward narrow end (HTNE), head over right wing (HORW), head over left wing (HOLW), head under left wing (HULW) and head between two shanks (HBTS)).

Egg quality traits

1 - External egg quality (egg weight in grams, length and width in centimeters, egg shape index calculated according to (Carter, 1968) equation as follows: I = [Breadth/Length] x 100, Egg volume according to Narushin (1997) depending on egg length (L) and maximum breadth (B) as follow: E vol Narushin = 0.496 x L x B^2, shell percentage, as well as shell thickness of egg in millimeters by using digital caliber.

2 - Internal egg quality (yolk index, yolk percentages, albumen percentages as well as haugh unit index). The haugh unit was calculated according to the following formula:

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$$HU = 100 * \log (H - 1.7W^{0.37} + 7.6)$$

Where,

HU = Haugh unit

H = observed height of the albumen in millimeters

W = weight of egg in grams

3 - Weight loss (in grams and as a percentage) during 12 days of storage at room temperature 18°C and 70% relative humidity divided into four periods 3 days each.

Statistical analysis

Least-square analysis for the obtained data was done by the aid of SAS software (2004) according to following model. $X_{ik} = \mu + G_i + e_{ik}$

Where: Xik = the Xth observation of the i th group

μ = overall mean

Gi = effect of the ith group of eggshell color (i = 1, 2, 3, 4 and 5)

eik = random error.

RESULTS AND DISCUSSION

Effect of shell color on fertility, scientific and commercial hatchability

Fertility, scientific hatchability and commercial hatchability percentages of different shell colors of Japanese quail eggs are presented in (Table, 1). Higher non-significant differences for fertility percentages were observed among colored verities of quail eggs, except for spotted shell of eggs, where blue stained eggs showed higher non-significant percentages for fertility (86.26%) followed by black stained eggs (85.02%) then brown and white eggs (83.99 and 83.30%). But spotted eggs expressed the lowest percentages ($P<0.05$) for fertility than other colors (67.50%). Hulet et al. (1985) found that fertility was not significantly affected by shell color. On the other hand Krystianiak et al. (2005) found that fertilization rate was lower in blue than in eggs of remaining colors. It was clear that scientific hatchability was significantly higher in blue, brown and black stained eggs (83.05, 81.47 and 80.13, respectively). While significantly lower scientific hatchability was recorded for spotted and white shelled quail eggs (55.77 and 55.33 %) comparable to the previous colors of shell. Hulet et al. (1985) reported that eggs with blue or tan colored shells tended to have a significantly lower hatchability in pheasant. In addition, (Anonymous, 1993) found an association between hatchability and shell color. Also, (Krystianiak et al., 2005) found that blue-shelled eggs were characterized by lower hatchability from fertilized eggs compared to the other egg color groups. Although there were non-significant differences for commercial hatchability among different egg shell colors of quail eggs but there were numerical increase in commercial hatchability percentages were recorded for blue, black and brown stained eggs (71.96, 68.39 and 63.35%, respectively) over spotted and white egg shell colors (53.05 and 48.30%). These results disagreed with those obtained by (Soliman et al., 2000) who found significant relationship between the percentages of commercial hatchability of four groups of quail eggshell colors.

Table 1 - Means ± standard errors (MSE) for fertility, scientific hatchability and commercial hatchability percentages of different shell colors of Japanese quail eggs

Color \ Parameter	Fertility	Scientific hatchability	Commercial hatchability
Black	85.02 ± 4.68^{ab}	80.13 ± 4.50^{a}	68.39 ± 5.02^{a}
Blue	86.26 ± 5.36^{a}	83.05 ± 3.37^{a}	71.96 ± 7.18^{a}
Brown	83.99 ± 1.44^{ab}	81.47 ± 2.79^{a}	68.35 ± 1.39^{a}
Spotted	67.50 ± 8.88^{b}	55.77 ± 10.66^{b}	53.05 ± 12.34^{a}
White	83.30 ± 2.53^{ab}	55.33 ± 2.95^{b}	48.30 ± 4.22^{a}

Means within the same column with different litters are significantly different at ($P<0.05$).

Effect of Shell color on embryonic mortality

Early, mid and late embryonic mortality percentages of different shell colors of Japanese quail eggs are presented in (Table, 2). White and spotted eggshell colors showed higher significant differences for early embryonic mortality percentages (57.32 and 55.00%) than blue, black and brown stained eggs (35.13, 34.27 and 32.18%; respectively). On the other hand non-significant differences were recorded for mid embryonic mortalities. on the contrary late embryonic mortality recorded higher significant percentages for black, brown and blue stained egg shell colors (52.34, 40.30 and 35.65%; respectively) than spotted and white shell eggs (27.22 and 27.28%).The same results were recorded by (Soliman et al., 2000) who reported that violet eggs had the highest early dead percentages, while the light brown eggs had the highest late dead percentages among all color groups. Also

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significant differences for embryonic mortalities among five color groups of quail eggs were recorded by (Darwish et al., 1997).

Table 2 - Means ± standard errors (MSE) for early embryonic mortality, mid embryonic mortality and late embryonic mortality percentages of different shell colors of Japanese quail eggs.

Parameter / Color	Early embryonic mortality	Mid embryonic mortality	Late embryonic mortality
Black	34.27±6.83[b]	13.39±4.10[a]	52.34±6.23[a]
Blue	35.13±0.92[b]	29.22±11.81[a]	35.65±10.94[ab]
Brown	32.18±5.80[b]	27.52±4.26[a]	40.30±2.08[ab]
Spotted	55.00±2.52[a]	17.78±1.11[a]	27.22±3.62[b]
White	57.32±3.36[a]	15.40±1.14[a]	27.28±3.56[b]

Means within the same column with different litters are significantly different at (P<0.05).

Effect of Shell color on embryonic malposition

Embryonic malposition of quail embryos of different egg shell colors (Table, 3) showed that brown eggs recorded higher and significant differences for HTNE than that black and white colors (9.00%), but not significant for blue and spotted shell colors, while black spotted eggs showed higher and significant differences for HORW (53.95%) compared to brown eggs, but not-significant for the other eggshell colors, on the other hand no differences were observed among different egg shell colors for HOLW, but spotted eggs recorded the highest significant differences for HULW (39.33%) compared to the other colors of shell, in addition higher non-significant differences were recorded for white and blue egg shell colors for HBTS (26.10 and 24.4%, respectively). But the lowest significant malposition of HBTS was recorded for spotted eggshell color (8.33%) compared to the other shell colors. Butcher et al. (2009) recorded that the most commonly reported malposition are head between thighs, head in the small end of egg, head under left wing, head not directed toward air cell, feet over head, beak above right wing.

Table 3 - Means ± standard errors (MSE) for embryonic malposition percentages of different shell colors of Japanese quail eggs.

Parameter / Color	HTNE	HORW	HOLW	HULW	HBTS
Black	1.67±1.67[b]	53.93±7.68[a]	11.17±1.97[a]	15.00±5.29[b]	19.9±2.58[ab]
Blue	3.33±3.33[ab]	45.77±7.76[ab]	14.73±2.64[a]	15.10±4.10[b]	24.40±5.20[a]
Brown	9.00±2.18[a]	31.34±2.86[b]	17.44±4.33[a]	24.43±3.49[b]	17.78±1.82[ab]
Spotted	3.33±1.67[ab]	40.00±2.89[ab]	9.00±2.08[a]	39.33±5.67[a]	8.33±3.33[b]
White	1.52±1.73[b]	48.33±6.01[ab]	14.73±2.15[a]	10.83±3.47[b]	26.10±4.61[a]

Means within the same column with different litters are significantly different at (P<0.05). HTNE=Head toward narrow end, HORW=Head over right wing, HOLW=Head over left wing, HULW=Head under left wing, HBTS=Head between two shanks.

Effect of shell color on egg quality traits

External and internal egg quality parameters of different shell colors of Japanese quail eggs are shown in (Table, 4). Difference in egg weight among different colors of quail eggs revealed higher significant differences for black, blue, brown stained and white egg shell over spotted quail egg shell (11.88, 11.61, 11.64 and 11.70 versus 11.02 g). Significant differences for egg weight among different egg shell colors were recorded by (Kirikci et al., 2005 And Krystianiak et al., 2005). But non-significant differences between different quail egg colors were recorded by (Soliman et al., 2000). Also disagreed with (Yang et al., 2009) found that no distinct correlations between shell.

The longest egg was brown stained eggs (3.24 cm) while the shortest one was spotted eggs (3.10 cm). The same pattern was recorded for egg width where brown stained eggs were wider than other color groups (2.62 cm) while the narrowest one also was spotted eggs. It was noticed that there were non-significant differences recorded for other three colors (black, blue stained and white egg shell) for length and width of the eggs. Although there were significant differences in egg length and width among colored verities of quail eggshell, egg shape index did not expressed any significant differences between different colors and ranged from (79.72 to 81.11) for blue and brown stained eggs. These results agreed with those obtained by (Choprakarn and Salangam, 1998) who found significant differences between egg sizes, length and width but not in egg shape index. Soliman et al. (2000) did not found any significant differences for egg shape between four eggshell colors of Japanese quails. But (Kirikci et al., 2005) found significant differences for egg shape index where white shell color eggs expressed lower significance shape index than blue, olive and brown egg shell colors. Significant differences among different egg shell colors for shape index also recorded by (Yang et al., 2009).

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Egg volume not well studied among different colored eggs so in our study we recorded that brown stained eggshell colors showed the highest significant egg volume (11.05) followed by black and blue stained eggs while the lowest egg volume recorded for spotted eggshell (9.48). Yolk index (Y.I) doesn't affected by eggshell color although there was numerical increases in brown eggshell color (0.75) while the lowest Y.I was recorded for blue eggshell color (0.46). The same results were recorded by (Kirikci et al., 2005) who found no significant variations for Y.I among white, blue, brown and olive egg shell colors of Pheasant. But disagreed with those obtained by (Soliman et al., 2000) who assessed Y.I for four color groups of quail eggs. Moreover, yolk percentage didn't varies among different eggshell color ranged from (31.75 to 33.86) for white and blue eggshell color; respectively. Yang et al., (2009) found that no distinct correlations between shell color and yolk weight in Yangzhou chicken. But disagreed with those obtained by (Soliman et al., 2000) who found significant differences for yolk percentage between four color groups of quail eggs.

White eggshell color recorded the highest significant values (0.95) for HU (measures of albumen quality) followed by brown eggshell color (0.92), while the same value was recorded for black, blue and spotted eggshell colors (0.91) the results disagreed with those obtained by (Yang et al., 2009) who found no distinct correlations between shell color and haugh unit in Yangzhou chicken. Also, (Kirikci et al., 2005) found no significant variations for HU among white, blue, brown and olive egg shell colors of Pheasant. On the other hand, Albumen percentage did not exhibit any significant differences among different egg shell colors of quail eggs and these results disagreed with those obtained by (Kirikci et al., 2005).

Non-significant values were recorded for eggshell weight and shell percentage between different eggshell colors. While, Kirikci et al. (2005) found significant differences among different eggshell colors for shell weight but no significance differences were recorded for shell percentage. On the other shell thickness varies significantly between different eggshell colors were black spotted and blue eggs shell showed the highest thickness (0.23 mm) over brown, white and spotted eggshell colors (0.19, 0.17 and 0.15 mm). These results disagreed with those obtained by (Joseph et al., 1999) who reported that the link between shell color and shell quality is still unclear, as no definitive conclusions have yet been reached concerning this relationship. While significant correlations between shell color and shell thickness were recorded by (Yang et al., 2009). In addition (Krystianiak et al., 2005) reported that shells of blue-shelled pheasant eggs were thinner. Our results indicated that shell thickness was positively correlated with higher egg quality and higher hatchability. The same results were recorded by (McDaniel et al., 1979) who reported that thinner eggshells are associated with lowering in hatchability percentage. Also (Roque and Soares, 1995) found that thick-shelled eggs showed an increased hatchability as a result of greater fertility and lower intermediate and late embryonic mortalities. On the other hand (Ingram et al., 2008) concluded that eggshell color was found to be lowly correlated to shell thickness.

Table 4 - Means ± standard errors (MSE) for egg weight in grams, external and internal egg quality parameters of different shell colors of Japanese quail eggs.

Color \ Parameter	Black	Blue	Brown	Spotted	White
Egg weight	11.88±0.11[a]	11.61±0.12[a]	11.64±0.10[a]	11.02±0.16[b]	11.70±0.12[a]
Length	3.21±0.03[ab]	3.21±0.04[ab]	3.24±0.04[a]	3.10±0.05[b]	3.17±0.02[ab]
Width	2.59±0.03[ab]	2.55±0.02[b]	2.62±0.02[a]	2.47±0.03[c]	2.54±0.02[b]
Egg shape index	80.84±0.67[a]	79.72±0.89[a]	81.11±1.03[a]	79.85±0.67[a]	80.11±0.65[a]
Egg volume	10.72±0.30[ab]	10.39±0.21[ab]	11.05± 0.25[a]	9.48±0.35[c]	10.17±0.21[bc]
YI	0.48±0.01[a]	0.46±0.01[a]	0.75±0.28[a]	0.49±0.01[a]	0.51±0.02[a]
Yolk %	32.82±0.86[a]	33.86±0.53[a]	32.88±0.67[a]	33.09±0.91[a]	31.75±0.59[a]
HU	0.91±0.01[b]	0.91±0.01[b]	0.92±0.01[ab]	0.91±0.01[b]	0.95±0.01[a]
Albumen %	52.92±0.75[a]	51.62±0.71[a]	53.38±0.77[a]	52.64±1.08[a]	55.29±2.12[a]
Shell weight (g)	1.67±0.08[a]	1.74±0.10[a]	1.67±0.11[a]	1.49±0.12[a]	1.57±0.05[a]
Shell %	14.26±0.74[a]	14.52±0.77[a]	13.74±0.89[a]	14.27±1.13[a]	13.72±0.43[a]
Shell thickness	0.23±0.02[a]	0.23±0.02[a]	0.19±0.01[ab]	0.15±0.01[c]	0.17±0.01[bc]

Means within the same row with different litters are significantly different at (P<0.05).

Effect of shell color on weight loss during storage

Egg weight loss due to water loss and evaporation from eggs depends upon shell quality, our study confirmed this statement. Table (5) showed that egg weight loss from different eggshell colors was recorded for four different period each was three days and the total weight loss from the first day up to the end of twelfth day of egg storage. It was observed that spotted eggs recorded the highest egg weight loss and percentage of weight loss during 0-3, 3-6, 6-9, 9-12 and 0-12 days of storage (0.25, 23, 25, 27 and 1.00 g) and (2.39, 2.26, 2.61, 2.85 and 9.71%); respectively followed by white eggshell color, on the other hand the lowest egg weight loss and percentage was recorded for blue stained egg shell color during 0-3, 3-6, 9-12 and 0-12 days (0.06, 0.11, 0.12 and 0.42 g) and (0.51, 1.00, 1.07 and 3.70%) but black spotted eggshell color recorded the lowest egg weight and percentage during 3-6 days (0.13 g and 1.18%; respectively) these results indicated that there were negative correlation

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between eggshell thickness and weight loss; thus by increasing shell thickness the weight loss decreased. AR et al., (1974) found that egg weight loss in Japanese quail eggs was 3.09 mg /day but (Romanoff and Romanoff 1949) describe the daily water loss of 10-100 g eggs under constant conditions (not specified) as a linear function of the initial egg weight.

Table 5 - Means ± standard errors (MSE) for weight loss in grams and percentage of weight loss of different shell colors of Japanese quail eggs.

Color \ Parameter		Black	Blue	Brown	Spotted	White
0-3 day	(g)	0.11±0.02[cb]	0.06 ±0.02[c]	0.13 ±0.02[b]	0.25 ±0.03[a]	0.17 ±0.01[b]
	(%)	0.92 ±0.17[cb]	0.51 ±0.19[c]	1.16 ±0.20[b]	2.39 ±0.27[a]	1.42 ±0.11[b]
3-6 day	(g)	0.15 ±0.02[b]	0.11 ±0.02[b]	0.15 ±0.03[b]	0.23 ±0.03[a]	0.17 ±0.03[ab]
	(%)	1.22 ±0.18[b]	1.00 ±0.15[b]	1.36 ±0.28[b]	2.26 ±0.26[a]	1.43 ±0.22[b]
6-9 day	(g)	0.11 ±0.02[b]	0.13 ±0.04[b]	0.15 ±0.04[b]	0.25 ±0.03[a]	0.16 ±0.02[b]
	(%)	0.95 ±0.16[b]	1.18 ±0.33[b]	1.37 ±0. 38[b]	2.61 ±0.31[a]	1.39 ±0.20[b]
9-12 day	(g)	0.19 ±0.05[ab]	0.12 ±0.01[b]	0.16 ±0.03[b]	0.27 ±0.02[a]	0.20 ±0.03[ab]
	(%)	1.63 ±0.44[b]	1.07 ±0.14[b]	1.53 ±0.33[b]	2.85 ±0.28[a]	1.72 ±0.25[b]
Overall	(g)	0.56 ±0.09[cb]	0.42 ±0.05[c]	0.60 ±0.11[cb]	1.00 ±0.07[a]	0.70 ±0.07[b]
	(%)	4.61 ±0.74[b]	3.70 ±0.48[b]	5.27 ±1.03[b]	9.71 ±0.72[a]	5.82 ±0.56[b]

Means within the same row with different litters are significantly different at (P<0.05).

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