IMPACT OF EGG SHELL AND SPOTS COLOUR ON THE QUALITY OF HATCHING EGGS DERIVED FROM THREE LINES OF LOCAL QUAIL

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ABSTRACT

This study was carried out to analyze the impact of lines, egg shell colour and intraction between (Line eggshell colours) on egg quality characteristics and hatching parameters assess the correlation between these traits in three local quail eggs (desert, brown and white). A total of 409 eggs were collected from female quails during 16 weeks divided into five groups on the basis of eggshell colour and spot colour for each line. The results revealed that there were significant (P≤0.05) variances among lines for quality characteristics of the whole egg (weight, length, width, Egg volume, Haugh unit), albumen (weight, height, diameter), yolk (weight, height, index, Yolk/albumen) and shell (weight, thickness, egg surface area, unit surface). The desert line resulted in the best quality. The results demonstrated that internal and external egg quality characters were differed significantly among egg shell colour. Whereas, yolk parameters such as: yolk weight, yolk height, Yolk diameter and Yolk percentage revealed no significance differences among these groups. Phenotypic correlation appeared that there were significant correlation coefficients among the internal and external egg quality traits. The incubation characteristics, fertility, hatchability of fertile eggs, hatchability of set eggs and Chick hatching weight were significantly differences among eggshell colour groups within lines.

Key words: correlation; egg quality; hatchability; spotted shell; local quail

تأثير قشر البيض ولون البقع على جودة البيض تفقيس من ثلاثة خطوط من السمان المحلي

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المستخلص

أجريت هذه الدراسة لتحليل تأثير الخطوط ولون قشرة البيض والتداخل بين (الخط ألوان قشر البيض) على خصائص جودة البيض ومعايير التفقيس لتقدير الارتباط بين هذه الصفات في ثلاث الخطوط السمان المحلية (صحراوي، بني، أبيض). تم جمع 409 بيضات من إناث السمان عند عمر 16اسبوع ومقسمة إلى خمس مجموعات على أساس لون قشر البيض ولون البقعة لكل خط. أظهرت النتائج بان وجود تباين معنوي (P≤0.05) بين الخطوط في الصفات جودة البيضة الكاملة (الوزن، الطول، العرض، حجم البيض، وحدة هاو)، بياض البيض (الوزن، الطول، القطر)، صفار البيض (الوزن، الارتفاع، دليل الصفار، الصفار/ بياض) والقشرة (الوزن، السمك، مساحة سطح البيض، الوحدة سطح). ونتج عن خط الصحراء أفضل جودة. كما وجد بأن الصفات جودة البيض الداخلية والخارجية تختلف اختلافًا كبيرًا بين االوان قشرة البيضة.. أظهر ارتباط مظهري بوجود معاملات ارتباط معنوية بين صفات جودة البيض الداخلية والخارجية. وكذلك بالنسبة للخصائص الحضانة: الخصوبة والفقس للبيض المخصب والفقس لبيض الكلي ووزن الافراخ مفقسة كانت فرقًا معنويًا بين مجموعات الوان قشر البيض ضمن الخطوط. من ناحية أخرى.

الكلمات المفتاحية: ارتباط، جودة البيضة، الفقس، لون بقعة، سمان المحلي.

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INTRODUCTION

Quails are highly prolific with shorter generation interval, less space require, feed and capital to begin with, have greater resistance to diseases and that they are often reared under wide selection of climate and farm conditions compared to other species of poultry, quails are worldly accepted because of the medicinal value of their meat and eggs, (10). Quail eggs vary from the eggs of different avian species in terms of their smaller volume, eggshell colour, spot size, spot colour, and a few internal and external quality traits. Quail eggs are spherical and have variance eggshell coloration from white to blue or green, on which spots of various size and colour are determined (5). whereas Taha, (42) assortment quail eggs as black-spotted eggs with different sizes on brown- or gray-colored eggshell, spotless white eggs, and eggs with small black or blue spots on gray-brown-colored eggshell. On the contrary, Hassan et al., (16) classified quail eggs as bright eggs (without spots or very small), dotted eggs (with small spots), spotted eggs (with large spots), and dark eggs (with some very large spots), as suggested by this researcher, the intensity of spottiness as properly as size and colour of the spots are often used as a tool to determines individual female animals. It had been confirmed that the eggshell colour may affect both the standard of eggs and their biological value. In blue-shelled eggs acquired from pheasants, higher activity of lysozyme was found, in relation to eggs with different shades of shell (29). Other researchers (11) also confirmed the connection between shell colour and albumen quality. Egg quality could be a common term referring to a number of standards which define each internal and external quality, external egg quality is targeted on eggshell cleanliness, texture, and shape, where as internal quality refers to egg white (albumen) clarity and viscosity, air cell size, yolk shape, and yolk membrane strength (10). A research conducted by others (26) uncovered that the egg quality characteristics of an egg is highly affected by the genotype of the birds, breeding systems, management, nutrition and egg weight. Furthermore of their utilitarian significance, these parameters are typically used to determine egg quality from several factors of view, including egg nutritional content, egg integrity for commercialization, storage and incubation, as well as preservation during storage (43). The egg shell is of particular importance for both protection of egg contents from mechanical influences and microbial invasion, whilst the egg shell also regulates the water and gas exchange through pores during the extra-uterine development of the chick embryo. Consequently egg shell integrity is not only an economic issue but also a matter of human health safety. Furthermore, egg shell quality influences the incubation weight loss of the egg, embryonic mortality, hatchability and early chick growth rates (36). Another necessary factor of the egg shell is that it acts as a packaging material and its quality influences the consumers' decision (37). Shell traits may also also affect hatchability and embryo development in domestic birds. Due to the actuality that the egg is a closed system in terms of the mineral presence, the shell constitutes

a source of establishment essential fora proper embryo improvement (31). The relationship has been exhibit between the intensity of shell pigmentation, its thickness and the chicken's hatchability, indicates an achievable positive correlation between shell pigmentation processes and its calcification (19). This can also be conducive to better hatchability, as it has been shown that hatching results from eggs with a thicker shell can be up to 9% higher than from eggs with a thinner one (12). A characteristic trait of Japanese quail eggs is the spotted pattern on the shell. Interestingly, the association of these spots is an individual feature for each female, enabling the identification of unique birds (40). Among the standard colored eggs, the eggs with a uniform shell can be found, in white to celadon colour, besides spots (20). Generally, consumers have no preferences in this regard. They are fully satisfied with the small size and taste of the egg (33). Although, breeders suppose that eggs may also be worse in terms of the internal quality, each as regards consumption and hatching (14). The aim of the study was to evaluate hatching eggs of Japanese quails (Coturnix coturnix japonica) depending on the lines, eggshell colour and interaction (Line □ eggshell colours).

MATERIALS AND METHODS

2.1Location of the study

The experiment was carried out at the Grdarasha Research Centre, Animal Resources department, College of Agriculture Engineering Science, Salahaddin University-Erbil, Iraq.

2.2Data collection

A total of 409 freshly eggs laid by 16 week-old of age, which were obtained daily and numbered individually from local quails, constituted the material of the study. Each birds belong to three morphologically different lines, in terms of plumage color, namely desert (n=48), brown (n=48), and white, (n=48) lines, While the eggs were divided into five equal groups on the basis of eggshell colour from each line. As a result of the individual examination of all of the quail eggs, five groups were established according to the eggshell colour, spot colour, and some external, internal egg quality and hatching parameters were investigated in these groups. The names of the study groups are presented in (Table 1). The quails were housed in battery cages system according to lines with sex ratio (1:3). They were fed with a diet containing 2900 kcal of metabolizable energy/kg and 20% of crude protein with free access to feed and water throughout the experimental period.

Table 1. Egg distribution according to spots and shell colures in three lines of local quails

N. of groups	Images of egg	Egg groups
(I)		black spots on white coloured eggshell
(II)		Pin dotted on greyish brown coloured eggshell
(III)		black spots of varing size on white coloured eggshell
(IV)		Very large brown spots on brown coloured eggshell
(V)		Widely distributed Blue spots on greyish brown coloured eggshell

2.3 Determination of external egg quality characteristics: During the study, digital display scale was used for measuring the eggs weight with 0.001g to 1000g sensitivity; a digital Vernier caliper (mm) was used for measuring the width, length, and a micrometer was used for measuring the shell thickness. Air-dried the shells were weighted together with the shell membrane. Shell thickness was measured at the sharp, blunt and equatorial parts, and the average shell thickness was obtained from the average values of these three parts. The external egg quality trait values listed below were calculated (35).

Shape index (%) = (Egg Width (mm)/ Egg Length (mm)) × 100

Shell ratio (%) = (Shell weight (g)/Egg weight (g)) × 100

Elongation = (Egg Length / Egg Width)

Eggshell Index (g/100 cm2) = [Eggshell Weight (g) / Eggshell Surface Area (cm2)] x 100

Eggshell Surface Area (cm2) = 3.9782 x (Egg Weight (g)).7056 =Eggshell Percentage (%) = [Eggshell Weight / Egg Weight] x 100

2.4 Determination of internal egg quality traits : Data measured on external egg quality traits included yolk diameter, albumen length and width of the eggs, each egg was broken out onto a flat glass cover. The diameter and height of the egg yolk and albumen were measured using a digital calliper and an electronic balance (0.01-g accuracy). Without damaging the egg yolk, the yolk and albumen were separated, and the weight of the egg yolk was measured. By using the albumen and egg yolk values obtained from these measurements, the internal egg quality values listed below were calculated (15, 27).

Albumen weight (g) = Egg weight – (Shell weight + Yolk weight)

Yolk ratio (%) = (Yolk weight (g)/Egg weight (g)) × 100

Albumen ratio (%) = (Albumen weight (g)/Egg weight (g)) × 100

Yolk index (%) = (Yolk height (mm)/Yolk diameter (mm)) × 100

Albumen index (%) = (Albumen height (mm)/ {(Albumen length (mm) + Albumen width (mm))/2}) × 100

Haugh unit = 100 log (Albumen height (mm) + 7.57 – 1.7× Egg weight (g) 0.37)

2.5 Determination of hatchability

A total of 409 eggs selected from eggs produced in 5 consecutive days by each line were used to assess fertility and hatchability in each line. They were placed on 15 separate hatching trays (135, 117 and 157) eggs for desert, brown and white lines, respectively. Eggs were candled on 14th days of incubation to determine the number of infertile eggs and or dead embryos were determined, as well as eggs being transferred to hatching nets and placed in the hatching compartment for 18 d. After that unhatched eggs were broken to confirm the number of fertile eggs, embryos that died in the early incubation phase, died embryos in the second incubation phase, and the numbers of healthy, crippled or weak chicks. This allowed the estimation of the following indicators: fertility, hatchability from fertile and from set eggs. These data were used for the calculation of the hatching results given below:

Fertility (%) = (Number of fertilized eggs/Number of eggs placed in the setter) × 100

Hatchability of fertile eggs (%) = (Number of hatched chicks/Number of fertilized eggs) × 100

Hatchability (%) = (Number of hatched chicks/Number of eggs placed in the setter) × 100 (21).

2.6 Statistical analysis

All data were analyzed with the SAS statistical package (38). General linear model procedure was used including effects of lines and eggshell colours and their interaction. The significant means were compared by Duncan's test.

$$Y_{ijkl} = \mu + L_i + S_j + LS_{ij} + \varepsilon_{ijkl}$$

Where

Yijk is the observation of measurement (egg weight, shape index, shell weight, shell ratio, shell thickness, yolk weight, albumen weight, yolk ratio, albumen ratio, yolk/albumen ratio, yolk index, albumen index and haugh unit).

μ = is the overall mean

Li= is the effect of line (desert, brown, and white),

Sj= is the effect of eggshell colours (I, II, III, IV, and V)

LSij = is the interaction of line with eggshell colours

Eijkl= is the random error

RESULTS AND DISCUSSION

In the present study, it was determined that in quail eggs, eggshell colour, lines and interaction between (Line eggshell colours) had significant impact on some external and internal quality traits. The results obtained from Table 2 indicate that the differences among variance studied lines and eggshell colour were significant (p≤ 0.05) influenced external egg traits (egg weight, egg width, egg volume) exception of shape index and egg length did not differ significantly between groups of eggs depending on their shell colour and lines respectively, while desert birds are lighter than brown and white, in quite agreement with this finding (39). However, Ahmed & AL-Barzinji, (2) found significant differences among variance lines for egg weight of the quails. On the other hand, the statistical analysis for those traits revealed that the effect of interaction (Line eggshell colours) was significant and recorded higher interaction in white IV Group, on egg weight, Egg length and egg volume was (14.63±0.03, 34.68±0.34and 13.17±0.27) respectively. The egg width (27.44±0.37) and Shape index (80.54±0.90) trait was higher in in white V Group. These results were in agreement with those observed by others (1 , 4, 5) it was ascertained that the impact of eggshell colour and spot colours on egg weight and egg width were statistically significant difeferences (p≤0.05). The results obtained in the present study differed from those reported in previous researches, which suggest eggshell colour to had a statistically significant impact on egg weight and eggshell weight in pheasant eggs. Others (14, 17) reported that, in pheasant eggs with an eggshell colour did not significantly impact on egg weight and volume.

Table 2. Means ± S. E. Effect of line, eggshell colour and interaction on some external egg quality characteristics in local quails

Traits		N.	Egg weight (g)	Egg length (mm)	Egg width (mm)	Shape index	Egg volume (cm3)
Overall mean		**409**	**13.26±0.17**	**33.85±0.17**	**26.52±0.14**	**78.37±0.28**	**12.18±0.16**
Local lines							
Desert		**135**	**13.75±0.21**^{a}	**34.23±0.17**^{a}	**26.94±0.14**^{a}	**78.70±0.48**^{a}	**12.65±0.19**^{a}
Brown		**117**	**12.55±0.24**^{b}	**33.31±0.28**^{b}	**26.01±0.27**^{b}	**78.06±0.45**^{a}	**11.55±0.23**^{b}
White		**157**	**13.47±0.34**^{a}	**34.02±0.25**^{a}	**26.63±0.23**^{a}	**78.34±0.54**^{a}	**12.34±0.31**^{a}
eggshell colours							
I		**76**	**12.82±0.53**^{bc}	**33.44±0.42**^{a}	**26.49±0.41**^{bc}	**79.23±0.52**^{b}	**11.80±0.49**^{ab}
II		**74**	**13.44±0.24**^{ab}	**34.32±0.18**^{a}	**26.45±0.28**^{bc}	**77.06±0.69**^{d}	**12.37±0.22**^{a}
III		**80**	**12.49±0.37**^{c}	**33.60±0.37**^{a}	**25.89±0.29**^{c}	**77.05±0.25**^{d}	**11.49±0.34**^{b}
IV		**86**	**13.78±0.28**^{a}	**34.01±0.35**^{a}	**26.57±0.19**^{b}	**78.16±0.54**^{c}	**12.58±0.24**^{a}
V		**93**	**13.74±0.29**^{a}	**33.90±0.32**^{a}	**27.22±0.18**^{a}	**80.33±0.30**^{a}	**12.66±0.27**^{a}
Line □ eggshell colours							
Desert	**I**	**19**	**13.77±0.98**^{ab}	**34.20±0.55**^{ab}	**27.46±0.33**^{a}	**80.28±0.33**^{ab}	**12.66±0.91**^{ab}
Desert	**II**	**23**	**14.23±0.33**^{ab}	**34.40±0.24**^{a}	**27.37±0.26**^{a}	**79.57±0.20**^{ab}	**13.09±0.30**^{ab}
Desert	**III**	**30**	**13.53±0.03**^{ab}	**34.62±0.04**^{a}	**26.62±0.14**^{abc}	**76.87±0.46**^{cd}	**12.45±0.03**^{ab}
Desert	**IV**	**32**	**13.87±0.15**^{ab}	**34.60±0.06**^{a}	**26.45±0.14**^{abcd}	**76.45±0.53**^{d}	**12.76±0.13**^{ab}
Desert	**V**	**31**	**13.33±0.38**^{abc}	**33.35±0.29**^{abc}	**26.79±0.18**^{abc}	**80.35±0.47**^{a}	**12.28±0.35**^{abc}
Brown	**I**	**16**	**11.77±0.19**^{cd}	**32.65±0.36**^{bc}	**25.40±0.52**^{de}	**77.72±0.90**^{cd}	**10.83±0.18**^{cd}
Brown	**II**	**26**	**12.87±0.26**^{abcd}	**34.47±0.38**^{a}	**26.14±0.42**^{bcde}	**75.83±0.40**^{d}	**11.84±0.25**^{abcd}
Brown	**III**	**26**	**11.47±0.09**^{d}	**32.42±0.33**^{c}	**24.97±0.35**^{e}	**77.01±0.54**^{cd}	**10.55±0.09**^{d}
Brown	**IV**	**25**	**12.83±0.35**^{bcd}	**32.75±0.41**^{bc}	**26.09±0.32**^{abcd}	**79.65±0.43**^{ab}	**11.81±0.32**^{abcd}
Brown	**V**	**24**	**13.83±0.20**^{ab}	**34.24±0.20**^{ab}	**27.42±0.32**^{a}	**80.09±0.18**^{ab}	**12.74±0.19**^{ab}
White	**I**	**41**	**12.93±1.17**^{abcd}	**33.47±1.02**^{abc}	**26.61±0.74**^{abc}	**79.70±0.71**^{ab}	**11.90±1.07**^{abcd}
White	**II**	**25**	**13.23±0.12**^{abc}	**34.10±0.37**^{ab}	**25.84±0.20**^{cde}	**75.79±0.93**^{d}	**12.18±0.12**^{abc}
White	**III**	**24**	**12.47±0.74**^{bcd}	**33.76±0.56**^{abc}	**26.08±0.44**^{bcde}	**77.27±0.45**^{cd}	**11.47±0.68**^{bcd}
White	**IV**	**29**	**14.63±0.03**^{a}	**34.68±0.34**^{a}	**27.18±0.14**^{ab}	**78.39±0.71**^{bc}	**13.17±0.27**^{a}
White	**V**	**38**	**14.07±0.84**^{ab}	**34.10±0.83**^{ab}	**27.44±0.37**^{a}	**80.54±0.90**^{a}	**12.97±0.76**^{ab}

$^{a-d}$: Differences between mean values with different superscripts in the same column are statistically significant (P<0.05)

The results in Table 3 indicate that lines significantly (p ≤ 0.05) influenced albumen parameters a like (albumen weight, albumen height, albumen diameter and albumen index) exception of albumen percentage, the desert lines was higher than others lines in those traits. These results are in agreement with our results, several reports were suggestive that albumen diameter and albumen index were appeared to be statistically significant (P≤ 0.05) between different lines of quails (17, 13, 7, 44). Values pertaining to some internal quality traits of eggs belonging to groups with different eggshell colours are presented in (Table 3). The impact of eggshell colour on the internal quality traits given in these tables, excluding albumen weight, albumen height, albumen percentage and albumen index was found to be statistically significant (P≤ 0.05), as reported by (5) the eggshell colour had effect on the albumen height and albumen index values. Drabik *et al.,* (14) showed the variance in egg quality depending on the eggshell colour of quails. The data from the effect of interaction (Line □ eggshell colours) on internal egg quality characteristics of quail significant differences noticed in all studied characteristics are shown in (Table 3). The albumen index (12.10±0.37) and albumen height5.19±0.30 values were the highest in white Group V, whilst the Albumen weight (8.20±0.15), Albumen diameter (43.51±1.65) and Albumen percentage (58.04±0.51) were the highest in white IV, desert II and brown II groups respectively.

Table 3. Means ± S. E. Effect of line, eggshell colour and interaction on albumen parameters in local quails

Traits		Albumen weight (g)	Albumen height (mm)	Albumen diameter (mm)	Albumen percentage (%)	Albumen index
Overall mean		**7.44±0.09**	**4.40±0.09**	**40.70±0.45**	**56.21±0.26**	**10.79±0.13**
Local lines						
Desert		**7.75±0.09^{a}**	**4.67±0.10^{a}**	**42.52±0.48^{a}**	**56.31±0.42^{a}**	**10.99±0.19^{a}**
Brown		**6.99±0.16^{b}**	**4.24±0.11^{b}**	**40.40±0.46^{b}**	**55.75±0.44^{a}**	**10.50±0.23^{b}**
White		**7.57±0.16^{a}**	**4.30±0.20^{b}**	**39.17±1.06^{b}**	**56.55±0.47^{a}**	**10.90±0.24^{ab}**
eggshell colours						
I		**7.13±0.28^{b}**	**4.25±0.23^{bc}**	**39.78±1.41^{a}**	**55.89±0.60^{ab}**	**10.63±0.23^{b}**
II		**7.67±0.08^{a}**	**3.96±0.13^{c}**	**40.09±1.31^{a}**	**57.10±0.64^{a}**	**9.91±0.18^{c}**
III		**7.07±0.24^{b}**	**4.35±0.18^{bc}**	**40.35±0.96^{a}**	**56.44±0.51^{ab}**	**10.75±0.26^{b}**
IV		**7.69±0.19^{a}**	**4.51±0.14^{b}**	**41.00±0.47^{a}**	**56.07±0.52^{ab}**	**10.99±0.26^{b}**
V		**7.62±0.12^{a}**	**4.95±0.11^{a}**	**42.27±0.60^{a}**	**55.53±0.56^{b}**	**11.70±0.16^{a}**
Line □ eggshell colours						
Desert	**I**	**7.80±0.45^{ab}**	**4.72±0.29^{abcd}**	**42.83±0.91^{a}**	**56.78±0.85^{abc}**	**10.99±0.44^{abcd}**
Desert	**II**	**7.80±0.10^{ab}**	**4.32±0.31^{bcde}**	**43.51±1.65^{a}**	**54.83±0.62^{c}**	**9.93±0.36^{de}**
Desert	**III**	**7.83±0.03^{ab}**	**4.86±0.06^{abc}**	**42.97±0.50^{a}**	**57.88±0.34^{ab}**	**11.3±0.02^{abc}**
Desert	**IV**	**7.83±0.09^{ab}**	**4.68±0.24^{abcd}**	**42.20±0.68^{ab}**	**55.79±1.33^{abc}**	**11.09±0.41^{abcd}**
Desert	**V**	**7.50±0.12^{ab}**	**4.77±0.11^{abcd}**	**41.10±1.25^{ab}**	**56.28±0.83^{abc}**	**11.61±0.10^{ab}**
Brown	**I**	**6.40±0.06^{c}**	**4.00±0.07^{cdef}**	**39.03±0.87^{abc}**	**54.99±1.02^{c}**	**10.26±0.19^{cde}**
Brown	**II**	**7.47±0.13^{ab}**	**3.89±0.06^{ef}**	**41.28±0.66^{ab}**	**58.04±0.51^{a}**	**9.43±0.15^{e}**
Brown	**III**	**6.33±0.07^{c}**	**4.27±0.20^{bcde}**	**39.19±0.26^{abc}**	**54.95±0.75^{c}**	**10.89±0.44^{bcd}**
Brown	**IV**	**7.03±0.22^{bc}**	**4.17±0.30^{bcde}**	**39.61±0.51^{abc}**	**55.09±0.39^{bc}**	**10.52±0.67^{bcde}**
Brown	**V**	**7.70±0.15^{ab}**	**4.88±0.03^{ab}**	**42.88±0.59^{a}**	**55.69±1.10^{abc}**	**11.38±0.14^{abc}**
White	**I**	**7.20±0.47^{b}**	**4.02±0.61^{bcde}**	**37.50±0.84^{cb}**	**55.91±1.32^{abc}**	**10.62±0.44^{bcd}**
White	**II**	**7.73±0.15^{ab}**	**3.68±0.07^{f}**	**35.47±0.23^{c}**	**58.43±0.64^{a}**	**10.37±0.15^{cde}**
White	**III**	**7.03±0.35^{bc}**	**3.92±0.35^{def}**	**38.89±2.34^{abc}**	**56.48±0.54^{abc}**	**10.04±0.43^{de}**
White	**IV**	**8.20±0.15^{a}**	**4.68±0.04^{abcd}**	**41.18±0.48^{ab}**	**57.35±0.25^{abc}**	**11.36±0.05^{abc}**
White	**V**	**7.67±0.35^{ab}**	**5.19±0.30^{a}**	**42.82±1.20^{a}**	**54.61±1.08^{c}**	**12.10±0.37^{a}**

$^{a-f}$: Differences between mean values with different superscripts in the same column are statistically significant (P<0.05)

The result of analyzing the yolk parameters of three quail lines with different plumage colors are shows n Table 4. The data from yolk weight, yolk height, Yolk diameter, yolk percentage and yolk index, were significantly higher in desert lines than other studied quail lines. These results are similar to those reported in a previous finding of the study by sari et al., (39) and Al-Kafajy *et al.,* (7) they found that the yolk weights and yolk index values significantly affected by variance types of color mutants or varieties of quails. In line with this finding, Hassan *et al.,* (17) showed significant (P≤0.05) variance among three lines of quail for yolk height, yolk index. This results in agreement with the results of Udoh *et al.,* (44) they found that there were no significant differences between two quail lines with regard to yolk Height and yolk Weight. Differences between eggshell colour and spot colour for yolk parameters were insignificant (P>0.05), exception of yolk index show the significant differences (P≤0.05) between groups of eggs depending on their shell colour. As reported by Drabik *et al.,* (14) indicated that the eggshell colour to have a significant impact on yolks weight and yolk index in quails, it was found that the spotted eggs had smaller yolks and considerably lower its index, which means that they were less spherical than in blue-shelled eggs. The results obtained in the present study variance from those observed in previous researches, which detected that the eggshell colour was not statistically significant impact on yolk index and yolk weigh in quails (6, 24). Furthermore, the impact of interaction (Line □ eggshell colours) was also found to be statistically significant (P≤0.05). While the yolk weight4.93±0.18 and percentage 34.64±0.45 values were ascertained to be the highest in desert II Group, the yolk height 11.85±0.02was the highest in desert I Group, the yolk index 45.83±0.55was the highest in desert III Group, and Yolk diameter 26.96±1.18were the highest in Group V.

Table 4. Means ± S. E. Effect of line, eggshell colour and interaction on yolk parameters in local quails

Traits	Yolk weight (g)	Yolk height (mm)	Yolk diameter (mm)	Yolk percentage (%)	Yolk index
Overall mean	**4.27±0.07**	**11.01±0.09**	**25.62±0.16**	**32.46±0.25**	**43.24±0.32**
Local lines					
Desert	**4.47±0.11^{a}**	**11.29±0.15^{a}**	**25.84±0.30^{a}**	**33.03±0.45^{a}**	**43.74±0.66^{a}**
Brown	**4.12±0.09^{b}**	**10.74±0.11^{b}**	**25.18±0.20^{a}**	**32.83±0.39^{a}**	**43.17±0.47^{ab}**
White	**4.23±0.13^{ab}**	**11.01±0.19^{ab}**	**25.85±0.30^{a}**	**31.52±0.38^{b}**	**42.81±0.54^{b}**
eggshell colours					
I	**4.14±0.20^{a}**	**11.01±0.25^{a}**	**25.15±0.54^{a}**	**32.10±0.49^{a}**	**43.79±0.78^{a}**
II	**4.32±0.17^{a}**	**11.16±0.17^{a}**	**25.93±0.18^{a}**	**32.07±0.71^{a}**	**43.19±0.65^{a}**
III	**4.06±0.11^{a}**	**10.91±0.21^{a}**	**25.36±0.13^{a}**	**32.69±0.30^{a}**	**43.70±0.88^{a}**
IV	**4.43±0.06^{a}**	**11.09±0.20^{a}**	**25.68±0.34^{a}**	**32.73±0.62^{a}**	**43.60±0.78^{a}**
V	**4.41±0.14^{a}**	**10.91±0.24^{a}**	**25.99±0.44^{a}**	**32.70±0.68^{a}**	**41.92±0.33^{b}**
Line □ eggshell colours					
Desert I	**4.37±0.38^{abc}**	**11.85±0.02^{a}**	**26.56±1.22^{ab}**	**31.63±0.58^{bcd}**	**44.81±2.23^{ab}**
Desert II	**4.93±0.18^{a}**	**11.07±0.30^{abc}**	**26.31±0.20^{ab}**	**34.64±0.45^{a}**	**42.05±0.92^{ab}**
Desert III	**4.37±0.07^{abc}**	**11.70±0.12^{ab}**	**25.53±0.18^{abc}**	**32.26±0.41^{abcd}**	**45.83±0.55^{a}**
Desert IV	**4.57±0.09^{ab}**	**11.3±0.19^{abc}**	**25.61±0.95^{abc}**	**33.64±1.10^{abc}**	**44.48±1.41^{ab}**
Desert V	**4.13±0.18^{bc}**	**10.47±0.09^{c}**	**25.20±0.15^{abc}**	**32.97±1.60^{abc}**	**41.53±0.19^{b}**
Brown I	**3.93±0.07^{bc}**	**10.50±0.15^{c}**	**24.01±0.44^{c}**	**32.91±0.66^{abc}**	**43.73±0.24^{ab}**
Brown II	**4.07±0.12^{bc}**	**11.23±0.18^{abc}**	**25.7±0.35^{abc}**	**31.60±0.39^{bcd}**	**44.23±0.79^{ab}**
Brown III	**3.73±0.03^{c}**	**10.57±0.22^{c}**	**25.09±0.11^{abc}**	**33.13±0.69^{abc}**	**44.12±1.66^{ab}**
Brown IV	**4.33±0.1^{3abc}**	**10.60±0.23^{c}**	**25.28±0.12^{abc}**	**33.77±0.61^{ab}**	**41.92±0.74^{ab}**
Brown V	**4.53±0.15^{ab}**	**10.80±0.36b^{c}**	**25.80±0.31^{abc}**	**32.73±1.60^{abcd}**	**41.85±0.92^{b}**
White I	**4.13±0.54^{bc}**	**10.67±0.44^{c}**	**24.89±0.39^{bc}**	**31.75±1.25^{abcd}**	**42.83±1.13^{ab}**
White II	**3.97±0.09^{bc}**	**11.17±0.49^{abc}**	**25.77±0.32^{abc}**	**29.97±0.40^{d}**	**43.30±1.56^{ab}**
White III	**4.07±0.18^{bc}**	**10.47±0.09^{c}**	**25.45±0.31^{abc}**	**32.68±0.52^{abcd}**	**41.15±0.83^{b}**
White IV	**4.40±0.06^{abc}**	**11.30±0.45^{abc}**	**26.16±0.53^{ab}**	**30.78±0.36^{abcd}**	**44.40±1.65^{ab}**
White V	**4.57±0.34^{ab}**	**11.45±0.56^{abc}**	**26.96±1.18^{a}**	**32.40±0.54^{abcd}**	**42.37±0.50^{ab}**

$^{a-d}$: Differences between mean values with different superscripts in the same column are statistically significant (P<0.05).

The result presented in Table 5, shows lines had a significant effect on Yolk/albumen ratio, Haugh unit, Shell thickness and egg surface area. Nonetheless, no significant differences were observed in Shell weight Percentage value and unit surface. This finding was in compliance with the report of (17). Al-Kafajy *et al.,* (7) detected that the shell thickness and shell weight significantly higher values were exerted in the desert and white lines respectively. This observation was disagrees with the reports of Inci *et al.,* (18) and Chimezie *et al.,* (13) suggesting egg shell thickness were not to differences among quail lines. On the other hand, the statistical analysis for this trait revealed that the differences between groups of eggs depending on their shell colour were significantly differ (p≤0.05) on Haugh unit, Shell weight, Shell percentage, Shell thickness, egg surface area and unit surface. In agreement with Drabik *et al.,* (14) it was ascertained that the eggshell colour and spot colour had a significant (P≤0.05) impact on Haugh unit and Surface area. The results of egg surface area and unit surface and Haugh unit means were compatible to those reported by Abdelfatah *et al.,* (1) and higher than that the reported values of egg surface area by (41). while regarding the significant (p≤0.05) effect of interaction Line □ eggshell colours the findings in Tables 4, showed the haugh unit, shell characters and unit surface values were the highest in white Group V, whilst the egg surface area 29.81±0.05 and yolk/albumen ratio 63.22±1.54, values were the highest in white Group IV and desert Group II respectively. Table 6, reveal correlation coefficients between measurable features of internal and external egg quality traits of quail eggs subjected to this study. The egg length and width values in this research were highly significant and positive correlations with egg weight and width, and the values of correlation found were 0.832and 0.845 for egg length and width, respectively. The significant and positive correlations indicated that the longer egg length had a positive effect on egg weight. Monira *et al.*, (25) they reported that the egg length significantly affect on egg weight. There was found a positive and significant correlation between shape index and egg width (0.525), while egg volume had a significant and correlation with each egg weight, egg length and egg width. This research found a positive relationship between albumen index with albumen height (0.866), albumen weight (0.494) and albumen diameter (0.437). According to Ozcelik, (34) albumen index, albumen height, albumen weight and albumen ratio give an indication of the density of albumen quality and are used in the estimation of Haugh unit, which is an important factor in the internal quality of the egg. Yolk and albumen weights were affected by egg weight groups, and yolk and albumen weight values increased depending on the increase of the egg weight. This research found a high phenotypic correlation between egg weight and albumen weight (0.494), and also a highly significant correlation between egg weight and yolk weight (0.884). The findings determined in this research are in agreement with the shows of (9, 22). They found highly significant correlations between the egg weight with yolk weight and albumen weight. The yolk width possibly constitutes the yolk portion which may have influenced the yolk weight positively. There was also found a negative significant correlation (0.511) between yolk width and yolk index. This result is similar to that reported by (32). The egg weight has an indirect relation with the shell quality of the egg. It has been reported by most researchers that the eggshell thickness and weight of shell has direct relation with the egg weight (8). Some researchers have mentioned positive correlations between the egg weight and eggshell thickness (23, 28). Also, Drabik *et al.*, (14) reported that egg weight increased significantly while shell thickness decreased. Interestingly, both the egg surface area and unit surface were had a higher positive correlation with egg weight (0.986 and 0.312), respectively as well as the yolk weight and albumen weight. Suggest that increasing egg weight will lead to increasing egg surface area and unit surface values in this study.

Table 5. Means ± S. E. Effect of line, eggshell colour and interaction on some internal egg quality characteristics in local quails

Traits		Yolk/albumen ratio	Haugh unit	Shell weight (g)	Shell percentage	Shell thickness (mm)	egg surface area	unit surface
Overall mean		57.46±0.57	87.70±0.45	1.53±0.03	11.59±0.16	0.26±0.01	27.61±0.27	5.51±0.09
Local lines								
Desert		57.63±0.99[b]	88.96±0.52[a]	1.55±0.05[a]	11.53±0.22[a]	0.26±0.01[b]	28.30±0.34[a]	5.44±0.15[a]
Brown		58.91±0.82[a]	87.32±0.57[ab]	1.44±0.03[a]	11.49±0.20[a]	0.26±0.01[b]	26.56±0.39[b]	5.42±0.09[a]
White		55.84±1.05[ab]	86.81±1.06[b]	1.59±0.08[a]	11.77±0.39[a]	0.27±0.02[a]	27.98±0.54[a]	5.66±0.21[a]
eggshell colours								
I		58.07±1.47[a]	86.84±1.18[b]	1.54±0.07[abc]	12.22±0.20[a]	0.27±0.02[a]	26.96±0.83[bc]	5.71±0.13[a]
II		56.32±1.87[a]	85.05±0.70[bc]	1.43±0.05[c]	10.61±0.32[b]	0.26±0.01[a]	27.97±0.37[ab]	5.12±0.15[b]
III		57.42±0.55[a]	87.94±0.96[b]	1.36±0.06[c]	11.55±0.36[ab]	0.24±0.01[b]	26.45±0.59[c]	5.12±0.21[b]
IV		57.70±1.27[a]	88.02±0.70[b]	1.59±0.05[ab]	11.49±0.24[ab]	0.26±0.01[a]	28.48±0.44[a]	5.57±0.14[ab]
V		57.79±1.12[a]	90.65±0.43[a]	1.71±0.08[a]	12.05±0.42[a]	0.27±0.02[a]	28.20±0.49[ab]	6.01±0.21[a]
Line eggshell colours								
Desert	I	55.77±1.81[cde]	89.26±0.93[abc]	1.60±0.15[ab]	12.17±0.39[abc]	0.27±0.02[ab]	28.44±1.54[ab]	5.60±0.26[abc]
Desert	II	63.22±1.54[a]	86.71±1.70[bcde]	1.50±0.06[ab]	10.36±0.14[c]	0.25±0.03[bc]	29.19±0.51[ab]	5.13±0.11[bcd]
Desert	III	55.75±0.99[cde]	90.12±0.31[ab]	1.33±0.03[b]	11.91±0.21[abc]	0.24±0.01[c]	28.11±0.05[ab]	4.74±0.12[d]
Desert	IV	58.33±1.67[abcd]	88.91±1.39[abcd]	1.60±0.06[ab]	11.43±0.13[abc]	0.26±0.01[abc]	28.63±0.23[ab]	5.59±0.23[abc]
Desert	V	55.06±1.54[cde]	89.81±0.33[ab]	1.70±0.10[ab]	11.58±0.53[abc]	0.26±0.01[abc]	27.11±0.47[abcd]	6.11±0.24[ab]
Brown	I	61.45±0.63[ab]	86.57±0.45[bcde]	1.43±0.07[ab]	12.17±0.39[abc]	0.27±0.02[ab]	25.30±0.30[cd]	5.66±5.66[abc]
Brown	II	54.46±1.15[cde]	85.02±0.14[cde]	1.33 ±0.03[b]	10.36±0.14[c]	0.25±0.03[bc]	27.06±0.41[abcd]	4.93±0.08[cd]
Brown	III	58.64±0.46[abcd]	88.30±1.16[abcd]	1.37±0.03[b]	11.91±0.21[abc]	0.24±0.01[c]	24.82±0.14[d]	5.50±0.11[abc]
Brown	IV	61.10±1.54[ab]	86.67±1.58[bcde]	1.47±0.03[b]	11.43±0.13[abc]	0.26±0.01[abc]	27.01±0.55[bcd]	5.43±0.05[abcd]
Brown	V	58.90±1.89[abcd]	90.05±0.18[ab]	1.60±0.06[ab]	11.58±0.53[abc]	0.26±0.01[abc]	28.58±0.31[ab]	5.60±0.24[abc]
White	I	56.97±3.63[bcd]	84.69±3.20[de]	1.60±0.17[ab]	12.33±0.44[ab]	0.27±0.02[ab]	27.13±1.83[abcd]	5.87±0.28[abc]
White	II	51.29±0.37[e]	83.41±0.54[e]	1.47±0.12[ab]	11.10±1.02[abc]	0.27±0.01[ab]	27.64±0.19[abc]	5.31±0.47[abcd]
White	III	57.86±0.39[bcd]	85.42 ±2.01[cde]	1.37 ±0.22[b]	10.82±1.04[bc]	0.26±0.01[bc]	26.41±1.18[bcd]	5.12±0.58[bcd]
White	IV	53.67±0.41[ed]	88.47±0.22[abcd]	1.70±0.12[ab]	11.62±0.81[abc]	0.26±0.01[abc]	29.81±0.05[a]	5.70±0.39[abc]
White	V	59.41±1.86[abc]	92.08±0.71[a]	1.83±0.20[a]	12.99±0.94[a]	0.29±0.01[a]	28.92±1.30[ab]	6.32±0.51[a]

[a-e]: Differences between mean values with different superscripts in the same column are statistically significant (P<0.05).

Table 6. Correlation coefficients among the internal and external egg quality traits in different quail lines

	EL	EWDT	SI	EV	AH	AD	AI	AW	YH	YD	YW	YI	Y/A	HU	ESA	US	SW	ST
EW	0.832□□	0.845□□	0.171	0.992□□	0.667□□	0.632□□	0.494□□	0.940□□	0.570□□	0.692□□	0.884□□	0.001	0.151	0.489□□	0.986□□	0.312□	0.688□□	0.427□□
EL		0.728□□	-0.199	0.837□□	0.527□□	0.594□□	0.304□	0.866□□	0.702□□	0.606□□	0.712□□	0.188	-0.012	0.362□	0.837□□	0.132	0.481□□	0.329□
EWDT			0.525□□	0.852□□	0.700□□	0.684□□	0.503□□	0.796□□	0.502□□	0.569□□	0.769□□	-0.040	0.148	0.567□□	0.827□□	0.318□	0.626□□	0.421□□
SI				0.175	0.335□	0.224	0.339□	0.063	-0.158	0.056	0.204	-0.295□	0.206	0.344□	0.139	0.298□	0.301□	0.199
EV					0.672□□	0.643□□	0.491□□	0.941□□	0.597□□	0.712□□	0.898□□	-0.040	0.169	0.497□□	0.977□□	0.334□	0.702□□	0.436□□
AH						0.828□□	0.866□□	0.546□□	0.512□□	0.465□□	0.679□□	0.170	0.322□	0.965□□	0.644□□	0.400□□	0.608□□	0.268
AD							0.437□□	0.522□□	0.549□□	0.447□□	0.748□□	0.216	0.464□□	0.803□□	0.618□□	0.149	0.402□□	0.101
AI								0.399□□	0.319□	0.322□	0.408□□	0.092	0.094	0.838□□	0.469□□	0.504□□	0.607□□	0.329□
AW									0.604□□	0.661□□	0.744□□	0.018	-0.130	0.366□	0.931□□	0.151	0.539□□	0.331□
YH										0.605□□	0.511□□	0.478□□	0.004	0.431□□	0.590□□	0.142	0.371□	0.212
YD											0.638□□	-0.227	0.126	0.336□	0.703□□	0.180	0.457□□	0.264
YW												-0.059	0.563□□	0.537□□	0.876□□	0.219	0.567□□	0.303□
YI													-0.127	0.209	0.016	-0.098	-0.077	-0.100
Y/A														0.335□	0.149	0.141	0.177	0.039
HU															0.468□□	0.367□	0.502□□	0.186
ESA																0.277	0.655□□	0.442□□
US																	0.903□□	0.632□□
SW																		0.679□□

EW, egg weight; EL, egg length; EWDT, egg width; SI, shape index; EV, egg volume; AH, albumen height ; AD, albumen diameter; AI, albumen index; AW, albumen weight; YH, yolk height; YD, yolk diameter; YW, yolk weight; YI, yolk index; Y/A, yolk/albumen ratio; HU, Haugh unit; EFA, egg surface area; US, unit surface; SW, shell weight; ST, shell thickness. *P < 0.05; **P < 0.01

Table 7. Means ± S. E. Effect of line, eggshell colour and interaction on hatching parameters in local quails

Traits		Fertility (%)	Hatchability of fertile eggs (%)	Hatchability of set eggs (%)	Chick hatching weight (g)
Overall mean		77.19±1.30	90.98±0.54	85.12±0.98	8.65±0.08
Local lines					
Desert		79.76±1.10[b]	92.23±0.75[a]	87.74±0.40[a]	8.90±0.12[a]
Brown		71.03±1.51[c]	88.95±0.50[b]	79.96±1.48[b]	8.22±0.18[b]
White		80.76±2.88[a]	91.77±1.23[a]	87.67±1.96[a]	8.78±0.11[a]
eggshell colours					
I		73.17±2.69[d]	89.01±0.51[b]	82.05±2.68[c]	8.37±0.13[bc]
II		73.11±1.51[d]	89.25±0.57[b]	81.86±1.27[c]	8.70±0.16[ab]
III		75.08±0.59[c]	88.99±0.47[b]	86.89±0.43[b]	8.06±0.18[c]
IV		81.05±1.31[b]	93.99±0.78[a]	86.20±0.98[b]	9.05±0.18[a]
V		83.51±4.82[a]	93.68±1.82[a]	88.62±3.45[a]	8.94±0.17[a]
Line eggshell colours					
Desert	I	78.95±0.57[c]	89.47±0.53[fgh]	88.23±0.52[bc]	8.79±0.11[abcd]
Desert	II	78.26±0.54[cd]	91.30±0.40[de]	90.00±0.51[e]	9.51±0.16[a]
Desert	III	88.23±0.53[g]	85.71±0.58[efg]	88.00±0.58[bcd]	8.55±0.37[bcde]
Desert	IV	84.38±0.51[b]	96.86±0.52[b]	87.10±0.52[cde]	8.95±0.18[abc]
Desert	V	83.87±0.56[b]	93.54±0.66[c]	89.66±0.43[b]	8.44±0.37 [bcde]
Brown	I	62.50±0.61[i]	87.33±0.50[i]	71.42±0.66[h]	7.67±0.16[e]
Brown	II	73.08±0.54[g]	88.46±0.44[ghi]	82.61±0.70[f]	8.20±0.54[cde]
Brown	III	76.92±0.55[de]	89.46±0.65[fgh]	86.96±0.56[cde]	7.78±0.22[e]
Brown	IV	76.00±0.58[ef]	92.00±0.58[dc]	82.61±0.65[f]	8.53±0.43 [bcde]
Brown	V	66.67±0.56[h]	87.50±0.40[i]	76.19±0.53[g]	9.05±0.33[abc]
White	I	78.05±0.57[cd]	90.24±0.54[ef]	86.49±0.51[de]	8.46±0.18[bcde]
White	II	68.00±0.58[h]	88.00±0.58[hi]	77.27±0.53[g]	8.47±0.11 [bcde]
White	III	75.00±0.58[f]	87.50±0.40[i]	85.71±0.55[e]	7.98±0.26[de]
White	IV	82.76±0.54[b]	93.10±0.52[c]	88.89±0.54[b]	9.56±0.22[a]
White	V	100.00±0.00[a]	100.00±0.00[a]	100.00±0.00[a]	9.21±0.16[ab]

[a-e]: Differences between mean values with different superscripts in the same column are statistically significant (P<0.05).

Table 7, summarizes the incubation results of quail eggs a according to lines, shell colour and interaction between them A slightly higher proportion of Hatchability of fertile eggs 92.23±0.75, Hatchability of set eggs 87.74±0.40 and chick hatching weight 8.90±0.12 traits were characteristic for eggs from desert lines. In contrast to the white line was given the higher value of fertility rate (80.76±2.88). These studies were also in the line with those of the results showed by Nwachukwu *et al.,* (30) and Ahmed & AL-Barzinji, (3) who detected that the fertility and hatchability percentage can be significantly (P≤0.05) impacted by different genotypes of quails. Also, the eggshell colour and spot colour had a significant effect on the incubation results. The highest fertility (83.51±4.82) and Hatchability of set eggs (88.62±3.45) determined in Group V. While the Hatchability of fertile eggs (93.99±0.78) and chick hatching weight (9.05±0.18) was the highest in Group IV, and the differences between the treatment groups were determined to be statistically significant (P≤0.05, Table 7). This finding was in compliance with the report of Drabik *et al., (*14) for quail eggs, but differed from previous reports Alasahan *et al.,* (6) that the fertility, hatchability of fertile eggs, and embryonic mortality rates did not differ with eggshell colour or the size of the spotted area. It was found that the impact of interaction (Line eggshell colours) on incubation results significantly (P≤0.05) higher characteristics of quail eggs. The highest fertility, Hatchability of fertile eggs and hatchability of set eggs was (100.00±0.00) determined in Group V in white lines and the chick hatching weight9 (56±0.22) was higher in white IV group. While the lowest values of fertility, hatchability of set eggs and Chick hatching weight traits were observed for the brown I group (62.50±0.61, 71.42±0.66 and 7.67±0.16) respectively as well as the hatchability of fertile eggs was lower in desert III groups.

Conclusions

It could be expressed that line, eggshell colour and interaction between (Line eggshell colours) in local quail are significantly affected egg quality characteristics and hatchability parameters. However no significant differences were observed among groups in albumen parameters. An interesting result that all of egg quality traits observed was positively correlated with each other.

REFERENCES

1. Abdulfatah, M. H., Mahfoz, O. Y., Abdellatif, H. Abd El-Halim H.A.H. and M.I. Badawy, 2018. Image analysis measurements and their correlations with egg quality traits and egg chemical composition of different egg shell patterns of japanese quail. Egypt. J. Agric. Res., 96(3): 1095–1109.

2. Ahmed, L.S, and Y.M.S, AL-Barzinji, 2020. Comparative study of hatchability and fertility rate among local quail. Iraqi Journal of Agricultural Sciences**.** 51(3):744-751

3. Ahmed, L.S, and Y.M.S, AL-Barzinji, 2020. Three candidate genes and its association with quantitative variation of egg production traits of local quail by using PCR-RFLP. Iraqi Journal of Agricultural Sciences. 51:124-131

4. Akram, M., Hussain, J., Ahmad, S., Rehman, A., Lohani, F., Munir, A., Amjad, R. and H, Noshahi, 2014. "Comparative study on production performance, egg geometry, quality and hatching traits in four close-bred stocks of Japanese quail. Agricultural Advances. 1 (3): 13-18

5. Alaşahan, S., Akpınar Çopur, G., Canoğulları, S. and M. Baylan, 2015. Determination of some external and internal quality traits of Japanese quail (*Coturnix coturnix* japonica) eggs on the basis of eggshell colour and spot colour. Eurasian J. Vet. Sci. 31:235-241

6. Alasahan, S., Copur Akpinar, G., Canogullari, S. and M. Baylan, 2016.The impact of eggshell colourand spot area inJapanese quails: I. Eggshell temperature during incubation and hatching results. R. Bras. Zootec. 45: 219-229.

7. Al-Kafajy, F.R., Al-Shuhaib, M.B.S., Al-Jashami, G.S. and T.M. Al-Thuwaini, 2018. Comparison of three lines of Japanese quails revealed a remarkable role of plumage color in the productivity performance determination. J. World Poult. Res. 8(4): 111-119.

8. Alkan, S., K. Karabag, A. Galic, T. Karsli, and M.S. Balcioglu , 2010. Effects of selection for body weight and egg production on egg quality traits in Japanese quails (Coturnix coturnix japonica) of different lines and relationships between these traits. Kafkas Univ. Vet. Fak. Derg. 17: 239- 244

9. Alkan, S., Karsli, T., Galic, A. and K. Karabag, 2013. Determination of phenotypic correlations between internal and external quality traits of Guinea fowl eggs. KafkasUniv Vet FakDerg. 19: 861–867

10. Aryee, G., Adu-Aboagye, G., Shiburah, M.E., Nkrumah, T. and D. Amedorme, 2020. Correlation between egg weight and egg characteristics in japanese quail. animal and Veterinary Sciences. 8(3): 51-54

11. Aygun, A., 4014. The relationship between eggshell colour and egg quality traits in table eggs. Indian J. Anim. Res. 48: 290–294

12. Bennett, C.D., 1992. The influence of shell thickness on hatchability in commercial broiler breeder flocks. Journal of Applied Poultry Research. 1(1):61-65

13. Chimezie, V.O., Fayeye, T.R., Ayorinde, K.L. and A. Adebunmi, 2017. Phenotypic correlations between egg weight and some egg quality traits in three varieties of Japanese quail (Coturnix coturnix japonica). Agrosearch. 17(1): 44-53

14. Drabik, K., Batkowska, J., Vasiukov, K. and A. Pluta, 2020. The Impact of eggshell colour on the quality of table and hatching eggs derived from Japanese quail. Animals. 10 (2): 264

15. Genchev, A., 2012. Quality and composition of Japanese quail eggs (Coturnix japonica). Trakia Journal of Sciences. 10(2): 91-101

16. .Hassan, H.A., El-Nesr, S., Osman, A. and G. Arram, 2013.Ultrastructure of eggshell, egg weight loss and hatching traits of Japanese quail varying in eggshell color and pattern using image analysis. Egypt. Poult. Sci. J. 34(I): 1-17.

17. Hassan, A. M., Mohammed, D. A., Hussein, K. N., and S. H. Hussen, 2017. Comparison among three lines of quail for egg quality characters. Sci. J. University of Zakho. 5:296-300

18. Inci, H., Sogut, B., Sengul, T., Sengul A.Y., and M.R. Taysi, 2015. Comparison of fattening performance, carcass characteristics, and egg quality characteristics of Japanese quails with different feather colors. Revista Brasileira de Zootecnia. 44(11):390–396

19. Ingram, D.R., Hatten, L.F., and K.D. Homan, 2008. A study on the relationship between eggshell color and eggshell quality in commercial broiler breeders. Int. J. Poult. Sci. 7:700–703

Japanese quail. Journal of Heredity. 84(2): 145-147

21. Kaye, J., Akpa, G. N., Alphonsus, C., Kabir, M., Zahraddeen, D. and D.M. Shehu, 2016. Responsed to Genetic improvement and heritability of egg production and egg quality traits in japanese quail (*Coturnix coturnix* japonica). American Scientific Research Journal for Engineering, Technology, and Sciences (ASRJETS). 16(1): 277-292

22. Khawaja, T., Khan, S.H., Mukhtar, N., Parveen, A. and T. Ahmed, 2013. Comparative study of growth performance, meat quality and haematological parameters of three-way crossbred chickens with reciprocal F1 crossbred chickens in a subtropical environment. Journal of Applied Animal Research. 41(3):300-308

23. Kul, S. and I. Seker, 2004. Phenotypic correlations between some external and internal egg quality traits in the Japanese quail (*Coturnix coturnix* japonica). Int. J. Poult. Sci. 3(6): 400-405

24 Lan, L.T.T., Nhan, N.T.H., Hung, L.T., Diep, T.H., Xuan, N.H., Loc, H.T. and N.T., Ngu, 2021. Relationship between plumage color and eggshell patterns with egg production and egg quality traits of Japanese quails. Veterinary World. 14(4): 897

25. Monira, K.N., Salahuddin, M., and G. Miah, 2003."Effect of breed and holding period on egg quality characteristics of chickens International Journal of Poultry Science. 2: 261– 263

26. Narushin, V. G., and M. N., Romanov, 2002. Egg physical characteristics and hatchability. World's Poultry Science Journal. 58: 297-303

27. Nasr, M. A. F., El-Tarabany, M. S., and M. J., Toscano, 2016. Effects of divergent selection for growth on egg quality traits in Japanese quail. Anim. Prod. Sci. 56: 1797–1802

28. Nowaczewski, S., Witkiewicz, K., Fratczak, M., Kontecka, H., Rutkowski, A., Krystianiak, S. and A., Rosinski, 2008. Egg quality from domestic and French guinea fowl.Nauka Przyr. Technol. 2: 1-9

29. Nowaczewski, S., Szablewski, T., Cegielska-Radziejewska, R., and H., Kontecka, 2013. Egg morphometry and eggshell quality in ring-necked pheasants kept in cages. Ann. Anim. Sci. 13: 531–541

30. Nwachukwu, E.N., Ogbu1, C. C. E., and N. G., Ifeanacho, 2015. Egg quality characteristics and hatchability of two Colour Variants of Japanese Quails (*Coturnix coturnix* japonica). Inter. J. Liv. Res.1(11) : 46- 54

31. Nys, Y., Gautron, J., Garcia-Ruiz, J. M., and M.T., Hincke, 2004. Avian eggshell mineralization: Biochemical and functional characterization of matrix proteins. C. R. Palevol. 3: 549–562.

32. Obike, O. M., and K. E., Azu, 2012. Phenotypic correlations among body weight, external and internal egg quality traits of pearl and black strains of guinea fowl in a humid tropical environment. Journal of Animal Science Advances. 2(10): 857-864

33. Ogunwole, O.A., Agboola, A.F., Mapayi, T.G., and O.J. Babayemi, 2015. Consumers' perception and preference for Japanese quail and the commercial chicken eggs in Akinyele local government area of Oyo State, Nigeria. Trop. Anim. Health Prod. 18: 108–119

34. Ozcelik, M., 2002. The phenotypic correlations among some external and internal quality characteristics in Japanese quail eggs. Vet. J. Ankara Univ. 49: 67-72

35. Rayan, G.N., Galal, A., Fathi, M.M., and A.H., El-Attar, 2010. Impact of layer breeder flock age and strain on mechanical and ultrastructural properties of eggshell in chicken. Int J Poult Sci. 9: 139-147

36. Roberts, J.R., 2004. Factors affecting egg internal quality and egg shell quality in laying hens. Poultry Science. 41: 161–177

37. Rodriguez-Navarro, A., Kalin, O., Nys, Y., and J.M., Garcia-Ruiz, 2002. Influence of the microstructure on the shell strength of eggs laid by hens of different ages. British Poultry Science. 9: 395–403

38. SAS, Statistical Analyses System, 2004. User's guide: statistics 8. 6th. SAS's Institute Inc. carry, North Carolina USA
39. Sari, M., Serpil, I., Önk, K., Tilki, M., and T., Kırmızıbayrak, 2012. Effects of layer age and different plumage colors on external and internal egg quality characteristics in Japanese quails (Coturnix coturnix japonica). Arch. Geflügelk. 76 (4): 254-258
40. Sezer, M., and O., Tekelioglu, 2009. Quantification of japanese quail eggshell colour by image analysis. Biol. Res. 42: 99–105.
41. Tabeekh, M.A.S.A., 2011. Evaluation of some external and internal egg quality traits of quails reared in Basrah City. Basrah Journal of Veterinary Research. 10 (2): 78-84.
42. Taha, A.E., 2011. Analyzing of quail eggs hatchability, quality, embryonic mortality and malpositions in relation to their shell colors. J. Anim. Feed Res. 1: 267–273
43. Willems, E., Decuypere, E., Buyse, J., and N., Everaert, 2014. Importance of albumen during embryonic development in avian species, with emphasis on domestic chicken. World's Poultry Science Journal .70:503-518.
44. Udoh, J.E., Adeoye, A.A., and E.N., Mbaba, 2020. Eggc characteristics in two strains of Japasese Quail Eggs (*Coturnix coturnix* japonica). Asian Journal of Agricultural and Horticultural Research. 20:1-7. o, opens interesting prospects for future selection programs, especially marker assisted selection**.**