Egg quality in F₁ cross between brown and black lines of Japanese quail

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Abstract. The objective of this study was to determine both external and internal egg quality in F₁ cross between Brown and Black lines of Japanese quail. A total of 186 eggs given basal diets have been collected at the age of ten weeks and those eggs were then tested to evaluate their external and internal qualities. They were produced by four group of F₁ cross between two lines of Brown male and Black female of Japanese quail and vice versa. Cross between Brown male and Black female lines produced Brown layer lines (B1 and B2 lines, respectively) while cross between Black male and Brown female lines was called L1 and L2 lines, respectively. The data was analyzed by using one-way analysis of variance (ANOVA) with an alpha level of 5%. Furthermore, the pairwise differences among populations were tested using Duncan’s multiple range test (DMRT). The results showed that egg weight, shell weight and egg interior traits including yolks index, albumin index, Haugh unit (HU), and yolk color score were significantly difference among F₁ populations (P<0.05). Egg and shell weights were highest in B1 line, on the other hand, albumin index, yolks index, HU, yolk color score were found highest in B2 line. In addition, no differences among lines have been observed for shell thickness, egg index, and air cavity of egg. These results suggested that Brown quail line was better both exterior and interior qualities of egg.

1. Introduction
Quail is poultry species raised for egg and meat productions due to easy to be raised, low feed consumption (about 20 g/head/day), and growing quickly. It is able to produce egg at 42 days of age. Quail egg contains 13.1% of proteins, 11.1% of fats and 168 kilocalories. In addition, quail predominantly lays eggs at 3.00 to 6.00 p.m. and sometime at night. In ideal environment, laying quail can produce until 250 eggs/year [1]. In Indonesia, the most popular quail raised by small holder farmers is Japanese quail (Coturnix coturnix japonica), especially Brown and Black lines of Japanese quail due to sexing reason.

Generally, cross-breeding among different quail lines is conducted to prevent inheritance of negative traits due to inbreeding. It also facilitates sexing at one day old quail (DOQ) by using criss-cross inheritance among them [2]. Moreover, performance of individual quail will be better than average performance of its parents [3].

One of the parameters which is possible to determine the quality of F₁ offspring is egg quality traits including both external and internal quality of egg [4]. Exterior quality consists of egg shape (egg length and width), egg weight, egg shell thickness and shell weight, whereas interior quality consists of albumin length and height, yolk diameter and height, and yolk color. This study was aimed to determine both external and internal egg quality in F₁ cross between Brown and Black lines of Japanese quail.
2. Materials and Methods

2.1. Quail population and management
A total of 186 eggs were produced by four Japanese quail lines. Eggs were produced by four group of F1 cross between two lines of Brown male and Black female of Japanese quail and vice versa. They were raised in colony cage sized 50×30×20 cm (width×length×height) with 15 to 16 quails per cage. Commercial feed for broiler starter was given to growing starter of quail (0-30 days old). Furthermore, commercial laying quail was started to be given to quail at the age of 31 days old. The nutrient content of commercial feed is showed in Table 1.

| Nutrient       | Content (%) |
|----------------|-------------|
| Crude protein  | 20.0-22.0   |
| Crude fat      | 4.0-7.0     |
| Crude fiber    | Max 6.0     |
| Calcium        | 3.0-3.5     |
| Phosphor       | 0.4-0.6     |

Source: PT. Japfa Comfeed Indonesia (2018)

2.2. Measurement of egg quality traits
Both exterior and interior quality of egg has been conducted in this study. Exterior quality included egg weight, shell weight, shell thickness, egg index, and air cavity, on the other hand, interior quality included index of albumen, yolk index, HU and yolk color score. Egg and shell weight were measured using digital scales. Shell thickness was obtained by measuring the blunt, equator and taper area after the shell was cleaned and aired. The measurement of the yolk color score was determined using yolk color fan with 1-15 scale. Data was calculated using the formula below:

1. Egg index (%) = \( \frac{\text{egg width (mm)}}{\text{egg length (mm)}} \times 100\% \)
2. Egg shell weight (%) = \( \frac{\text{Egg shell weight (g)}}{\text{Egg weight (g)}} \times 100\% \)
3. Yolk Index = \( \frac{0.5 \times (\text{yolk max. (mm)} + \text{yolk min. (mm)})}{\text{albumen height (mm)}} \times 100\% \)
4. Albumen Index = \( \frac{0.5 \times (\text{albumen max. (mm)} + \text{albumen min. (mm)})}{\text{albumen height (mm)}} \times 100\% \)
5. HU = 100 log [(albumen height (mm) + 7.57) – (1.7 x egg weight (g) x 0.37)]

2.3. Experimental design and data analysis
This study used completely randomized design (CRD). The data obtained was analysed using one-way analysis of variance (one-way ANOVA) and pairwise differences among lines was tested using Duncan’s multiple range test (DMRT) with 5% alpha. Mathematic model used in this study was as follows:

\[ Y_{ij} = \mu + L_i + \epsilon_{ij} \]

where, \( Y_{ij} \) is the phenotype of the \( i \)th quail, \( \mu \) is population mean, \( L_i \) is line effect, and \( \epsilon_{ij} \) is random error.

3. Results and Discussion

3.1. External quality of quail egg
This study was conducted on 28°C average environment temperature and 61% average humidity. Average of feed consumption was 8 g/quail/day in the morning, 7 g/quail/day in the afternoon, and 10 g/quail/day in the evening, respectively. Data of external quality of quail eggs were egg weight, shell weight, shell thickness, egg index and air cavity which are presented in Table 2.
Plumage color differences of Japanese quail affected egg and shell weight, but no effect on shell thickness, egg index and air cavity were observed. The average value of egg weight was significantly higher in brown lines (10.66-11.8 g) than black lines (9.30-10.9 g). The shell weight of brown lines was 1.32-1.44 g while the black line was 1.33-1.37 g.

**Table 2.** External quality of egg in four different Japanese quail lines

| Variable          | B1          | B2          | L1          | L2          | P-Value |
|-------------------|-------------|-------------|-------------|-------------|---------|
| Egg weight (g)    | 11.08 ± 0.88a | 10.66 ± 0.63b | 10.09 ± 0.68c | 9.30 ± 0.82ab | P<0.050 |
| Shell thickness (mm) | 0.29 ± 0.19 | 0.36 ± 0.24 | 0.30 ± 0.24 | 0.26 ± 0.17 | P=0.097 |
| Shell weight (g)  | 1.44 ± 0.14a | 1.32 ± 0.19b | 1.33 ± 0.11b | 1.37 ± 0.12b | P<0.050 |
| Egg index (%)     | 79.00 ± 2.99 | 78.86 ± 2.65 | 78.10 ± 2.26 | 78.94 ± 2.33 | P=0.404 |
| Air cavity (mm)   | 0.62 ± 0.51 | 0.78 ± 0.49 | 0.58 ± 0.50 | 0.64 ± 0.54 | P=0.238 |

B1 (Brown 1) and L1 (Black 1) are from VBC 1, B2 (Brown 2) and L2 (Black 2) are from VBC 2

*a,b,c Superscript on the same line shows a significant difference (P<0.05)

Egg weight is influenced by genetic inheritance [5]. Egg weight is influenced by quail line [6] and age [7]. This study showed that egg weight from different line had congruency with the results. Previous study reported that Brown quail (base population) has 10.88 g of egg weight while black quail has 10.74 g of egg weight in average [8]. Egg weight and most qualified characteristic are dominantly possessed by Brown quail [9].

Shell weight on Brown quail was better than Black quail. Shell weight contributes on 10% of whole egg weight [10]. Shell weight ranged from 0.56-0.9 g. Shell weight is influenced by shell and membrane thickness [7]. Calcium (Ca) and Phosphor (P) contents in feed affected shell thickness [5,11]. The shell weight difference in this study was due to different quail line having different genetic trait, instead of having same feed nutrition.

Shell thickness, egg index and air cavity difference were not observed on this study. Height of air cavity was ranged from 0.58 to 0.78 mm. Shell thickness was ranged from 0.26 to 0.36 mm and egg index was ranged from 78.10 to 79.00%. Previous study measured shell thickness average in 0.234 mm containing 2.3% of calcium [12]. Shell thickness average generated by seven weeks old quail fed on low protein fodder fortified by commercial enzyme was 0.302 mm [13].

### 3.2 Internal quality of quail egg

The results showed that differences plumage color of Japanese quail lines significantly effected egg interior quality represented by albumen index, yolk index, HU and yolk color as displayed in Table 3. Brown quail albumen index is higher than Black quail (13.20 vs 13.10%) [14]. Additionally, higher albumen index value in Brown quail (13.10 – 15.81%) than black quail (13.6-14.73%) was observed in this present study. Different albumen index may be caused by the influence of various factors including egg weight, diameter of albumen, line and age. Thicker and higher egg albumen represents better egg albumen quality [14].

**Table 3.** Internal quality of quail egg from four different Japanese quail lines

| Variable           | B1          | B2          | L1          | L2          | P-Value |
|--------------------|-------------|-------------|-------------|-------------|---------|
| Albumin Index (%)  | 13.10 ± 2.83c | 15.81 ± 2.74a | 13.65 ± 2.59bc | 14.73 ± 2.55ab | P<0.05  |
| Yolk index (%)     | 40.13 ± 3.88b | 42.75 ± 5.05a | 39.85 ± 5.21b | 39.24 ± 2.93b | P<0.05  |
| Haugh Unit (%)     | 76.92 ± 8.42c | 84.48 ± 5.92a | 80.45 ± 6.78b | 84.87 ± 5.01a | P<0.05  |
| Yolk Color (%)     | 4.89 ± 0.89ab | 5.15 ± 0.85a | 4.63 ± 0.66ab | 5.14 ± 0.86a | P<0.05  |

B1 (Brown 1) and L1 (Black 1) are from VBC 1, B2 (Brown 2) and L2 (Black 2) are from VBC 2

*a,b,c Superscript on the same line shows a significant difference (P<0.05)

Yolk index represents freshness of the yolk which is measured by yolk height and diameter [15]. This study showed significant difference yolk index among quail lines. Brown quail yolk index was better than black quail’s yolk index (Table 3). Yolk index of quail egg fed by 18% protein in the diet...
was 40.6% and increasing until 20.1% crude protein in the diet also increased yolk index 42.2% [13]. Yolk index is varied from 30-50% [16] and it even can reach 52% [17].

Haugh Unit (HU) represents quail egg’s quality. Previous study reported that HU value of quail egg was 84.49 [18]. According to HU value, egg is classified into four groups, i.e. HU > 79 belongs to AA class, HU 79 > U > 55 belongs to A class, HU 55 > U > 31 belongs to B class, and HU < 31 belongs to C class [19]. The HU value calculated in this study was ranged from 76.92–84.48 for Brown quail population, on the other hand the HU value of Black line was ranged from 80.45–84.87. The HU may be affected by egg weight and albumen height.

Yolk color of Brown and Black lines were ranged from 4.89 to 5.15 and 4.63 to 5.14, respectively. Pigment on egg yolk is carotene and riboflavin which are classified as lipochrome (xanthophyll) colouring egg yolk into reddish orange. Orange on yolk presents carotenoid rich-containing zeaxanthin, criptoxantin and lutein or xantofil [7]. Factors affecting yolk color were breed, genetic, environment condition, disease, heat stress, xanthophyll oxidation and egg production rate. Previous studies reported that yolk color was 4 in accordance to yolk color fan [21, 22]. Orange yolk color represented presence of carotenoids containing a lot of zeaxanthin, cryptoxanthine, and lutein (xanthophyll) [7].

4. Conclusions

Different plumage color lines affected on the internal and external quality of the Japanese quail eggs. Brown quail has better quality than Black quail lines in both external and internal quality of egg of F₁ cross between brown and black lines of Japanese quail, thus brown quail is more appropriate to be layer quail.

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