

Japanese Quail (*Coturnix coturnix japonica*) Eggs' Quality after Treatment with *Moringa oleifera* Leaf Flour as Feed Supplement

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Abstract. Quail egg quality is influenced by feed nutrition. Phytogetic feed supplements may improve egg quality. Moringa leaves (*Moringa oleifera* Lam.) contain phytonutrients that may improve quail egg quality. This study aimed to evaluate the effects of Moringa leaf flour on quail egg quality. Sixty female quails were used in this study and randomly divided into five treatment groups: P0 (quails fed a standard diet), P1 (quails fed a diet containing 97.5% standard feed and 2.5% Moringa leaf flour), P2 (quails fed a diet containing 95% standard feed and 5% Moringa leaf flour), P3 (quails fed a diet containing 92.5% standard feed and 7.5% Moringa leaf flour), and P4 (quails fed a diet containing 90% standard feed and 10% Moringa leaf flour). Egg samples were collected and evaluated at 55, 62, and 76 days of age. The data were analyzed using analysis of variance (ANOVA) at a 5% significance level. The results showed that Moringa leaf flour supplementation had no significant effect on egg weight, egg shape index, yolk weight, yolk index, Haugh unit, eggshell thickness, or eggshell weight. However, albumen weight differed significantly among treatments ($P < 0.05$). Eggshell pigmentation may be influenced by the antioxidant compounds in *M. oleifera*. This study concluded that Moringa leaf flour supplementation could help maintain quail egg quality.

Keywords: Egg quality, quail eggs, moringa leaf flour, feed supplement, HU value

Abstrak. Mutu telur puyuh berkaitan dengan nutrisi pakan yang diberikan. Suplemen pakan fitogenik dapat mengoptimalkan mutu telur. Daun kelor (*Moringa oleifera* Lam.) mengandung fitonutrien yang dapat meningkatkan mutu telur puyuh. Tujuan dari penelitian adalah menganalisis pengaruh pemberian tepung daun kelor terhadap mutu telur puyuh. Puyuh betina sebanyak 60 ekor digunakan dalam penelitian ini dan dibagi menjadi 5 kelompok perlakuan, yaitu P0 (puyuh diberi pakan standar), P1 (puyuh diberi pakan standar 97,5% dengan tambahan tepung daun kelor 2,5%), P2 (puyuh diberi pakan standar 95% dengan tambahan tepung daun kelor 5%), P3 (puyuh diberi pakan standar 92,5% dengan tambahan tepung daun kelor 7,5%), dan P4 (puyuh diberi pakan standar 90% dengan tambahan tepung daun kelor 10%). Koleksi telur dan pengukuran parameter dilakukan pada hari ke-55, 62, dan 76. Hasil penelitian dianalisis menggunakan uji ANOVA dengan taraf signifikansi 5% dan menunjukkan bahwa pemberian perlakuan tepung daun kelor berpengaruh tidak nyata terhadap bobot telur, indeks bentuk telur, bobot kuning telur, indeks kuning telur, *Haugh unit*, ketebalan kerabang, dan bobot kerabang. Bobot putih telur berbeda nyata antarperlakuan. Deposisi pigmen kerabang dipengaruhi oleh antioksidan dalam *M. oleifera*. Kesimpulan dari penelitian ini adalah bahwa penggunaan tepung daun kelor sebagai suplemen pakan dapat mempertahankan mutu telur puyuh.

Kata kunci: mutu telur, telur puyuh, tepung daun kelor, suplemen pakan, nilai HU

Introduction

Protein is a fundamental component of life. Poultry products, including meat and eggs, are widely consumed worldwide because they are readily available and provide high-quality protein. Among poultry species, Japanese quail (*Coturnix coturnix japonica*) have attracted considerable attention because of their desirable characteristics. They are easy to rear, relatively resistant to disease, adaptable to various environments, and capable of producing eggs at an early age. Quail begin laying eggs at

approximately 42 days of age and can produce 250–300 eggs per year (Maknun et al., 2015). Despite these advantages, quail egg production in Indonesia tends to fluctuate. Inadequate feed management and nutrition may compromise egg quality and contribute to an unstable supply of quail eggs. Egg quality is closely associated with nutrition, and various strategies have been implemented to improve feed quality, including the use of feed supplements.

In parts of Asia and Africa, moringa leaves have traditionally been used as animal feed

because of their rich phytonutrient content. *Moringa oleifera* is commonly used as a phytogenic feed supplement (Fuglie, 2001). The leaves contain 28.25% protein (Zakaria et al., 2013), which may contribute to meeting the protein requirements of quail during the laying period. Moringa is also known for its antioxidant properties. Kasolo et al. (2010) reported that moringa contains various phenolic compounds that can help counteract free radicals. They also reported that the leaves contain high levels of antioxidants, which may contribute to improved health in birds. A positive association between moringa supplementation and egg quality has been reported in several studies. Kasiyati et al. (2019) found that the inclusion of 7.5% and 10% moringa leaf flour in the diet of Pengging ducks reduced malondialdehyde (MDA) levels in the liver and ovaries, increased follicle size, and promoted the development of small yellow follicles.

Lower MDA levels in the liver and ovaries indicate reduced lipid peroxidation and may reflect lower oxidative stress, potentially supporting hepatic vitellogenesis and yolk deposition in the ovaries. Meanwhile, Rossida et al. (2019) reported that adding 10% moringa leaf flour to the diet increased the protein content and reduced the cholesterol levels of duck eggs. Similarly, Nuraeni et al. (2019) and Marcelina et al. (2020) reported that adding 10% moringa leaf flour increased the Haugh unit (HU) values of duck eggs without increasing egg weight or the egg index of laying ducks.

Egg quality is determined by various parameters. External quality parameters include cleanliness, egg weight, eggshell weight, and eggshell thickness. Internal quality parameters, such as the yolk index, Haugh unit, and chemical composition, are also important (Hrnčár et al., 2014). Consumers, however, often assess egg quality based on external characteristics, including egg weight, size, shape, and shell appearance (Ondrušíková et al., 2018). The limited information available on the quality of

quail eggs produced by birds fed diets supplemented with moringa leaf flour motivated the present study. This study aimed to evaluate the effects of different inclusion levels of moringa leaf flour as a feed supplement on quail egg quality. External quality parameters included eggshell color, eggshell thickness, eggshell weight, and egg shape index, whereas internal quality parameters included albumen weight, yolk index, and Haugh unit. The findings are expected to provide a scientific basis for the use of moringa leaf flour as an alternative feed ingredient.

Materials and Methods

The study was conducted using female Japanese quail (*Coturnix coturnix japonica*) that were 28 days old at the start of the study. Sixty quails were randomly selected and acclimatized for one week, during which they were fed a standard commercial diet *ad libitum* to allow them to adapt to the experimental conditions.

Moringa leaf flour was obtained from a local market associated with PT Moringa Organik Indonesia. The leaf powder was prepared according to the method described by Suci (2013). Briefly, harvested moringa leaves were air-dried until they changed color or wilted. The leaves were then oven-dried at 50 °C for 48 hours, ground using a blender or grinder until a fine powder was obtained, and sieved before being used as a livestock feed supplement. No specific phytochemical analysis of the moringa leaf powder was conducted in this study; therefore, its phytochemical composition was not characterized. The quail feed used in this study was a commercial layer diet for quail produced by PT Japfa Comfeed Indonesia. The feed was in crumble form and contained yellow corn, soybean meal (SBM), meat and bone meal (MBM), corn gluten meal (CGM), palm oil, wheat bran, essential amino acids, minerals, a premix, and vitamins. The nutritional composition of the layer feed is presented in Table 1.

Table 1. Nutritional content of feed for laying quails

Nutrients	Total (%)
Crude protein	19-21
Crude fat	3-7
Crude fiber	Max 6
Ash	Max 13
Calcium	2.5-3.1
Phosphorus	0.6-0.9
Water	Max 12
Antibiotic	+

Source: PT Japfa Comfeed Indonesia

The standard commercial feed and moringa leaf flour were thoroughly mixed according to the assigned treatment groups. A 25-g portion of the feed mixture was provided to the quails at 7:00 a.m. and 4:00 p.m. daily.

All female quails were identified using cable ties of different colors. They were housed in two wire cages, each with five tiers, and each tier was divided into two compartments. Each compartment housed three birds. The cages were equipped with drinking bowls and feeders. After one week of acclimation, the quails were assigned to five treatment groups, with four replicates per treatment. Each treatment group consisted of 12 quails. The treatment groups are presented in Table 2.

Table 2. Quail Feed Composition Based on Treatment Groups

Groups	Standard	Moringa	Total
P0	100	-	100
P1	97.5	2.5	100
P2	95	5	100
P3	92.5	7.5	100
P4	90	10	100

Samples Collection and Parameters Measurement

At 48 days of age, the cages were checked daily to collect eggs because the quails had entered the laying period. Egg samples were collected on four occasions over two months, at 55, 62, 69, and 76 days of age, and grouped according to treatment. The collected samples were measured immediately at the Laboratory of Animal Structure and Function, Department of

Biology, Faculty of Science and Mathematics, Diponegoro University.

The parameters measured in this study included egg weight, egg shape index, yolk index, Haugh unit (HU), eggshell thickness, eggshell weight, and eggshell color. Quail body weight was recorded as supporting data. Egg weight was measured using a digital laboratory scale. Egg shape index was measured using a digital caliper with an accuracy of 0.05 mm (Genchev, 2012). The egg shape index was calculated using the formula described by Renukadevi et al. (2018).

$$\text{Egg Shape Index} = \frac{\text{average egg width (mm)}}{\text{average egg length (mm)}} \times 100$$

Components that were used to measure yolk index were yolk height and yolk diameter. Yolk index was measured using the formula that Alkan et al. (2010) stated.

$$\text{Yolk Index} = \frac{\text{Yolk height (mm)}}{\text{Yolk diameter (mm)}} \times 100$$

The calculation of the HU value used the formula according to the procedure performed by Haugh (1937).

$$\text{HU} = 100 \log (H + 7.57 - 1.7 \cdot W^{0.37})$$

Exp: HU: Haugh Unit

H: Albumen height (mm)

W: Egg weight (g)

The thickness of the shell was measured at the acute pole, obtuse pole, and equatorial pole using a digital caliper with 0.05 mm accuracy. The shell thickness value was calculated from the average thickness of the three poles. The eggshell weight was measured using a digital laboratory scale with an accuracy of 0.01 g (Hrnčár et al., 2014). Eggshell color was determined by categorizing them into two different groups based on their color, which are the brown spotted eggshell and the blue-based eggshell. Eggshell distribution percentages were then calculated (Drabik et al., 2020).

Data Analysis

A completely randomized design was used in this research. The data obtained from this research consist of quantitative data regarding the measurement of quail egg quality. Normality and homogeneity tests were carried out as prerequisites, then analyzed using the one-way ANOVA (Analysis of Variance) with a significance level of 5%. Post hoc tests were conducted using Duncan's multiple range test at a 5% significance level. All data were analyzed with SPSS® version 23.

Results and Discussion

Egg quality analysis results are summarized in Table 3. The supplementation of moringa leaf meal in the diet did not have a significant effect on the measured variables, except for albumen weight (g) and proportion of albumen weight (%), which showed significant differences ($P < 0.05$).

Effect of Moringa Leaf Flour on Egg Weight and Egg Shape Index

Supplementation of quail feed with moringa leaf meal did not significantly affect egg weight or egg shape index (Table 3). Egg weight reflects the combined weights of the yolk, albumen, and eggshell. In this study, yolk and eggshell weights

were relatively similar among treatments, whereas albumen weight differed between treatments. Although moringa leaf meal contains nutrients, including protein, vitamins, and minerals, as well as phytochemicals, supplementation did not significantly affect overall egg weight. These findings are consistent with those of Yadav et al. (2024) and Marcelina et al. (2020), who reported that dietary supplementation with moringa leaf flour did not affect egg weight. Sari et al. (2016), Hossain et al. (2024), and Fenita et al. (2025) reported that quail egg weight generally ranges from 10 to 15 g. The egg weights obtained in the present study fell within this range. Wheindrata (2014) and Sari et al. (2016) reported that egg weight is associated with body weight, genetic factors, environmental conditions, and the age of the birds.

Egg shape is another physical characteristic used to evaluate egg quality and can be assessed using the egg shape index, which represents the ratio of egg width to egg length. The results showed that moringa leaf meal supplementation did not significantly affect the egg shape index. This finding indicates that the ratio of egg width to egg length remained relatively stable across treatments.

Table 3. Results of Moringa leaf flour as a feed additive on quail's egg quality

Variables	Level of <i>Moringa oleifera</i> leaf flour (%)				
	P0 ($\bar{X} \pm SD$)	P1 ($\bar{X} \pm SD$)	P2 ($\bar{X} \pm SD$)	P3 ($\bar{X} \pm SD$)	P4 ($\bar{X} \pm SD$)
Egg Weight (g)	10.32 $\pm$ 0.33	9.87 $\pm$ 0.33	10.04 $\pm$ 0.6	9.96 $\pm$ 0.38	10.19 $\pm$ 0.38
Egg Shape Index	80.51 $\pm$ 0.50	78.95 $\pm$ 1.95	78.29 $\pm$ 1.06	78.18 $\pm$ 3.69	78.41 $\pm$ 3.43
Yolk Weight (g)	3.79 $\pm$ 0.62	3.69 $\pm$ 0.35	3.67 $\pm$ 0.45	3.76 $\pm$ 0.16	3.50 $\pm$ 0.10
Yolk Index	0.41 $\pm$ 0.02	0.24 $\pm$ 0.03	0.38 $\pm$ 0.04	0.37 $\pm$ 0.02	0.41 $\pm$ 0.03
Albumen Weight (g)	4.50 ^b $\pm$ 0.16	4.34 ^b $\pm$ 0.25	4.24 ^b $\pm$ 0.28	4.41 ^b $\pm$ 0.06	4.94 ^a $\pm$ 0.21
Haugh Unit	89.61 $\pm$ 0.56	91.73 $\pm$ 2.05	90.06 $\pm$ 5.85	90.12 $\pm$ 2.50	91.87 $\pm$ 1.25
Eggshell Weight (g)	1.18 $\pm$ 0.05	1.31 $\pm$ 0.16	1.31 $\pm$ 0.09	1.31 $\pm$ 0.08	1.25 $\pm$ 0.11
Eggshell Thickness (mm)	0.18 $\pm$ 0.08	0.17 $\pm$ 0.02	0.16 $\pm$ 0.01	0.16 $\pm$ 0.01	0.17 $\pm$ 0.01
Proportion of egg component (%)					
Yolk Weight	36.48 $\pm$ 4.51	36.45 $\pm$ 2.96	36.01 $\pm$ 2.43	37.02 $\pm$ 1.08	34.74 $\pm$ 2.40
Albumen Weight	43.36 ^b $\pm$ 0.16	42.74 ^b $\pm$ 2.15	41.84 ^b $\pm$ 2.98	43.96 ^b $\pm$ 1.49	47.24 ^a $\pm$ 1.39
Eggshell Weight	11.52 $\pm$ 0.02	13.66 $\pm$ 0.70	13.49 $\pm$ 0.45	13.62 $\pm$ 0.32	12.25 $\pm$ 1.46

^{a-b}Different superscripts on the same rows show a significant difference ($P < 0.05$). P0 (quail given standard feed), P1 (quail fed 97.5% standard feed with the addition of 2.5% Moringa leaf flour), P2 (quail fed 95% standard feed with the addition of 5% Moringa leaf flour), P3 (quail fed 92.5% standard feed with the addition of 7.5% Moringa leaf flour), and P4 (quail fed 90% standard feed with the addition of 10% Moringa leaf flour). The data are shown as average ($\bar{X}$) $\pm$ Standard Deviation (SD)

Thus, supplementation did not produce a detectable change in egg shape under the conditions of this study. The egg shape index obtained in this study was consistent with the findings of Yadav et al. (2024). Igugo et al. (2022) and Hasyim et al. (2021) reported that the egg shape index is influenced by genetic characteristics, strain, and the egg formation process in the oviduct. Based on the egg shape index, the eggs examined in this study were classified as round. This classification is consistent with Sujana et al. (2020), who reported that quail eggs generally have a rounded shape, with an egg shape index above 77.

Effect of Moringa Leaf Flour on Internal Qualities of Egg

The internal quality of quail eggs, as assessed by yolk weight and yolk index, was not significantly affected by the treatments. In contrast, albumen weight and albumen proportion increased significantly ($P < 0.05$) in the group supplemented with 10% moringa leaf flour compared with the other treatment groups. Roberts (2004) stated that dietary nutrients may influence yolk formation and albumen synthesis. Moringa leaf meal contains protein, phytosterols, vitamins, and minerals. However, the extent to which phytochemicals in moringa leaf meal influence yolk biosynthesis and yolk deposition in the ovary remains unclear. The yolk weights reported by Sari et al. (2016) and Drabik et al. (2020) ranged from 3.2 to 4.1 g; thus, the yolk weights obtained in the present study were comparable to those reported in previous studies. Consistent with the yolk weight results, the yolk index also did not differ significantly among treatments (Table 3). The yolk index values in this study ranged from 0.24 to 0.41, consistent with the findings of Pritisa et al. (2022) and Fenita et al. (2025). Factors influencing the yolk index include dietary protein, fat, and essential amino acid content. Other factors, such as egg size, storage duration,

temperature, vitelline membrane quality, and dietary composition, may also affect yolk characteristics (Pritisa et al., 2022; Lu et al., 2021; Drabik et al., 2020).

Unlike yolk weight and yolk index, albumen characteristics responded significantly to moringa leaf meal supplementation. Albumen weight increased significantly in the group receiving 10% moringa leaf flour compared with the other treatment groups. Albumen proportion also increased in this group, indicating that the response involved not only an increase in albumen mass but also a change in the proportion of albumen relative to total egg weight. Dietary protein may be digested, absorbed, and utilized for albumen biosynthesis in the oviduct, particularly in the magnum, where most albumen secretion occurs. Ndong et al. (2007) reported that the digestibility of moringa leaf protein was 56.14%. Because albumen is rich in protein, changes in albumen weight and proportion may reflect differences in nutrient utilization during egg formation. These findings differ from those of de Silva Junior et al. (2024) and Abdel-Wareth and Lohakare (2021), who reported that moringa leaf flour supplementation at levels below 10% did not increase albumen weight or its proportion in eggs.

In this study, the increase in albumen weight and proportion was not accompanied by a significant increase in Haugh unit (HU) values. This finding suggests that an increase in albumen quantity does not necessarily correspond to an improvement in internal egg quality as assessed by HU. Several factors may influence HU values, including storage duration, temperature, humidity, and dietary nutrients (Fenita et al., 2025). The HU values of the quail eggs in this study ranged from 89.61 to 91.87, consistent with the findings of Abdel-Wareth and Lohakare (2021), Rajesh et al. (2022), da Silva Junior et al. (2024), and Fenita et al. (2025). According to the USDA (2000) egg quality standards, eggs with HU values greater than 72 are classified as Grade AA.

However, the applicability of this grading threshold to quail eggs should be verified. Overall, the response to 10% moringa leaf flour supplementation was more evident in albumen weight and proportion than in HU values.

Effect of Moringa Leaf Flour on External Qualities of Egg and Eggshell Color

The results presented in Table 3 indicate that eggshell thickness and weight did not differ significantly among treatments ($P > 0.05$). These findings are consistent with those reported by Fenita et al. (2025), who found that quail eggshell weight ranged from 1.30 to 1.34 g and eggshell thickness was approximately 0.19 mm. However, the eggshell weight and thickness observed in the present study were slightly higher than those reported by Yadav et al. (2024). These differences may be attributable to variations in quail strain, age, laying period, moringa leaf meal inclusion level, herbal composition, moringa cultivation practices, and microclimatic conditions during rearing. Eggshell formation in the uterus requires calcium, which can be obtained from the diet or mobilized from skeletal reserves. Moringa leaf meal contains a relatively high calcium concentration, approximately 2,003 mg/100 g of dry matter (Gopalakrishnan et al., 2016). However, the bioavailability of calcium from moringa leaf meal incorporated into commercial feed may be limited. Calcium can interact with compounds such as oxalic acid and phytic acid, forming poorly soluble salts that may reduce its absorption (Dai et al., 2020). Sotelo et al. (2010) reported that phytic acid could reduce calcium bioavailability because of its strong affinity for minerals. Nevertheless, because eggshell thickness and weight did not differ significantly among treatments in the present study, moringa leaf meal supplementation did not produce a detectable effect on these parameters under the conditions tested.

As shown in Figures 1 and 2, eggshell color and spotting patterns varied considerably

among the treatment groups. This observation is consistent with Sezer and Tekelioglu (2009), who reported substantial variation in Japanese quail eggshell appearance, with background colors ranging from white and blue-green to light yellow-brown, accompanied by darker speckles or spots of varying sizes, shapes, and colors. Two major pigments involved in eggshell coloration are biliverdin and protoporphyrin. Biliverdin contributes to blue-green coloration in the eggshells of many bird species, whereas protoporphyrin is associated with reddish-brown speckling (Hargitai et al., 2016). These observations are consistent with previous research indicating that eggshell background color and spotting patterns are influenced by genetic factors and may also be associated with external factors, including diet and feed composition (Drabik et al., 2021; Ismael et al., 2024).

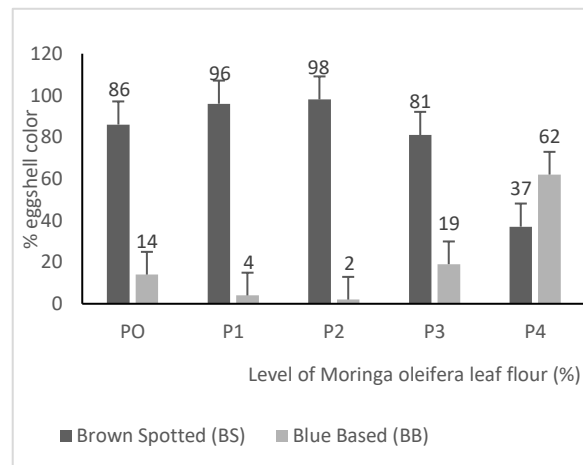


Figure 1. The percentage of eggshell color distribution among treatment groups

Eggshell coloration may also be associated with the physiological condition of female birds and their antioxidant status. In the present study, eggshell color appeared to vary with moringa leaf meal supplementation. Among the treatment groups, eggs from quails receiving 10% moringa leaf meal appeared to have the palest and bluest coloration (Figure 2), whereas eggs from the other groups appeared lighter yellow-brown.



Figure 2. Eggshell color category. A) Brown spotted eggshell, B) Blue-based eggshell

This observation should be interpreted cautiously because the extent to which dietary supplementation affected eggshell pigmentation requires further investigation. Hargitai et al. (2016) reported that biliverdin exhibits antioxidant activity against free radicals and reactive oxygen species, whereas protoporphyrin may have pro-oxidant properties. Ishikawa et al. (2010) further suggested that females in poorer body condition may deposit more protoporphyrin in their eggshells, potentially contributing to antimicrobial protection for the developing embryo.

A limitation of this study is that the commercial basal diet was reported to contain antibiotics, although the specific type and concentration were not provided by the manufacturer. Since the same basal diet was provided to all treatment groups, antibiotic exposure was consistent across treatments; however, potential interactions between the antibiotics and *Moringa oleifera* supplementation cannot be completely excluded. In addition, most egg quality parameters did not differ significantly among treatments, with significant responses observed only in albumen weight and albumen percentage. Therefore, the effects of *Moringa* supplementation should be interpreted as parameter-specific rather than as a generalized improvement in egg quality.

Conclusions

In conclusion, *Moringa oleifera* leaf flour can be used as a quail feed supplement at levels up to 10% without adversely affecting the

measured egg quality parameters or body functions. At the 10% supplementation level, *Moringa* leaf flour increased albumen weight and albumen percentage, while most other egg quality parameters remained unchanged. Further research is needed to elucidate the chemical composition of quail eggs and the underlying mechanisms of egg biosynthesis in response to *Moringa oleifera* supplementation.

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