Determination of Egg Internal and External Quality Characteristics with Mathematical Formulas in Guinea Hens

Mehmet Hanifi AYSONDU1, Selçuk ÖZYÜREK2*

1Malatya Turgut Özal Üniversitesi, Akçadağ Meslek Yüksekokulu, Laborant ve Veteriner Sağlık Programı, Malatya / Türkiye
2Erzincan Binali Yıldırım Üniversitesi, Çayırlı Meslek Yüksekokulu, Laborant ve Veteriner Sağlık Programı, Erzincan / Türkiye

Abstract

This study was carried out to determine some internal and external quality characteristics of 378 eggs collected between March and July from 42-week-old Guinea Hens (Numidae meleagris) raised by the public in Erzincan province, using mathematical formulas. Egg external quality features include shape index 73%, elongation 1.37, egg surface area 55.65 cm², egg volume 40.39 cm³, shell thickness 0.28 mm, shell weight 3.19 g, number of pores-1 6686.05, number of pores-2 5156.10, number of pores-3 5043.33 pieces, pore density-1 120.22 pore number/cm², pore density-2 92.62 pore number/cm², pore density-3 90.52 pore number/cm²; The yolk weight and white weight of the egg were determined as 6.02 g and 30.89 g, from the egg internal quality characteristics.

As a result, in this study, yolk weight, shell weight and shell thickness values of egg internal and external quality characteristics calculated using mathematical formulas based on egg weight without spoiling the egg integrity were found to be lower than the values in some studies determined by measurement, while the white weight value was found to be higher.

Key words: Guinea fowl, Egg Weight, Shape Index, Shell Thickness and Weight, Egg Yolk and White Weight

Öz

Bu çalışma, Erzincan ilinde halk elinde yetiştirilen 42haftalık yaşta olan Beç Tavuklarından (Numidae meleagris) Mart-Temmuz ayları arasında toplanan 378 adet yumurtanın matematiksel formüller kullanarak bazı iç ve dış kalite özelliklerinin belirlenmesi amacıyla yapılmıştır. Yumurta dış kalite özelliklerindenシェルインデックス73, elongasyon 1.37, yumurta yüzey alanı 55.65 cm², yumurta hacmi 40.39 cm³, kabuk kalınlığı 0.28 mm, kabuk ağırlığı 3.19 g, gözenek sayısı-1 6686.05 adet, gözenek sayısı-2 5156.10 adet, gözenek sayısı-3 5043.33 adet, gözenek yoğunluğu-1 120.22 gözenek sayısı/cm², gözenek yoğunluğu-2 92.62 gözenek sayısı/cm², gözenek yoğunluğu-3 90.52 gözenek sayısı/cm²; yumurta iç kalite özelliklerinden sarı ağırlığı 6.02 g ve ak ağırlığı 30.89 g olarak belirlenmiştir. Sonuç olarak bu çalışmada yumurta bütününlüğü bozulmadan yumurta ağırlığı baz alınarak matematiksel formüller kullanarak hesaplanan yumurta iç ve dış kalite özelliklerinden sarı ağırlığı, kabuk ağırlığı ve kabuk kalınlığı değerleri ölçümlü belirlenen bazı çalışmalardaki değerlerden düşük bulunurken ak ağırlığı değeri ise yüksek bulunmuştur.

Anahtar Kelimeler: Beç Tavuğu, Yumurta Ağırlığı, Şekil İndeksi, Kabuk Kalınlığı ve Ağırlığı, Yumurta Sarı ve Ak Ağırlığı

*Corresponding Author: sozyurek@erzincan.edu.tr
1. Introduction

Guinea fowl, which is the native chicken of the African continent, (Smith, 1990) is in the Galliformes order of the Numididae subfamily of the Phasinidae family (Koch and Rossa, 1973; Austin et al., 1975; Demirsoy, 1992). The meat of guinea fowl, known as game and ornamental bird, has a pleasant aroma in terms of taste and flavor. Guinea fowl meat is rich in lean and essential unsaturated fatty acids (Petek, 2004).

Guinea fowls start to lay eggs at an average age of 26-32 weeks, usually in March or April, and laying can continue until October (Nwagu, 1997). It is important to determine the quality characteristics of the egg, which is the breeding material with its nutritive feature. Different criteria and methods are used to determine quality characteristics. It is used in some mathematical formulas developed to determine egg quality characteristics (Paganelli et al., 1974; Hoyt et al., 1979; Sotherland and Rahn, 1987; Rahn and Paganelli, 1988, Çopur Akpınar vd., 2017).

It is important to preserve the shell integrity of the eggs obtained in order to maintain the flock in poultry species produced in limited numbers. Mathematical formulas can be used to determine the quality characteristics of eggs obtained from these species. With the help of the formulas used to determine the quality characteristics, economic gain can be maintained for the breeder by protecting the integrity of the eggs without breaking them (Çopur Akpınar vd., 2017).

This study was carried out to determine some internal and external quality characteristics of 378 eggs collected from 42 weeks old Guinea fowl (Numidae meleagris) raised by the public in Erzincahn between March and July, using mathematical formulas.

2. Material and Method

In the study, 378 eggs collected between March and July from 42-year-old Guinea hens raised in a private enterprise in the city center of Erzincahn were used. After the eggs were numbered, they were weighed with an electronic scale sensitive to 0.01 mg and the egg weight was determined as g. Egg internal and external quality characteristics were determined with the help of mathematical formulas without breaking the eggs whose weights were determined. In this context, the following formulas were used.

\[
\text{Egg length (mm)} = 14.7 \times (\text{Egg weight})^{0.341} \quad \text{(Rahn and Paganelli, 1988)}
\]

\[
\text{Egg width (mm)} = 11.3 \times (\text{Egg weight})^{0.327} \quad \text{(Rahn and Paganelli, 1988)}
\]

\[
\text{Shape Index (\%)} = \frac{\text{Egg Width}}{\text{Egg Length}} \times 100 \quad \text{(Rahn and Paganelli, 1988)}
\]

\[
\text{Elongation} = \frac{\text{Egg Length}}{\text{Egg Width}} \quad \text{(Rahn and Paganelli, 1988)}
\]

\[
\text{Egg surface area (cm}^2) = 4.835 \times (\text{Egg Weight})^{0.662} \quad \text{(Paganelli et al., 1974)}
\]
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**Egg Volume (cm³)** = \((0.452 + 0.069 \frac{\text{Egg Length}}{\text{Egg Width}}) \times (\text{Egg Length} \times \text{Egg Width}^2)\)  
(Paganelli et al., 1974)

**Shell weight (g)** = 0.0524 \times (\text{Egg Weight})^{1.113}  
(Rahn and Paganelli, 1989)

**Shell thickness (mm)** = 0.0546 \times (\text{Egg Weight})^{0.441}  
(Rahn and Paganelli, 1989)

**Number of Pores-1** = 1041 \times (\text{Egg Weight})^{0.504}  
(Hoyt et al., 1979)

**Number of Pores-2** = 304 \times (\text{Egg Weight})^{0.767}  
(Rahn and Paganelli, 1990)

**Number of Pores-3** = 3520 \times (\text{Egg Weight} / \text{Incubation Time})  
(Rahn et al., 1980)

**Pore Density (Pore/cm²)** = (\text{Pore Number} / \text{Egg Surface Area})  
(Paganelli et al., 1974)

**Yellow Ratio (%)** = 0.346 \times (\text{Egg Weight})^{1.02}  
(Sotherland and Rahn, 1987)

**Egg Yolk Weight (g)** = (\text{Egg Weight} \times \text{Yolk Ratio}) / 100

**White weight (g)** = \text{Egg Weight} - (\text{Shell Weight} + \text{Yolk Weight})  
(Sarica and Erensayın, 2009)

**Whitening ratio (%)** = (\text{White weight} / \text{Egg Weight}) \times 100

2.1. Statistical Analysis

SPSS 21. package program was used in the statistical evaluation of the data obtained in the study.

3. Result and Discussion

The results of egg length and width, shape index, elongation parameters of guinea fowl eggs based on egg weight are given in Table 1. Average egg weight was 40.10 g, shape index was 73% and elongation was 1.37.

**Table 1. External quality characteristics of Guinea fowl eggs**

| Features       | n   | Minimum | Maximum | Average     |
|----------------|-----|---------|---------|-------------|
| Egg weight (g) | 378 | 30.10   | 49.01   | 40.10 (2.95)|
| Egg length (mm)| 378 | 46.94   | 55.42   | 51.73 (1.31)|
| Egg width (mm) | 378 | 34.40   | 40.35   | 37.76 (0.92)|
| Shape index (%)| 378 | 72.79   | 73.29   | 73.00 (0.8) |
| Elongation     | 378 | 1.36    | 1.37    | 1.37 (0.00) |

Shell characteristics of guinea fowl eggs are given in Table 2. It was determined that the shell thickness of guinea fowl eggs varied between 0.25 and 0.30 mm, shell weight between 2.32 and 3.99 g, egg surface area between 46.05 and 63.59 cm², and egg volume between 30.34 and 49.33 cm³.
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Data on shell pore number and pore density in guinea fowl eggs are given in Table 3. The pore number 1, the pore number 2 and the pore number 3 values were calculated as 6686.05, 5156.10 and 5043.33, respectively, pore density 1, pore density 2 and pore number. density 3 values were found to be 120.22, 92.62 and 90.52 pores/cm$^2$, respectively.

**Table 2.** Shell characteristics of guinea fowl eggs

| Features            | n   | Minimum | Maximum | Average       |
|---------------------|-----|---------|---------|---------------|
| Shell thickness (mm)| 378 | 0.25    | 0.30    | 0.28 (0.01)   |
| Shell weight (g)    | 378 | 2.32    | 3.99    | 3.19 (0.26)   |
| Surface Area (cm$^2$)| 378 | 46.05   | 63.59   | 55.65 (2.72)  |
| Egg volume (cm$^3$) | 378 | 30.34   | 49.33   | 40.39 (2.96)  |
| Surface/Volume ratio| 378 | 1.289   | 1.518   | 1.380         |

Statistical descriptive data regarding the weights and ratios of yellow, white and bark, which are internal quality characteristics, are given in Table 4. Average yellow weight was 6.02 g, white weight was 30.89 g and shell weight was 3.19 g. It has been calculated that 14.94% of guinea fowl eggs consist of yellow, 77.11% white and 7.95% shell.

**Table 3.** Number of shell pores and pore density in guinea fowl eggs

| Features                    | n   | Minimum       | Maximum       | Average       |
|-----------------------------|-----|---------------|---------------|---------------|
| Number of Pores 1 (pcs)     | 378 | 5789.89       | 7401.94       | 6686.05 (249.50) |
| Pore density 1 (pore/cm$^2$)| 378 | 116.41        | 125.73        | 120.22 (1.42)  |
| Number of Pores 2 (pcs)     | 378 | 4139.68       | 6016.01       | 5156.10 (291.57) |
| Pore density 2 (pore/cm$^2$)| 378 | 89.89         | 94.61         | 92.62 (0.73)   |
| Number of Pores 3 (pcs)     | 378 | 3784.38       | 6161.01       | 5043.33 (370.04) |
| Pore density 3 (pore/cm$^2$)| 378 | 82.18         | 96.89         | 90.52 (2.31)   |

**Table 4.** Internal quality characteristics of guinea fowl eggs

| Features          | n   | Minimum | Maximum | Average       |
|-------------------|-----|---------|---------|---------------|
| Shell weight (g)  | 378 | 2.32    | 3.99    | 3.19 (0.26)   |
| yellow weight (g) | 378 | 3.36    | 8.98    | 6.02 (0.88)   |
| Ak weight (g)     | 378 | 24.43   | 36.04   | 30.89 (1.81)  |
| Shell rate (%)    | 378 | 7.70    | 8.13    | 7.95 (0.07)   |
| Yellow rate (%)   | 378 | 11.15   | 18.33   | 14.94 (1.12)  |
| White percentage (%) | 378 | 73.54 | 81.15 | 77.11 (1.19) |
4. Conclusion

In this study carried out to determine guinea fowl egg quality, the weight of the eggs was found to be minimum 30.10 g, maximum 49 g and average 40.10 g. In some studies conducted in guinea pigs, the average egg weight was reported as 40 g. (Vekic et al., 2019, Yamak vd., 2015; Alkan vd., 2013; Bernacki et al., 2013; Ivanova et al., 2020; Nickolova, 2009; Eleroğlu vd., 2016) and the results obtained in our study were similar. However, the average egg weight obtained in our study was lower than the values reported by Tebesi et al. (2012) (43.16 g); Dudusola (2010) (46.65 g); Nowaczewski et al. (2008) (55.3 g) and Song et al. (2000) (46.65 g), was higher than Oke et al. (2004) (29.1-38.4 g); Sing and Kumar (2008) (36.8 g); Obike et al. (2011) (37.67-37.91 g) and Gholipour et al. (2017) (36.21-39.22 g).

The average elongation value was 1.37, and the shape index value was found to be 73% on average. The elongation value is similar to the value reported by Eleroğlu and Bircan (2019a) (1.37); It was found to be higher than the value reported by Eleroğlu and Bircan (2019b) (1.28). Eleroğlu and Bircan (2019a) found the shape index 73.1%, Nowaczewski et al. (2008) 73.7% and Patrick et al. (2013) reported the shape index value as 73.97% in Lavender (Lavender) genotype, 74.77% in Purple genotype (Royal Purple) and 73.62% in White (White) genotype in the study conducted by guinea pigs of different genotypes. The findings of this study were similar to our research findings. However, the average shape index value obtained in our study was found lower than Dudusola (2010) (79.57%), Ivanova et al. (2020) (2016: 76.32%, 2017: 76.54%, 2018: 77.96%), Obike et al. (2014) (Pearl x Pearl: 78.93%, Black x Black: 77.45%, Pearl x Black: 76.70%), Alkan et al. (2013) (76.60%) and Eleroğlu et al. (2016) (78.18%).

In our study, the average number of pores-1, number of pores-2 and number of pores-3 was 6686.05, 5156.10 and 5043.33, respectively; pore density-1, pore density-2 and pore density-3 were found to be 120.22, 92.62 and 90.52 pores/cm², respectively. In the study conducted by Eleroğlu and Bircan (2019a) to determine the internal and external quality characteristics of guinea fowl eggs with the same methods, the average number of pores-1, number of pores-2 and number of pores-3 was 6666.25, 5132.39 and 5011.12, respectively; pore density-1, pore density-2 and pore density-3 were found to be 120.32, 92.56 and 90.31 pores/cm², respectively, and the results were similar to our study.

Egg surface area was determined as 55.65 cm² (min=46.05-max=63.59 cm²) and egg volume was determined as average 40.39 cm³ (min=30.34-max=49.33 cm³).

The obtained values were reported by Alkan et al. (2013) (55.69 cm²- 38.21 cm³), Wilkanowska and Kokoszyński (2010) (Pearl=54.84 cm2), Bernacki et al. (2013) (Grey=56.3 cm2, White=56.2 cm²2), Patrick et al. (2013) (White=57.06 cm², 40.87 cm³) and Eleroğlu and Bircan (2019a) (55.43 cm²-40.14 cm³) were similar to our results; but Dudusola (2010) (73.13 cm²), Patrick et al. (2013) (Lavender=60.98 cm², 44.38 cm³, Royal Purple=62.44 cm², 47.05 cm³, Pearly grey=60.24 cm², 45.84 cm³), Wilkanowska and Kokoszyński (2010) (White=61.40 cm²) were lower than our results.
In the study, average shell thickness, shell weight and shell ratio were found to be 0.28 mm, 3.19 g and 7.95%, respectively. These values were found to be similar to the study of Eleroğlu and Bircan (2019a) to determine the egg quality characteristics of guinea fowl with the same method, but lower than the other studies conducted to determine egg quality characteristics by measuring method. Eleroğlu and Bircan (2019a) reported average shell thickness, shell weight and shell ratio as 0.28 mm, 3.17 g and 7.95%, respectively. These values were reported as 0.50 mm, 6.23 g and 15.32%; 0.55 mm by Vekic et al. (2019), 0.55 mm, 8.25 g and 20.18% by Song et al., (2000), 0.4628 mm, 6.31 g and 13.5% by Niclova (2009).

Egg core quality characteristics, yolk weight and ratio 6.02 g and 14.94%; The white weight and ratio were found to be 30.89 g and 77.11%. Eleroğlu and Bircan (2019a) determined the weight and rate of yellow as 5.95 g and 14.85% in guinea fowls; white weight and rate of 30.75 g and reported as 77.21%. The results obtained in our study were similar to the findings of this study, which was carried out to determine egg quality characteristics with the same method. However, the results obtained from our study, which were compared with the literature, were lower than other research values in terms of yellow weight and ratio (Vekic et al., (2019) (12.55 g and 30.94%), Niclova (2009) (11.84 g and 29.29%), Alkan et al. (2013) (13.58 g and 33.81%), Dudusola (2010) (14.26 g and 30.6%); It is high in white weight and ratio value (Vekic et al. (2019) (21.84 g and 53.75%), Niclova (2009) (20.79 g and 51.34%), Alkan et al. (2013) (21.62 g 50.03%), Dudusola (2010) (26.08 g and 55.9% ) was determined. H.E. BEGLI ET AL. (2010) reported the weight of yellow as 12.91 g and the weight of white as 22.66 g.

As a result, in this study, it was aimed to determine the egg internal and external quality characteristics of guinea fowl by using mathematical formulas based on egg weight without spoiling the egg integrity. The results obtained were similar to those of the studies carried out to determine the internal and external quality characteristics of guinea fowl eggs, but were different in terms of some characteristics with the other study values carried out to determine the egg quality of guinea fowl with the measurement method. While yellow weight, peel weight and peel thickness values were found to be lower than the values determined by measurement, the white weight value was found to be high.

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