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Araştırma Makalesi

# Comparison of Egg Quality and Microbiology Traits in Eggs Obtained Different Genotypes under Different Storage Conditions

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**ABSTRACT**
The present study was conducted to compare egg quality and microbiology traits in eggs from different genotypes under different storage conditions. A total of 880 eggs, obtained from Nick Chick, Dekalb, Lohmann Brown and Atabey (Native Hybrid) hens, flocks aged 56 weeks, were used in the experiment. The eggs were divided into two groups which were stored in wholesaler conditions and consumer conditions for 4 weeks during the summer season. External and internal quality traits of eggs and mold-yeast and total bacteria levels were measured. Egg quality criteria results suggest that Lohmann eggs are less affected by wholesaler conditions. Haugh unit, which is an important indicator of albumin quality, was least effective in Atabey eggs stored under wholesaler conditions. The microorganism load of the eggshell did not increase under both store conditions. The total amount of microorganisms, mold and yeast were generally acceptable limits at the end of the 4th week.
**Keywords:** Egg microbiology, egg quality, shelf life, storage temperature, different genotypes

# Farklı Depolama Koşullarında Saklanan Farklı Genotipe Ait Yumurtaların Kalite ve Mikrobiyolojik Yönden Karşılaştırılması

**ÖZ**
Bu çalışma farklı genotiplere ait yumurtaların farklı depolama koşullarında depolanmasının yumurta kalitesi ve mikrobiyolojisine etkisini karşılaştırmak amacıyla yürütülmüştür. 56 haftalık Nick Chick, Dekalb, Lohmann Brown ve Atabey (yerli hibrit) tavuklara ait toplam 880 adet yumurta ile yapılmış ve yumurtalar toptancı ve tüketici koşullarında 4 hafta süreyle yaz mevsiminde depolanmıştır. Yumurtaların dış ve iç kalite özellikleri ile küf-maya ve toplam bakteri düzeyleri ölçülmüştür. Yumurta kalite kriterleri sonuçları, Lohmann yumurtalarının toptancı koşullarından daha az etkilendiğini göstermiştir. Yumurta iç kalite kriterlerinin en önemli göstergelerinden biri olan Haugh birimi toptancı koşullarında depolanan Atabey yumurtalarında en az düzeyde etkilenmiştir. Yumurta kabuğunun mikroorganizma yükü her iki koşulda da artmamış ve araştırma sonunda toplam mikroorganizma, küf ve maya miktarı genel olarak kabul edilebilir sınırlar içerisinde kalmıştır.
**Anahtar Kelimeler:** Yumurta mikrobiyolojisi, yumurta kalitesi, raf ömrü, depolama sıcaklığı, farklı genotip

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# Comparison of Egg Quality and Microbiology Traits in Eggs Obtained Different Genotypes under Different Storage Conditions

## Introduction

The interior structure of an egg includes all nutrients that are sufficient for the development of a new living being. However, its consumption may be harmful to human health since nutrients content starts deteriorating by time when they are not preserved with care before consumption. As soon as the egg is laid due to its natural structure and contents, the egg is resistant against microbiologic disruptions and can keep its freshness. However, after eggs are laid, certain biological, chemical, and physical changes commence in it. The egg starts to cool down and its interior volume decreases, creating an air cell. Eggshell is covered with a water-resistant 20-30 microns' thick mucus layer, made of protein during laying. This protein coat prevents gas and any external microorganisms from penetrating it. There are 7000-17000 stomas on the eggshell and their size may vary based on several conditions (high temperature, high humidity, longtime storage, etc.). These stomas widen over time and the structure of mucus decays and cannot prevent microorganism penetration to egg at long-term storage conditions (Solomon, 2010; Kulshreshtha et al., 2022). This causes deterioration in the internal quality of the egg.

Parameters such as albumen index, yolk index, Haugh unit, ΔE (yolk color differences), albumen pH, *L*, *a**, *b** color value are used in determining the internal quality of the egg. The albumen index, pH and Haugh unit are the most important criteria used in determining internal egg quality (Doğan and Uluocak, 2008; Sarıbaş and Yamak, 2021). Albumin pH of fresh eggs is 7.6-8.5 and as the duration of storage is extended, the pH value of the albumin increases as carbon-dioxide and moisture loss does. Parallel to this, mucin, a component that gives the albumin a colloidal form loses this trait, and albumin becomes somewhat liquid. The quality of albumin is measured using the Haugh unit, invented by Raymond Haugh (Haugh, 1937). For edible eggs, this value should be higher than 79 in AA qualities, between 55-78 for A quality, between 31-54 for B quality, and 30 or lower in C quality (Şenköylü, 1995). Egg yolk should be yellow and located in the middle for fresh eggs. In time, due to the deterioration of the vitelline membrane, egg yolk drains water from albumin and loses its circular shape and becomes flatter. Egg yolk pH value is around 6.0 in fresh eggs and this value increases during the storage extend, as in albumin (Wang et al., 2017). It is possible to slow down such deteriorations by storing the eggs under better conditions.

This study was conducted to determine the quality and microbiology of eggs from chickens with four different genotypes stored under wholesaler and consumer conditions during the summer season and to contribute to the consumer's egg preference.

## Material and Methods

This experiment was carried out with a total of 880 eggs (220x4) obtained from Nick Chick, Dekalb, Lohmann Brown and Atabey (Native Hybrid) hens, 56 weeks old age in summer season (average temperature 36ºC) in Adana, Turkey. The quality criteria and microorganism level were evaluated in eggs stored under different temperature conditions. Each genotype of eggs was divided into two groups which were stored under room temperature (+29±2ºC; wholesaler conditions) and under refrigerator conditions (+4±1°C; consumer conditions) for four weeks. During the experiment, which lasted four weeks, internal quality traits of eggs were measured weekly. Albumen index, yolk index, and albumen pH value were measured. Egg weight loss (%), albumin and egg yolk weight, *L*, *a**, *b** value (HunterLab, Colorflex EZ, United States of America), albumin and egg yolk height, albumin and egg yolk diameter were measured and changes in the yolk index, albumen index, Haugh unit, albumen pH, ΔE were recorded in terms of interior quality measures.

## Preparations of Egg Shells

Randomly selected 5 eggs from each group were put in a sterile plastic bag, and bags considered as one composite sample. Buffered peptone water was (100 mL) poured into the egg samples in sterile bags, washed and scrubbed with fingers five min (ISO, 1993). Then first dilution from homogenized eggshell surfaces was obtained using other dilutions.

**Total Mesophilic Aerobic Bacteria (TMAB) Count**

Ten-fold dilution was obtained from sterile peptone water up to $10^{-9}$ from homogenized eggshell surfaces. Then 1 mL taken from the first homogenized sample added in 9 mL sterile peptone water. Thus secondly dilution was prepared. Different dilution of samples was inoculated 0.1 mL on PCA (Plate Count Agar) with drigalski spatula and incubated 24-48 h at 37°C. After incubation, colonies are counted by the Most Likely Number Method and calculated with the logarithmic Colony Forming Units (log CFU) per mL (Harrigan, 1998).

**Total Mold-Yeast Count**

For mold-yeast counts, eggshell dilutions from samples used up to $10^{-9}$ with 0.5 mL sterile pipettes and spread plate technique on Potato Dextrose Agar (PDA) plates with drigalski spatula. Plates incubated five days at 25˚C and colonies counted (by MPN Method) and calculated by log CFU per mL (Andrew, 1992).

**Statistical analysis**

All data obtained from the experiment were analyzed using the IBM SPSS 19.0 (IBM, 2010) statistical software package program. The normal distribution of data was analyzed as a completely randomized variance design (ANOVA) and the Tukey test used the comparison of means. The statistical significance level was defined as $P \leq 0.05$.

**Results**

The results of the experiment, egg weight loss increased linearly with storage time and highest at wholesaler condition ($P<0.05$). It was affected weeks and genotypes but not with conditions (Table 1).

**Table 1.** Interactions of different storage condition on egg quality characteristics obtained from different genotypes

| Parameters n=880 | Condition | Week | Genotype | Condition x Week | Condition x Genotype | Week x Genotype | Condition x Week x Genotype |
|---|---|---|---|---|---|---|---|
| **Egg weight loss (%)** | 0.056 | 0.020 | 0.05 | 0.189 | 0.505 | 0.831 | 0.010 |
| **Yolk weight (g)** | <0.01 | <0.01 | <0.01 | <0.01 | 0.106 | 0.111 | 0.071 |
| **pH** | <0.01 | <0.01 | <0.01 | <0.01 | 0.993 | <0.01 | 0.112 |
| **Yolk index** | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| **Albumen index** | <0.01 | <0.01 | 0.01 | <0.01 | <0.01 | 0.044 | <0.01 |
| **Haugh Unit** | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 | <0.01 |
| **ΔE** | <0.01 | <0.01 | <0.01 | <0.01 | 0.032 | 0.550 | 0.047 |
| ***L*** | <0.01 | 0.060 | <0.01 | <0.01 | <0.01 | 0.049 | <0.01 |
| ***a**** | 0.037 | <0.01 | 0.142 | 0.086 | 0.836 | 0.560 | 0.809 |
| ***b**** | <0.01 | <0.01 | 0.071 | <0.01 | 0.166 | 0.372 | 0.321 |

*L:* Brightness, *a**: Redness, *b**: Yellowness, ΔE: Yolk color differences

The best results were obtained at Lohmann eggs 5.90% and 3.68% respectively at the 4th week for wholesaler and consumer conditions (Table 2, 3).

As indicated in Table 1, egg pH was affected by week, genotype, storage conditions and their interactions ($P<0.01$). At the end of the 4th week, pH value was lower in Nick eggs (9.49) under wholesaler conditions, and in Lohmann eggs (9.25) under consumer conditions (Table 2, 3). At the end of the 4th week, there are no differences on yolk index, albumen index, HU, *L* and *a** values under wholesaler conditions (Table 2). The highest yolk index was obtained from Lohmann eggs and was found to be 49.76 at the beginning of the experiment (0 day), 15.65 under wholesale conditions and 45.37 under consumer conditions at the end of the 4th week (Table 2, 3). The best results in terms of albumen index were obtained from Nick eggs, it was determined as 12.33 at the beginning of storage time, and as 1.66 at the end of the 4th week under

wholesaler condition. It was also determined the highest albumen index on Dekalb eggs was 8.87 in consumer conditions (Table 2, 3).
Nick genotype showed the highest HU value (95.33) at the beginning of the storage day. The best Haugh unit value was determined from Atabey eggs (42.00) under wholesaler condition and from Dekalb eggs (83.77) under consumer condition at the end of the 4$^{th}$ week (Table 2, 3).

**Table 2.** Effect of wholesaler storage condition on egg quality characteristics obtained from different genotypes

| **Parameters n=440** | **0 day** | | | | **2.week** | | | | **4.week** | | | | **P** |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **N** | **D** | **LH** | **A** | **N** | **D** | **LH** | **A** | **N** | **D** | **LH** | **A** | |
| **Egg weight loss (%)** | - | - | - | - | 3.71 | 4.28 | 3.34 | 3.96 | 6.77 | 7.17 | 5.90 | 7.25 | <0.01 |
| **Yolk weight (g)** | 15.49 | 15.46 | 13.98 | 15.39 | 17.78 | 16.20 | 15.53 | 16.66 | 18.14 | 17.53 | 16.45 | 17.37 | <0.01 |
| **pH** | 8.34 | 8.35 | 8.28 | 8.43 | 8.71 | 8.65 | 8.65 | 8.72 | 9.49 | 9.59 | 9.54 | 9.64 | <0.01 |
| **Yolk index** | 42.15 | 41.61 | 49.76 | 40.99 | 24.11 | 23.58 | 26.51 | 20.88 | 12.81 | 13.70 | 15.65 | 13.03 | 0.069 |
| **Albumen index** | 12.33 | 11.01 | 10.54 | 10.47 | 3.05 | 3.30 | 3.21 | 2.52 | 1.66 | 1.61 | 1.56 | 1.59 | 0.310 |
| **HU** | 95.33 | 90.97 | 88.06 | 90.53 | 52.13 | 58.33 | 58.02 | 49.74 | 39.23 | 40.75 | 39.54 | 42.00 | 0.479 |
| **ΔE** | 85.77 | 87.18 | 85.68 | 86.87 | 99.73 | 100.03 | 97.89 | 99.77 | 100.50 | 100.10 | 99.97 | 101.02 | <0.01 |
| ***L*** | 60.53 | 60.23 | 59.15 | 60.38 | 61.10 | 60.15 | 60.86 | 61.50 | 60.63 | 60.73 | 60.39 | 60.89 | 0.527 |
| ***a* *** | 17.53 | 17.61 | 17.70 | 17.85 | 18.63 | 19.26 | 18.73 | 18.03 | 19.36 | 19.05 | 18.52 | 19.43 | 0.418 |
| ***b* *** | 58.09 | 60.27 | 59.33 | 59.79 | 76.47 | 77.52 | 74.30 | 76.39 | 77.69 | 75.15 | 77.38 | 78.12 | <0.01 |

*L:* Brightness, *a**: Redness, *b**: Yellowness, N: Nick, D: Dekalb, LH: Lohmann Brown, A: Atabey, ΔE: Yolk color differences, HU: Haugh Unit

In the study, no difference was observed between the genotypes in terms of *L* value, but *a** and *b** values were statistically important (P<0.01). Lightness (*L*), redness (*a**), yellowness (*b**) of yolk were affected by the storage conditions (P<0.01, P<0.05, P<0.01, respectively).

**Table 3.** Effect of consumer storage condition on egg quality characteristics obtained from different genotypes

| Parameters n=440 | 0 day | | | | 2.week | | | | 4.week | | | | P |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | N | D | LH | A | N | D | LH | A | N | D | LH | A | |
| Egg weight loss (%) | - | - | - | - | 1.91 | 2.62 | 2.43 | 2.39 | 3.78 | 4.80 | 3.68 | 4.26 | <0.01 |
| Yolk weight (g) | 15.49 | 15.54 | 13.98 | 15.39 | 15.57 | 16.05 | 15.27 | 16.24 | 16.70 | 16.47 | 16.43 | 16.74 | 0.020 |
| pH | 8.40 | 8.34 | 8.28 | 8.43 | 8.73 | 8.78 | 8.75 | 8.84 | 9.32 | 9.29 | 9.25 | 9.37 | 0.026 |
| Yolk index | 46.40 | 44.77 | 49.76 | 46.73 | 42.87 | 43.57 | 46.42 | 44.12 | 40.73 | 40.82 | 45.37 | 41.23 | <0.01 |
| Albumen index | 12.33 | 10.83 | 10.54 | 10.47 | 9.26 | 9.07 | 6.56 | 7.81 | 8.55 | 8.87 | 6.31 | 7.14 | <0.01 |
| HU | 95.33 | 90.97 | 88.06 | 90.53 | 84.95 | 80.17 | 80.32 | 81.27 | 81.88 | 83.77 | 74.16 | 77.66 | <0.01 |
| ΔE | 85.77 | 87.38 | 85.68 | 86.87 | 88.10 | 88.44 | 86.26 | 89.71 | 92.25 | 90.83 | 89.23 | 91.89 | 0.012 |
| *L* | 60.53 | 60.20 | 59.15 | 60.38 | 59.25 | 60.11 | 58.44 | 60.76 | 57.88 | 59.43 | 57.66 | 59.57 | 0.022 |
| *a* * | 17.53 | 17.69 | 17.70 | 17.85 | 18.51 | 18.02 | 17.85 | 18.32 | 19.32 | 18.59 | 19.03 | 19.09 | 0.772 |
| *b* * | 58.09 | 60.57 | 59.33 | 59.79 | 62.27 | 62.03 | 60.76 | 63.29 | 68.99 | 65.98 | 65.21 | 67.17 | 0.041 |

*L*: Brightness, *a**: Redness, *b**: Yellowness, N: Nick, D: Dekalb, LH: Lohmann Brown, A: Atabey, ΔE: Yolk color differences, HU: Haugh Unit

Color change (ΔE value) of yolk was affected by storage condition, week, genotype (P<0.01) (Table 1).

The lowest total bacteria level was measured for Lohmann eggs at the beginning of the storage day (4.22 log CFU/mL) (Figure 1).

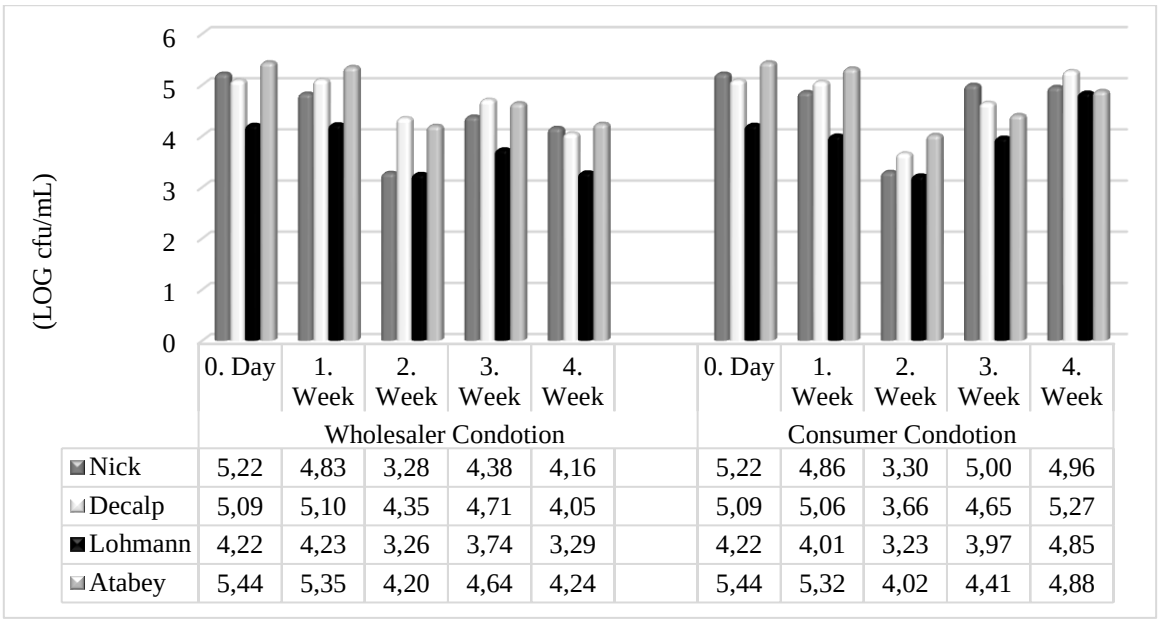
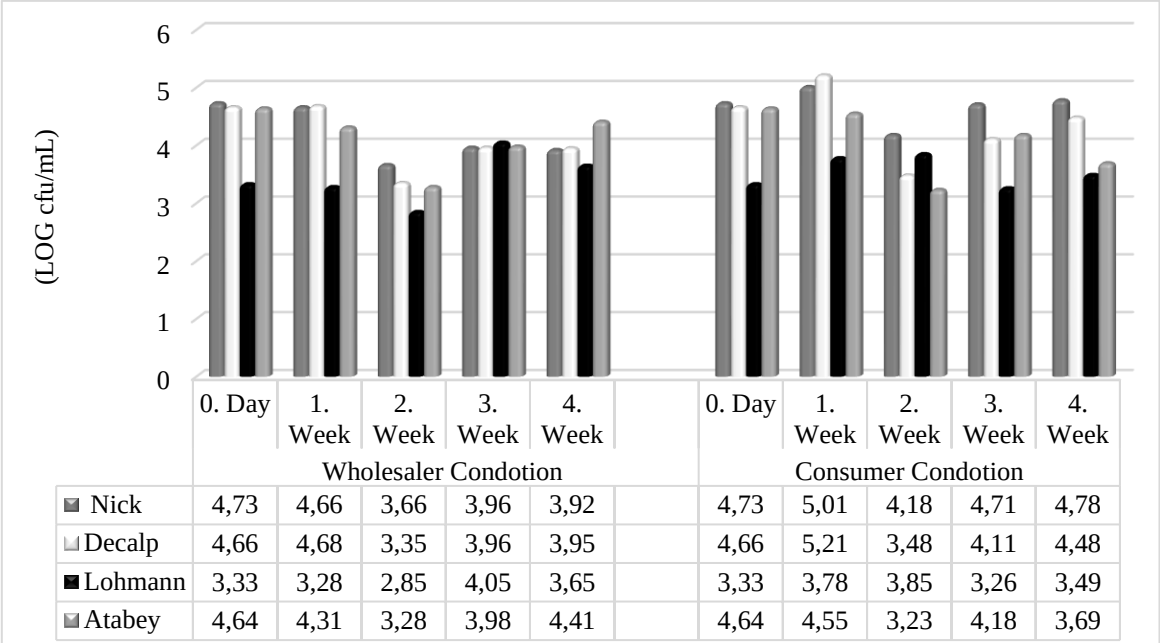



**Figure 1.** Total bacteria of eggs of different genotypes stored under wholesaler and consumer storage condition (n=200)

The total bacteria level decreased Lohmann genotype (3.29 log CFU/mL) in the wholesale storage condition and the Atabey hybrid (4.88 log CFU/mL) in the consumer storage condition at the end of the 4th week (Figure 1).




| | Wholesaler Condotion | | | | | | Consumer Condotion | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | 0. Day | 1. Week | 2. Week | 3. Week | 4. Week | | 0. Day | 1. Week | 2. Week | 3. Week | 4. Week |
| Nick | 4,73 | 4,66 | 3,66 | 3,96 | 3,92 | | 4,73 | 5,01 | 4,18 | 4,71 | 4,78 |
| Decalp | 4,66 | 4,68 | 3,35 | 3,96 | 3,95 | | 4,66 | 5,21 | 3,48 | 4,11 | 4,48 |
| Lohmann | 3,33 | 3,28 | 2,85 | 4,05 | 3,65 | | 3,33 | 3,78 | 3,85 | 3,26 | 3,49 |
| Atabey | 4,64 | 4,31 | 3,28 | 3,98 | 4,41 | | 4,64 | 4,55 | 3,23 | 4,18 | 3,69 |

**Figure 2.** Total mold-yeast of eggs of different genotypes stored under wholesaler and consumer storage condition (n=200)

According to the results of the research, the lowest mold-yeast level was measured with 3.33 log CFU/mL in Lohmann genotype at the beginning of the storage day. Similarly, the lowest mold-yeast level was determined as 3.65 log CFU/mL for wholesaler storage condition and as 3.49 log CFU/mL for consumer condition in Lohmann at the end of the 4th week (Figure 2).

**Discussion**

When purchasing eggs, consumers initially priorities the assessment of egg freshness. The degree of freshness in eggs is directly correlated with the extent to which internal quality features are maintained. Therefore, it is imperative to establish suitable conditions that can effectively maintain the freshness of eggs throughout storage. The negative effect of extended storage period and elevated temperatures on egg quality, freshness, and shelf life has been documented in several studies (Mathew et al., 2016; Ronald Santos et al., 2019; Altunatmaz et al., 2020; Chousalkar et al., 2021). According to Martinez et al. (2021), the duration and temperature of storage were found to have a substantial effect on both the internal and external quality of eggs. Several studies have documented a notable reduction in egg weight with increasing temperature and period of storage (Siyar et al., 2007; Lee et al., 2016; Hagan and Eichie, 2019; Yamak et al., 2021). The present study observed a linear rise in egg weight loss as storage time increased, which aligns with the findings reported in the aforementioned publications. Upon evaluating the study findings with respect to genotypes, it was seen that the most favourable outcomes in relation to wholesaler and consumer conditions were observed during the fourth week in Lohmann eggs, with percentages of 5.90% and 3.68% respectively.

As temperature and storage time rise, it is well known that the egg's internal quality decreases (Jin et al., 2011; Martinez et al., 2021). Furthermore, storage is said to have an impact on quality even in the short term (Gavril and Usturoi, 2012). The parameters that are most effected by these conditions include electrical conductivity, albumin and yolk pH, Haugh unit,

air cell height, and albumin height (Şamlı et al., 2005; Jin, et al., 2011; Okur and Şamlı, 2013). Numerous studies have shown that while albumin and yolk width, pH, and yolk weight are increasing during storage, albumin weight, albumin and yolk height, Haugh unit, and albumin and yolk index decrease (Siyar et al., 2007; Chung and Lee, 2014; Kralik et al., 2014; Hagan and Eichie, 2019; Altunatmaz et a., 2020). In this study, throughout the storage period for both conditions and all genotypes, Haugh Unit, albumen index, albumen height, and yolk height declined while the yolk weight, yolk width, albumen widths, albumen lengths, pH, and ΔE value rose. The results of this investigation were consistent with those of other investigations.

It was also mentioned that room temperature and refrigerator temperature conditions differed significantly from one another. Eggs that are intended for consumption must be refrigerated and should not be kept longer than two weeks since eggs that are kept at room temperature decay more quickly than eggs that are kept in a refrigerator (Avan and Alişarlı, 2002; Yenilmez et al., 2017). To the extent that, in refrigerated settings, the quality of the yolk height, albumen, and Haugh unit also significantly decreases (Yamak et al., 2021). In the same way, under both wholesaler and consumer conditions in this investigation, the Haugh unit and albumen height decreased, while under wholesaler conditions, yolk height increased.

Numerous researchers have reported that pH values rise with storage temperature and duration (Scott and Silversidest, 2000; Siyar et al., 2007; Alsobayel and Albadry, 2011; Chung and Lee, 2014; Kralik et al., 2014; Mathew et al., 2016). In a similar vein, all genotypes in this study under both conditions have seen an elevation in pH during the course of storage. The analyses revealed that, whereas Nick eggs had the lowest pH value under wholesaler conditions, Lohmann eggs had the lowest pH value under consumer conditions.

The yolk in the Turkish Food Codex Egg Communique should be visible in the center during a light examination as a circle and a shadow; it should also not include any foreign objects and should not detach from the center when the egg is turned (TSE, 2015). In TS 1068, there is no specified value for egg yolk. Furthermore, according to Mineki and Kobayashi (1998), the yolk index value, which measures the egg yolk's capacity to hold erect without spreading, can range from 36-44% in fresh eggs. According to Doğan and Uluocak (2008), the yolk index of fresh eggs ranges from 40 to 46, but Sarıca and Erensayın (2018) assert that the egg yolk index need to exceed 46. In this research, Lohmann eggs had the highest yolk index at the end of storage under both wholesaler (15.65) and consumer conditions (45.37). In consumer conditions, Lohmann eggs were able to maintain their freshness for up to four weeks based on the yolk index; in wholesaler conditions, this preservation was limited to the first day. Conversely, in both consumer and wholesaler conditions, other genotypes eggs only satisfied the first-day freshness requirements.

The Turkish Food Codex Egg Communique (TSE, 2015) and Turkish Standards Institute TS 1068 both provide no value for the egg albumen index. However, one of the most crucial factors in assessing the quality of eggs is the albumen index. It is desirable that it be high in both table and breeding eggs. The normal limits of the albumen index value are between 8-11.8% (Jin et al., 2011). As per the results of this investigation, Nick eggs showed the best albumen index values on the first day of examination. Similarly, when four genotypes of eggs are examined at the end of $4^{th}$ week, the best outcomes are achieved from Nick eggs under wholesaler conditions and Dekalb eggs under consumer conditions. At the end of $4^{th}$ week, it was found that, under consumer conditions (in the refrigerator), Lohmann and Atabey eggs stayed below standard limits, whereas Nick and Dekalb eggs were within normal limits (8.55, 8.87). Only the first day's albumen index under wholesaler settings was within normal bounds; in the first, second, third, and fourth weeks, it was below normal limits. These findings show that eggs from Nick and Dekalb can be kept fresh

for four weeks under consumer conditions (+4Cº), whereas eggs from the other groups can only keep freshness for the first week under wholesaler conditions (+29Cº) in the summer. The results of this study are same line with to the findings of Altunatmaz et al. (2020).

For a variety of applications, it is the most often used Haugh unit for determining albumen quality. In addition, Doğan and Uluocak (2008) state that the Haugh unit is a crucial factor in assessing the freshness of eggs. The Turkish Food Codex Egg Communique (TSE, 2015) and Turkish Standards Institute TS 1068 both list the minimum quality requirements for Class A eggs as ≥72 for extra fresh eggs, 71–51 for fresh eggs, and ≤50 for class B eggs. Haugh unit value and quality are positively correlated (Feddern et al., 2017). The quality increases with the Haugh unit value. The Haugh unit experiences a decrease due to negative effects from temperature and storage duration (Hagan and Eichie, 2019). Our study's findings indicate that while the four genotype eggs could only maintain their fresh feature for two weeks at room temperature, they were able to maintain their extra fresh feature for four weeks when stored under consumer condition. The Haugh unit was observed from Dekalb eggs in consumer condition and from Atabey eggs wholesaler conditions. Because of its superior performance in commercial conditions, local Atabey eggs are able to retain their freshness in the summer, even when left at room temperature. It is possible that this indicates the Atabey local genotype is more flexible in response to environmental changes, but the Dekalb foreign genotype can preserve its quality in standard conditions.

Egg yolk color is affected by genotype, age, lysine level in feed, rearing system, fats and antioxidants, vitamin A and calcium consumption, antibiotics and drugs, and some unknown factors (Sarıca and Erensayın, 2018). Consumers' yolk color preferences vary and this is one of the most important factors affecting consumers' purchasing preferences. While dark color yellow is popular in Turkey, pale yellow is chosen in Western nations. This is because dark yellow eggs are thought to have more flavor and nutritional value. The egg's flavor and nutritional content are unaffected by its color, though. According to consumer preference, the color of food can be changed with the help of different additives (Doğan and Uluocak, 2008; Mızrak et al., 2012; Kamanlı and Türkoğlu, 2018). In reference to egg yolk color, the Turkish Standards Institute specifies in TS 1068 that the yolk color should be distinct, although the Turkish Food Codex Egg Communique does not provide a statement for egg yolk color (TSE, 2015). In the current study, $a^*$ and $b^*$ values varied between the genotypes, but no change in color was seen in terms of $L$ value. A difference between the $L$ and $b^*$ values was also found with regard to storage conditions. Egg color variations (ΔE value) were influenced by week, genotype, and different conditions ($P<0.01$). The color of egg yellow becomes darker with a lower ΔE value. By the end of the 4$^{th}$ week, the yolk color of Lohmann eggs was darker under both conditions. The availability and profile of carotenoids in the diets are the primary determinants of egg yolk color. However, egg yolk color is also significantly influenced by genetics, hen age and breed, illnesses, living circumstances, cleanliness, use of antibiotics and other drugs (Onbaşılar and Yalçın, 2021). Given that all other experimental settings were identical, genetics might be the cause of the darker of the yolk color.

Eggshell bacterial contamination may be impacted by storage conditions (Mallet et al., 2010). To ensure that the egg is safe and does not pose a health risk to humans, the overall number of bacteria on egg shell must remain below specific thresholds. A threshold of 5 log CFU/mL was reported by De Reu et al. (2009), which may be interpreted as indicating eggshells of a hygienic quality that is acceptable. The eggshell total viable count and mean log mean values above the permitted limitations established by the International Commission on the Microbiological Specification for Food (ICMSF) of $10+10^5$ and 6.00, respectively. By the conclusion of the fourth week, the overall number of microorganisms on the eggshell was, on the whole, within allowable bounds, according to the research findings. The first day's

measurements of Lohmann eggs showed the lowest amount of total bacteria. Similar to this, the lowest total bacterial level was found for consumer condition in Atabey eggs, but for wholesaler condition in Lohmann eggs at the end of the 4th week. According to Kraus et al. (2022), the total number of microorganisms varied between genotypes at the conclusion of the experiment.

Kardal et al. (2018) found mold and yeast load of market and village eggshells 6.80 and 6.97 log CFU/mL. Whereas, in the current research, the mold and yeast level was less than 5 log CFU/mL. By the end of the 4th week the mold-yeast level in Lohmann eggs under both conditions was the lowest.

The experiment's findings showed that the weight loss of the eggs increased linearly with storage time and highest under wholesaler conditions. Haugh Unit, albumen index, albumen height, and albumen width decreased over the storage period for all conditions and all genotypes, but the yolk weight, yolk width, albumen widths, albumen lengths, pH, and ΔE value increased. In comparison, all group eggs can only keep their freshness for the first week under wholesale conditions (+29ºC), while in the summer, Nick and Dekalb eggs may be kept fresh for 4th week under consumer conditions (+4ºC). The excellent performance of Atabey regarding the Haugh unit under wholesaler conditions demonstrates that local Atabey eggs retain their freshness better even in hot weather. The lowest pH value was found in Nick eggs under wholesaler conditions and in Lohmann eggs under consumer conditions as a consequence of our evaluation of pH values. In consumer conditions, Lohmann eggs were able to maintain their freshness for up to four weeks based on the yolk index; in wholesaler conditions, this preservation was limited to the first day. Conversely, in both consumer and wholesaler conditions, other genotypes eggs only satisfied the first-day freshness requirements.

Lohmann eggs were therefore less impacted than other genotypes from wholesaler conditions. By the end of the 4th week, the overall number of microorganisms, mold, and yeast on the eggshell was mostly within acceptable limits, and the eggshell's microbial load had not increased under wholesaler or consumer conditions. In the summer, local Atabey eggs kept their quality better even when kept in a room. Consequently, native Atabey can be preferred by breeders instead of foreign genotypes.

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