Introduction

Albumen quality is a measurable trait and it is a function of the height for the inner thick albumen, the Haugh unit is an outcome of this measurement [11], or more properly only the albumen height alone [17,19]. The major factors in determining egg quality are egg storage time, conditions, strain and age of hen. There also are minor influences of nutrition in specific cases Williams [25].

The impact of pre-incubational egg storage on embryonic viability depends on storage time, environmental conditions, age, and strain [5]. According to many studies, the Haugh unit, albumen index, yolk index, egg weight, albumen weight, yolk weight, shell weight, shell thickness and shell membrane thickness are affected by storage time [2,12,22,23,24].

As the age of the layer increases the albumen height decreases even as the egg weight and total amount of albumen increases. The albumen height, Haugh unit, albumen and yolk indices of all eggs are at maximum when the eggs are laid and decrease with increased storage time [12,18,19,23,24].

Prolonged storage of hatching eggs has been shown to interfere with normal progress and egg constituents of chicken [BRAKE 1997]. Though, hatchability decreases rapidly after 6-7 day holding periods although eggs, properly stored, can be held 10 to14 days with reasonable results [8]. Hatchability of eggs decreases quickly after 7 days of storage period for pheasant [27], 14 days of storage time for quail, hen and geese [4,10,27,], 28 days of storage length for partridge [26,27].

Partridge eggs weights vary from 16 to 25 g (about 21 g), and are oblong in shape, and are an average 42 mm long and 31 mm wide. Egg shell thickness of partridge eggs are about 0.228 mm and shell membrane is about 0.047 mm. The wet proportion of shell, yolk and albumen to total egg weight are 15.2%, 35.0% and 49.8%, respectively [27]. WOODARD and MORZENTI [26] reported the hatchability of partridge eggs stored 1-7, 8-14, 15-21 and 22-28 days as 60.2, 62.8, 62.4 and 52.7% respectively. In addition, WOODARD [27]
also reported the hatchability for the eggs stored in 1-7, 8-14, 15-21, 22-28, 29-35 and 36-42 days as 78.4, 77.1, 79.4, 66.0, 37.7 and 22.3%, respectively.

Freshly laid and stored eggs of partridge (\textit{Alectoris graeca}) were examined in this study to investigate the importance of storage time on external and internal egg characteristics in partridge.

### Material and methods

#### BIRDS AND HOUSING

The research was conducted in poultry unit of the research farm in Kafkas University, Turkey. Partridge was settled with 1 male and 1 female in the layer cages. Partridges were fed with a concentrate as explained in Table I, to meet the National Research Council recommendations for laying pheasant [14]. The concentrate and the water were \textit{ad libitum} during the laying period.

#### EGG CHARACTERISTICS

Eggs were collected daily after the numbering with their physical measurements and weights. According to storage time eggs were broken and evaluated in days of 0 (n=33), 7 (n=30), 14 (n=34), 21 (n=32), 28 (n=37) and 35 (n=40). Eggs were stored at room temperature (about 15-18°C). At sampling, eggs were weighed and broken on to a flat surface where the height of the albumen was measured, half way between yolk and edge of the inner thick albumen by using albumen height gauge. The diameters of the thick albumen were measured using micrometer. The yolk was separated from the albumen and weighed. The shells were dried at room temperature and weighed according to SCOTT and SILVERSIDES [17]. The shell thickness were measured from the three different parts of shell in each (equator, top and truncated edge) egg using a micrometer and was averaged and recorded as shell thickness. The weight of the albumen was calculated as the difference between the weight of the egg and the weight of the yolk and shell. Then, Haugh unit, albumen index, yolk index and egg weight loss were calculated as follows:

\[
\text{Haugh unit} = 100 \times \log \left( \frac{\text{Albumen height} + 7.57 - 1.7 \times \text{Egg weight}^{0.37}}{} \right)
\]

\[
\text{Albumen index} = \frac{\text{Albumen height (mm)}}{[\text{Albumen length (mm)} + \text{Albumen width (mm)}]} \times 100
\]

\[
\text{Yolk index} = \frac{\text{Yolk height (mm)}}{\text{Yolk diameter (mm)}} \times 100
\]

\[
\text{Egg weight loss} = \left[ \frac{\text{Egg weight} - \text{Egg broken weight}}{\text{Egg weight}} \right] \times 100
\]

The maximum widths and lengths of each egg were measured with callipers and their shape indices were calculated using the formula:

\[
\text{Shape index} = \frac{\text{maximum width (mm)}}{\text{maximum length (mm)}} \times 100
\]

#### STATISTICAL ANALYSIS

All data were analysed with the One-Way ANOVA procedure using SPSS statistical package. The significant means were compared by Duncan’s test [21].

### Results

Means with their standard errors for egg weight, egg broken weight, egg weight loss, shape index, egg shell thickness, shell weight and shell ratio were presented in Table II. Effect of storage time was statistically significant on egg broken weight, egg weight loss and shell weight (P < 0.05-0.001). The egg weights of all stored eggs were nearly identical (20.58-20.95 g). The egg weight loss increased with the increasing of storing days. Storage of 0 to 35 days did not affect shape index, egg shell thickness and shell ratio (P > 0.05).

Table III shows albumen weight, albumen ratio, yolk weight, yolk ratio, yolk index, albumen index and Haugh unit according to storage time. Effect of storage time was statistically significant on albumen weight, albumen ratio, yolk ratio, yolk index, albumen index and Haugh unit (P <0.001). Yolk weight, Haugh unit, albumen and yolk indices decreased with increasing storage days. The values yolk weight of all storage times was close to each other. In addition yolk weight, albumen weight and albumen ratio were displayed irregular distribution. Storage time from 0 to 35 days did not affect yolk weight (P > 0.05).

### Discussion

Average weight of partridge eggs is 16-25 g [27]. Overall mean for egg weight in this study was found as 20.77 g. This result agrees generally with the findings of ÇETIN et al. [6] and SONG et al. [20]. The egg weight loss increased together with days of storage as reported by IMAI [12], ALTAN et al. [2], FASENKO.
EFFECTS OF STORAGE TIME ON CHARACTERISTICS IN PARTRIDGE EGGS


et al. [10] and TILKI and INAL [23,24] for many poultry species. Egg weight loss increased together with storage time by 1.38%.

The overall mean values for shape index in this study (77.06%), which was affected by storage time (P > 0.05), agree with values reported by WOODARD [27] for partridge eggs and SONG et al. [20] for pheasant, chukar, quail and guinea fowl eggs.

The shell thickness was not changed with days of storage as reported by TILKI and INAL [23,24] for geese eggs. The overall mean values for shell thickness in our study (0.23 mm) agree with the values reported that by SONG et al. [20] and WOODARD [27] for partridge eggs.

With the increase of storage period, the percentage of egg yolk increased, and the percentage of albumen decreased, but the percentage of shell did not change. The findings are generally in agreement with the results reported by other researches [17,18,23,24], who have found that shell weight does not change with storage. SONG et al. [20] reported the percentage of egg yolk, albumen and shell as 33.9%, 57.4%, and 9.7%, respectively. Reported [20] shell and yolk percentage were slightly larger than the findings of this study, but albumen percentage was lower then the current study. In addition, the percentage of albumen was lower than those found in pheasant, chukar and guinea fowl by SONG et al. [20]. The percentages of yolk, albumen and shell in this study were similar to the reported values by WOODARD [27].

Any literature about Haugh unit, albumen and yolk indices could not be found for partridge; therefore present findings were discussed with the results of other poultry species.

Haugh unit, albumen and yolk indices decreased with storage, as expected [12,19,23]. Haugh unit, yolk and albumen indices decreased with increasing days of storage. Haugh unit, yolk and albumen indices were 87.18, 49.53%, and 7.39%, respectively for fresh eggs (without storage). They also were determined as 61.67, 40.64% and 1.99%, respectively for 35 days of storage, respectively. Haugh unit, yolk and albumen indices decreased 25.51 units, 8.89%, and 5.40% from 0 to 35 days. The Haugh units of fresh partridge eggs were almost the same as hen,

Table II. — Effect of storage time on exterior characteristics feature of partridge egg.

<table>
<thead>
<tr>
<th>Days of Storage</th>
<th>0 day (n=33)</th>
<th>7 (n=30)</th>
<th>14 (n=34)</th>
<th>21 (n=32)</th>
<th>28 (n=37)</th>
<th>35 (n=40)</th>
<th>Overall (n=206)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Egg weight, g</td>
<td>20.58 ± 0.25</td>
<td>20.70 ± 0.22</td>
<td>20.70 ± 0.24</td>
<td>20.90 ± 0.25</td>
<td>20.76 ± 0.20</td>
<td>20.95 ± 0.15</td>
<td>20.77 ± 0.09 NS</td>
</tr>
<tr>
<td>Egg broken weight, g</td>
<td>20.58 ± 0.25^a</td>
<td>20.26 ± 0.22^a</td>
<td>20.00 ± 0.24^a</td>
<td>19.98 ± 0.25^a</td>
<td>19.25 ± 0.21^b</td>
<td>19.13 ± 0.20^b</td>
<td>19.82 ± 0.10 ***</td>
</tr>
<tr>
<td>Egg water loss, %</td>
<td>0.00 ± 0.00</td>
<td>0.44 ± 0.02^a</td>
<td>0.70 ± 0.01^a</td>
<td>0.92 ± 0.03^c</td>
<td>1.51 ± 0.04^d</td>
<td>1.82 ± 0.06^e</td>
<td>0.95 ± 0.05 ***</td>
</tr>
<tr>
<td>Shape index, %</td>
<td>78.33 ± 0.65</td>
<td>77.39 ± 0.46</td>
<td>76.38 ± 0.31</td>
<td>76.66 ± 0.54</td>
<td>76.99 ± 0.42</td>
<td>77.62 ± 0.47</td>
<td>77.06 ± 0.20 NS</td>
</tr>
<tr>
<td>Egg shell thickness, mm</td>
<td>0.24 ± 0.01</td>
<td>0.25 ± 0.01</td>
<td>0.22 ± 0.01</td>
<td>0.23 ± 0.01</td>
<td>0.22 ± 0.01</td>
<td>0.21 ± 0.01</td>
<td>0.23 ± 0.00 NS</td>
</tr>
<tr>
<td>Shell weight, g</td>
<td>2.78 ± 0.04^a</td>
<td>2.75 ± 0.06^a</td>
<td>2.64 ± 0.03^b</td>
<td>2.64 ± 0.04^c</td>
<td>2.65 ± 0.03^d</td>
<td>2.65 ± 0.03^e</td>
<td>2.66 ± 0.02^f</td>
</tr>
<tr>
<td>Shell ratio, %</td>
<td>13.58 ± 0.22</td>
<td>13.59 ± 0.24</td>
<td>13.25 ± 0.14</td>
<td>13.24 ± 0.24</td>
<td>13.83 ± 0.18</td>
<td>13.91 ± 0.16</td>
<td>13.58 ± 0.08 NS</td>
</tr>
</tbody>
</table>

Mean ± standard error, a-e : Differences between values having different letters in the same line are statistically significant (P < 0.05). NS: Non significant (P > 0.05), **: P < 0.01, ***: P < 0.001.

Table III. — Effect of storage time on interior characteristics feature of partridge egg.

<table>
<thead>
<tr>
<th>Days of Storage</th>
<th>0 day (n=33)</th>
<th>7 (n=30)</th>
<th>14 (n=34)</th>
<th>21 (n=32)</th>
<th>28 (n=37)</th>
<th>35 (n=40)</th>
<th>Overall (n=206)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Albumen weight, g</td>
<td>10.16 ± 0.17^a</td>
<td>9.88 ± 0.17^b</td>
<td>9.62 ± 0.15^b</td>
<td>9.42 ± 0.19^b</td>
<td>8.83 ± 0.17^b</td>
<td>8.76 ± 0.19^b</td>
<td>9.40 ± 0.08 ***</td>
</tr>
<tr>
<td>Albumen ratio, %</td>
<td>49.37 ± 0.48^a</td>
<td>48.77 ± 0.47^ab</td>
<td>48.07 ± 0.27^b</td>
<td>47.01 ± 0.49^c</td>
<td>45.87 ± 0.55^c</td>
<td>45.69 ± 0.77</td>
<td>47.31 ± 0.25 ***</td>
</tr>
<tr>
<td>Yolk weight, g</td>
<td>7.64 ± 0.12</td>
<td>7.63 ± 0.08</td>
<td>7.73 ± 0.09</td>
<td>7.93 ± 0.10</td>
<td>7.77 ± 0.10</td>
<td>7.73 ± 0.11</td>
<td>7.74 ± 0.04 NS</td>
</tr>
<tr>
<td>Yolk ratio, %</td>
<td>37.12 ± 0.35^a</td>
<td>37.73 ± 0.42^ab</td>
<td>38.68 ± 0.22^d</td>
<td>39.75 ± 0.37^c</td>
<td>40.37 ± 0.46^c</td>
<td>40.46 ± 0.59^c</td>
<td>39.11 ± 0.20 ***</td>
</tr>
<tr>
<td>Yolk index, %</td>
<td>49.53 ± 0.42^a</td>
<td>47.29 ± 0.26^b</td>
<td>44.46 ± 0.33^b</td>
<td>43.52 ± 0.51^c</td>
<td>42.40 ± 0.45^d</td>
<td>40.64 ± 0.47^a</td>
<td>44.43 ± 0.27 ***</td>
</tr>
<tr>
<td>Albumen index, %</td>
<td>7.39 ± 0.21^a</td>
<td>5.37 ± 0.12^a</td>
<td>4.30 ± 0.03^b</td>
<td>4.14 ± 0.14^b</td>
<td>2.81 ± 0.06^b</td>
<td>1.99 ± 0.03^c</td>
<td>4.21 ± 0.13 ***</td>
</tr>
<tr>
<td>Haugh Unit</td>
<td>67.18 ± 0.46^a</td>
<td>62.53 ± 0.35^b</td>
<td>80.69 ± 0.25^b</td>
<td>78.01 ± 0.73^c</td>
<td>66.75 ± 0.39^d</td>
<td>61.67 ± 0.38^e</td>
<td>75.78 ± 0.65 ***</td>
</tr>
</tbody>
</table>

Mean ± standard error, a-e : Differences between values having different letters in the same line are statistically significant (P < 0.05). NS : Non significant (P > 0.05), ***: P < 0.001.
quail and geese eggs [3,12,13,16]. But Haugh unit of fresh partridge eggs were higher than that reported by ERISIR et al. [9] for turkey eggs, ROSINSKI [15], TILKI and INAL [23,24] for goose eggs, ALTINEL et al. [2] for hen eggs.

Albumen index of fresh partridge eggs were lower than that reported by several researches [1,3,13,16,23,24]. But albumen index of fresh partridge eggs was higher than that reported by ERISIR et al. [9] for turkey eggs. Yolk index of fresh partridge eggs were similar with the values reported by ALTINEL et al. [3] for quail eggs. But yolk index was higher than that reported by several researches [1,2,9,13,16,23,24].

Fertility, hatchability and hatchability of fertile eggs decrease with increasing storage time [7,10,26,27]. Changing in some interior quality (Haugh unit, albumen and yolk indices), with the effect of storage time might indirectly affect the fertility, hatchability and hatchability of fertile eggs. It is acceptable that fertility, hatchability and hatchability of fertility eggs may easily be affected by the Haugh unit yolk and albumen indices. It is the well-known reality that hatchability is one of the most important traits in poultry breeding. Therefore, determination of the egg properties in partridge is important, because of the relationship between the egg properties and hatchability. Conversely, internal and external characteristics of partridge eggs showed a resistance to storage time, much better than other domestic poultry such as chicken. This might be a result of the domestication level of partridge; these birds can not be called as domestic poultry yet. Therefore, there might be still protection on their eggs against the damage of storage condition and time as similar as in the natural environment.

References