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Research Article

Evaluation of Quality Parameters of Chicken Eggs Stored at Different Temperatures

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Abstract

This study was carried out to evaluate the effect of temperature and time on the internal and external quality of chicken eggs stored at room and fridge temperature for 28 days. A total of 176 eggs of Lohmann Brown (LSL) laying hens were used for the study. The eggs from the same batch were stored at fridge (5°C) and room temperature (25°C), internal and external quality parameters and microbiological analyzes of eggs were evaluated on days 0, 1, 8, 18, 21 and 28. No coliform bacteria, *E. coli* and *Salmonella* spp. were detected. At the end of the evaluation, the eggs stored at room temperature were found to have been negatively affected in terms of albumen index and Haugh unit parameters from day 8 onwards. When a comparison was made between the eggs kept in the room and the fridge temperature, significant differences were found in terms of albumen index, Haugh unit, egg yolk index and egg yolk height parameters ($P<0.05$). As a result, it is predicted that the storage temperature and duration play an important role in preserving the freshness of the eggs and the eggs should be kept under the cold chain, especially from day 8 onwards after the egg laying date.

Keywords: *Chicken egg, Storage temperature, Storage duration, Shelf life, Quality*

Farklı Sıcaklıklarda Depolanan Tavuk Yumurtalarının Kalite Parametrelerinin Değerlendirilmesi

Öz

Bu araştırma oda ve buzdolabı sıcaklığında 28 gün depolanan tavuk yumurtalarında sıcaklık ve sürenin yumurtaların iç ve dış kalitesine etkisini değerlendirmek amacıyla yapıldı. Araştırma için Lohmann Brown (LSL) cinsi yumurtacı tavuklara ait toplam 176 adet yumurta kullanıldı. Aynı partiden alınan yumurtalar buzdolabı (5°C) ve oda sıcaklığında (25°C) muhafaza edildi. 0, 1, 8, 18, 21 ve 28. günlerde, yumurtaların iç ve dış kalite parametreleri ile mikrobiyolojik analizleri değerlendirildi. Örneklerin hiçbirinde koliform bakteri, *E. coli* ve *Salmonella* spp. tespit edilmedi. Değerlendirme sonucunda, oda sıcaklığında muhafaza edilen yumurtalar 8. günden itibaren yumurta akı indeksi ve Haugh ünitesi parametreleri açısından belirgin düzeyde olumsuz etkilendi. Oda ve buzdolabı sıcaklığında muhafaza edilen yumurtalar arasında kıyaslama yapıldığında; albumen indeksi, Haugh ünitesi, yumurta sarısı indeksi ve yumurta sarısı yüksekliği parametreleri açısından anlamlı farklar olduğu belirlendi ($P<0.05$). Sonuç olarak, yumurta tazeliğinin korunmasında depolama sıcaklığının ve sürenin önemli bir rolü olduğu, yumurtaların yumurtlama tarihinden sonra en fazla 8. günden itibaren soğuk zincirde muhafaza edilmesi gerekliliği öngörülmüştür.

Anahtar sözcükler: *Tavuk yumurtası, Depolama sıcaklığı, Depolama süresi, Raf ömrü, Kalite*

INTRODUCTION

Egg is an important animal food that contains many nutrients required for a balanced human nutrition. In particular, it is indispensable for being rich in essential amino acids, its digestibility of 95% and its biological value of 100% [1-3].

All eggs offered in retail markets as well as used in the production processes as a raw material must be fresh, reliable and meet the quality criteria. The eggs can be exposed to microbial contamination during storage, transportation, sales and also quality losses depending on the storage conditions. Egg quality is significantly influenced by

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environmental conditions such as temperature, humidity and also duration of storage [4]. Various studies were carried out to minimize the quality changes in eggs. In the long-term preservation of eggs, some technologies such as cold storage, UV, ozone, modified atmosphere packaging, coating and washing are used [5,6].

The eggshell is covered with a layer of water-proof mucous featured cuticle, which is very thin (5-10 µm). The cuticle layer generates a barrier for microorganisms and a natural defence mechanism for the egg while allowing the passage of gas and moisture. This layer may lose its properties in a short time after the egg laying. The cuticle layer can be destroyed via mechanical washing of the eggs and thus the mechanism of preventing the eggs from microorganism penetration may be impaired [6-8]. There are about 7500 pores in the eggshell. Depending on the storage conditions, the size of these pores increases and allows microorganisms to penetrate the egg [9].

It is possible to cover the eggs with various coating materials and to extend the storage period [10]. According to the egg relevant legislation in Turkey, an A-class egg cannot be cleaned by washing or any other cleaning method and must not be oiled. Therefore, the best preservation method for the eggs sold in retail markets in order to limit the quality changes caused by the storage is the cold storage. It is stated that the best conditions for the cold storage are 4-5°C and moisture of 75-85% [11].

The storage of the egg in improper storage conditions causes a change in the quality parameters within a few days. Especially the air sac widths, albumen and egg yolk height are affected by these changes.

Changes in egg albumen are the most prominent parameters that vary depending on storage temperature and duration. Depending on the storage duration and temperature, the height of the egg albumen which is measured from the nearest part of egg yolk, reduces, also thins and the fluidity increases. Depending on the decrease in density, the fluidity towards the thin albumen section increases. Increased pH and loss of carbon dioxide depending on the progress of the storage process causes changes especially in lysozyme-ovomucine complex as an egg white protein. This has negative effects on the gelatinous structure of the albumen. Another important alteration of the storage process having an effect on egg quality is a decrease in egg yolk height and the easy disintegration of the storage in the subsequent processes depending on the thinning of vitelline membrane. Another change is regarding pH values. The pH of egg yolk is approximately 6.0 and does not contain carbon dioxide. Depending on the storage process the egg yolk pH value does not show any significant change. The pH value of albumen is initially about 7.6. Depending on storage time, due to the outflow of carbon dioxide, pH can rise to about 9.0 [4,8,12].

Changes in egg quality parameters affect consumers' consumption and quality classification of the egg. The eggshells of high quality, class-A eggs sold in retail markets in Turkey must be clean, uncracked, unbroken and have a normal shape. Air sac cannot be higher than 4 mm in eggs for eggs sold as "extra fresh" (from the date of egg laying up to the ninth day) and must not exceed 6 mm for others. Egg albumen should be clear, transparent, gel and free from foreign substances. Egg yolk should be in the center of the egg and free from foreign substances. The egg should not contain a visible embryo and should not contain foreign odor. According to the egg-related Turkish legislations, there is no obligation for eggs to be cooled until the 18th day after the egg laying, however, they must be stored between (+8)/(+5)°C after day 18. Under these conditions, it is stated that a class A egg should be delivered to the consumer within 21 days from the laying date and the expiry date must be within 28 days from the date of egg laying [11]. One of the most important quality parameters for the egg is the Haugh unit value. This value varies considerably with the changes in the albumen of the egg depending on the storage. The Haugh unit value can show variations in direct proportion to the egg weight. Turkish Food Codex does not specify any parameters for this value.

It is possible to slow down the spoilage and undesired quality changes when the eggs are stored in appropriate storage conditions from the time they are taken from the chicken. Therefore, the purpose of this study is to evaluate the effects of the preservation of the eggs at room and fridge temperatures on some quality parameters.

MATERIAL and METHODS

Clean, brown, unfertilized, fresh (from day 0) and uncleared eggs were used in this research. A total of 176 eggs of Lohmann Brown (LSL) chickens were used for the study. The eggs were randomly selected from those chickens which had laid eggs on the same day. Egg samples were delivered to the laboratory within 2 h complying with the aseptic conditions. Selected eggs were divided into two equal groups. The first group, the ambient temperature group (AT) was stored in a 25°C incubator (Nüve) whereas the other group, the fridge temperature group (FT) was stored in a 5°C fridge (Siemens). The day-0 eggs were analysed. Each of the AT and FT groups included 5 eggs. The internal and external quality parameters of the eggs were measured on days 0, 1, 8, 18, 21 and 28. The research was conducted in two repetitions between June 2018 and August 2018. The average of the measurement results was evaluated statistically.

Thirteen different parameters were measured to evaluate the quality changes of the eggs depending on their storage.

Internal Quality Policy: Albumen index, Haugh unit, albumen height, egg yolk index, albumen ratio, egg yolk ratio, egg yolk height, albumen weight and egg yolk weight.

External Quality Parameters: Egg shape index, eggshell

percentage, egg weight and eggshell thickness. After eggs were collected and brought to the laboratory, they were grouped and weighed with their shells before storage. During the storage period, the weight of the eggs were measured and the width and height diameters were also measured by a digital caliper. The eggs were broken in a clean petri dish. The diameter and height of the egg yolk (from the center of the yolk), albumen height (from the side of the chalaza region), albumen diameter and width were measured by a caliper. Then, egg yolk and albumen were separated and each was weighed on a sensitive scale (Radwag).

Eggshells were also transferred to a clean petri dish and were weighed. Then, the eggshells were left to dry in an incubator at 37°C for 24 h. The eggshells were measured from two different parts (side and top) after they had been dried in the incubator. The pH values of egg yolk and albumen were measured by pH meter (Hanna HI 2211).

All parameter measurements were made for all eggs on determined days. The data obtained from the measurements were used to determine the following parameters: [13-18].

Albumen index: Albumen height/(Albumen length + Average of albumen width) *100

Albumen ratio: Albumen weight/Egg weight * 100

Egg yolk index: Egg yolk height/Egg yolk diameter * 100

Egg yolk ratio: Egg yolk weight/Egg weight * 100

Eggshell ratio: Eggshell weight/Egg weight * 100

Haugh unit: 100 log (Albumen height-1.7* Egg weight $^{0.37}$+7.6)

Egg shape index: Egg width/Egg length * 100

Eggshell percentage: Eggshell thickness/Egg weight * 100

Microbiological analyses of eggs were performed from day 0 onwards and during the storage conditions. The analyses were carried out separately for inner and shell part of the eggs allocated for microbiological analyses at specified times. Total mesophilic aerobic bacteria [19], *Salmonella* spp. [20], coliform bacteria [21], *E. coli* [22] and mold-yeast [23] were analyzed for both inner and shell area of the egg.

The eggshell was disinfected with 70% of alcohol to analyze the inside of the egg. Then, the egg was broken under aseptic conditions and analysed. For the analyses of the shell area of the egg, the eggs were washed with the dilution of a 1:9 physiological saline. Then, total mesophilic aerobic bacteria, coliform bacteria, *E. coli* and mold-yeast microbiological analyses were carried out.

Shell eggs were incubated inside buffered peptoned water in order to determine *Salmonella* spp. and for further continued analysis.

Statistical Evaluation: The data of all groups were tested for normality via Shapiro-Wilk tests. Data found to be normally distributed were then analyzed with one-way ANOVA. The non-parametric Kruskal-Wallis tests were conducted for data not normally distributed. The Mann-Whitney U tests with Bonferroni correction were used for pairwise comparisons between groups. Differences at P=0.05 level were accepted as being statistically significant. SPSS software was used for statistical analysis (SPSS for Windows, edition 17.0 (Release 17.0.0 - Aug 23, 2008).

RESULTS

The results obtained from the research we conducted in order to evaluate the quality parameters in the chicken eggs stored at different storage temperature are shown in *Table 1, 2, 3* and *Fig. 1, 2, 3, 4*. According to these results, it is observed that there are significant changes in the internal quality characteristics of the eggs due to the temperature differences during the storage period. The changes in the external quality characteristics are not statistically significant.

When the microbiological analysis findings were evaluated, there was no coliform bacteria. *E. coli* and *Salmonella* spp. detected in any of the interior and exterior areas of the egg samples.

On day 0, in eggs' internal area microbiological analyses, total mesophilic aerobic bacteria were detected with the number of $5x10^2$ CFU/mL. In addition, the high yeast presence was remarkable. In eggs' external area microbiological analyses, total mesophilic aerobic bacteria were detected with the number of $1.2x10^3$ CFU/mL only from the fridged storage eggs analysed on day 18. Except for these findings, there was no microbial growth or it was the detected to be below limits.

In our study, there was no significant difference in pH change between groups. The pH changes in albumen and egg yolk dependent on the time and temperature are shown in *Table 3*.

DISCUSSION

In this study, the groups kept at room (25°C) and fridge (5°C) temperature were evaluated within and between the groups in terms of internal and external quality criteria. While temperature and time did not significantly affect the external quality characteristics of the eggs (P>0.05), it was found that it remarkebly affected most of the internal quality characteristics (P<0.05) *(Table 1, 2)*. In our study, the internal quality characteristics of the eggs were adversely affected by being kept at room temperature, compared to the eggs kept at the fridge temperature. Differences in albumen index, egg yolk index, HU and egg yolk height were found to be statistically significant when the two groups were compared (P<0.05).

Although weight loss occurred in the eggs in both groups of our study, this change was not found to be statistically

Table 1. *Quality changes in eggs stored at fridge temperature*

Group	Albumen Index (%)		Egg White Height (mm)		Haugh Unit		Egg Shape Index (%)		Egg Yolk Index (%)		Egg White Ratio (%)		Egg Yolk Ratio (%)		Eggshell Percentage (%)		Egg Weight (g)		Egg Yolk Height (mm)		Egg White Weight (g)		Egg Yolk Weight (g)		Eggshell Thickness (mm)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
FT1	3.63	0.85	6.71[b]	0.386	80.95	1.61	79.35	0.7	48.41	1.18	61.47	3	22.7	1.3	9.6	0.34	55	2.09	17.35[a]	0.45	33.63	1.68	12.42	0.709	0.32	0.03
FT8	4.36	0.62	8.27[a]	0.22	91.66	1.03	78.27	0.83	44.29	0.4	60.68	1.19	23	0.9	9.4	0.44	53.6	1.38	16.11[a]	0.23	32.63	1.42	12.28	0.33	0.31	0.01
FT18	3.76	0.16	7.44[ab]	0.12	85.7	1.74	79.1	0.92	41.75	0.98	56.19	1.06	24	0.4	9.1	0.34	53	0.78	15.52[ab]	0.27	29.82	0.94	12.74	0.18	0.29	0.02
FT21	3.18	0.68	6.75[b]	0.21	85.41	3.67	79.2	1.08	43.13	0.75	57.29	1.19	24.6	0.5	9.2	0.16	52.6	1.51	16.00[ab]	0.38	30.23	1.44	12.91	0.35	0.24	0.02
FT28	3.67	0.33	6.54[b]	0.26	79.48	2.38	80.89	0.9	40.06	0.62	53.35	1.64	23.9	1.5	9.4	0.39	53.1	1.76	14.87[b]	0.23	28.38	1.2	12.6	0.58	0.38	0.04
P -value	>0.05		<0.05		>0.05		>0.05		>0.05		>0.05		>0.05		>0.05		>0.05		<0.05		>0.05		>0.05		>0.05	

[a,b] There is a significant differences between the means indicated with different letters on the same column (P<0.05)

Table 2: *Quality changes in eggs stored at room temperature*

Group	Albumen Index (%)		Egg White Height (mm)		Haugh Unit		Egg Shape Index (%)		Egg Yolk Index (%)		Egg White Ratio (%)		Egg Yolk Ratio (%)		Eggshell Percentage (%)		Egg Weight (g)		Egg Yolk Height (mm)		Egg White Weight (g)		Egg Yolk Weight (g)		Eggshell Thickness (mm)	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD
RT0	4.92[a]	1.65	9.20[a]	1	89.94[a]	6.87	77.95	0.51	48.54[a]	1.93	60.2	1.58	21.2	0.75	9.25	0.37	54.77	1.46	17.14[a]	0.4	33	1.55	11.66	0.57	0.36	0.06
RT1	3.99[a]	0.47	8.39[ab]	0.52	92.38[a]	3.93	79.76	1.14	49.39[a]	0.82	59.2	1.52	23.7	0.71	10.5	1.53	54.55	0.28	17.56[a]	0.1	32.4	0.93	12.91	0.36	0.27	0.03
RT8	2.34[a]	0.12	5.58[b]	0.62	73.52[a]	6.8	84.96	5.22	37.88[b]	1.63	59.2	0.63	23.6	0.72	9.91	0.14	52.76	1.48	14.12[b]	0.5	31.3	0.98	12.44	0.63	0.27	0.01
RT18	0[b]		0[c]		0[b]		78.69	0.96	27.77[c]	0.83	54.6	1.11	26.2	1.34	9.92	0.2	53.45	1.55	11.40[c]	0.4	29.2	1.12	13.93	0.65	0.29	0.01
RT21	0[b]		0[c]		0[b]		79.68	0.08	28.81[c]	1.04	55.9	1.5	26.7	1.4	9.43	0.28	53.19	1.36	11.40[c]	0.4	29.8	1.48	14.14	0.54	0.28	0.02
RT28	0[b]		0[c]		0[b]		78.44	1.27	23.32[c]	1.59	55.4	1.98	26.1	1.4	9.06	0.3	53.48	2.08	9.98[c]	0.6	29.6	1.21	13.71	0.64	0.4	0.03
P -value	<0.05		<0.05		<0.05		>0.05		<0.05		>0.05		>0.05		>0.05		>0.05		<0.05		>0.05		>0.05		>0.05	

[a,b] There is a significant differences between the means indicated with different letters on the same column (P<0.05)

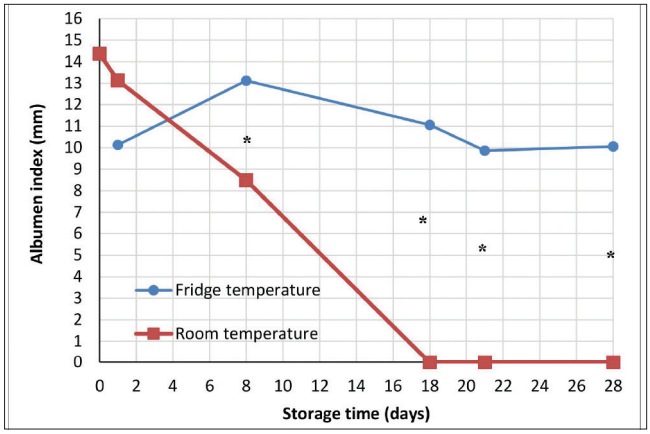

Fig 1. Effect of storage time and temperature on albumen index (mm) of chicken eggs; * The difference between the marked results is significant

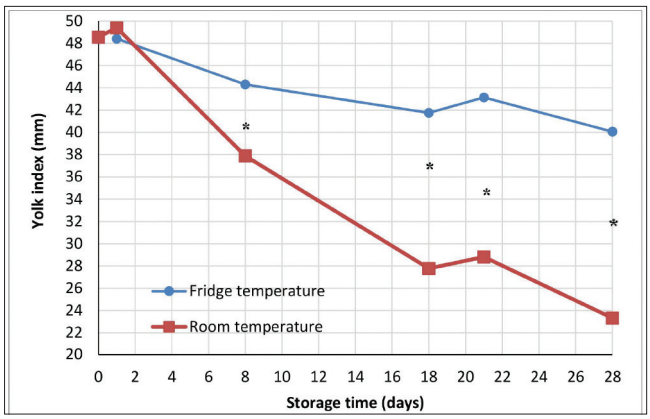

Fig 2. Effect of storage time and temperature on yolk index (mm) of chicken eggs; * The difference between the marked results is significant

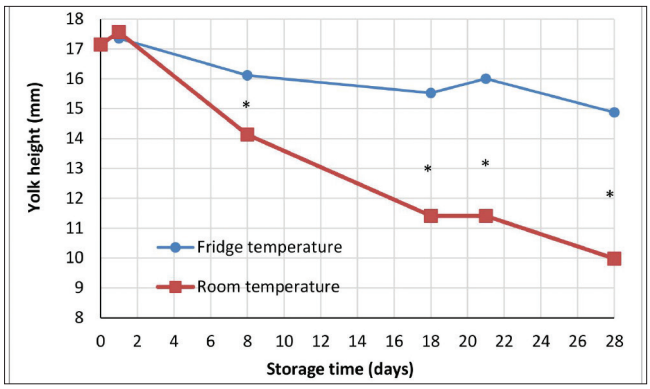

Fig 3. Effect of storage time and temperature on yolk height (mm) of chicken eggs; * The difference between the marked results is significant

significant (P>0.05). Several studies have been conducted to investigate the effect of storage time and temperature on the weight loss and internal quality characteristics of eggs. Eggs' weight loss depending on the storage time and the temperature was found to be significant by various researchers [3-5,7,12,24-26]. Şamlı et al.[26] stated that the cold storage did not affect the weight loss. Scott et al.[27] found that the weight loss in the eggs was not important depending on the storage in their research.

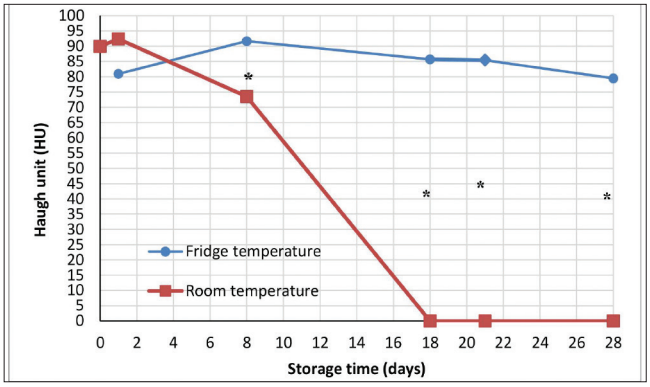

Fig 4. Effect of storage time and temperature on haugh unit (HU) of chicken eggs; * The difference between the marked results is significant

Table 3. *The pH changes in albumen and egg yolk dependent on the time and temperature*

Ambient Temperature	Day	Albumen	Egg Yolk
Room Temperature	Day 0	8.09	6.07
	Day 1	7.80	6.40
	Day 8	8.46	6.28
	Day 18	8.77	6.57
	Day 21	8.68	6.57
	Day 28	8.83	6.84
Fridge Temperature	Day 1	8.03	6.29
	Day 8	7.33	6.34
	Day 18	8.66	6.4
	Day 21	8.71	6.69
	Day 28	8.72	6.43

In our study, the mean average egg weight in the room temperature group decreased from 54.77 g to 53.48 g at the end of the day 28. The reason of the decrease in weight loss may be related with the ambient conditions. In our study, egg yolk weight increased in both storage temperature treatments. This value increase is not found to be statistically significant. The increase in egg yolk weight may have been caused by the diffusion of water from the albumen to the egg yolk depending on the extended storage time.

When the groups from both of the storage temperature treatments were compared with each other depending on the time, we found that there were statistically significant changes in albumen index, haugh unit, egg yolk index and egg yolk height (P<0.05). When the group stored at the fridge temperature was evaluated in terms of time, statistically significant results were only found for albumen height and egg yolk height parameters (P<0.05). When the other group stored at room temperature was evaluated in terms of time, albumen height, Haugh unit, egg yolk index and egg yolk height parameters were found to be statistically significant (P<0.05). In eggs stored at room

temperature, the albumen height, HU and albumen index values could not be calculated due to the inability of measuring some parameters after day 8. When the eggs kept in the fridge except those from day 8 group were analyzed, the albumen height did not show any significant change between the 1st and 28th days. The HU values of the eggs kept in the fridge were found in the fresh egg (Class A) values even on the 28th day. When the albumen of room temperature eggs were compared with the eggs kept at the fridge temperature, the values of the fridge group on the 28th day were found to be higher than the values of the room temperature eggs from the 8th day. Similar to our study, some researchers found that the storage temperature negatively affects the albumen index, egg yolk index, egg yolk height and albumen height [4-6,24].

Haugh unit value is one of the most important quality parameters which changes depending on the storage process of the egg. Changes in the value of haugh unit were investigated by various researchers. Jones and Musgrove [28] found that HU value decreased from 82.59 to 67.43 in 10 weeks and in cold conditions (4°C). Similarly, Jones et al.[29] also found that the HU value in eggs kept in cold storage for 12 weeks decreased from 84.62 to 66.21. Caner et al.[7] stated that HU value decreases within time and at the end of 5 weeks, it decreased from 81.23 to 58.93 in their research where the eggs were kept at 24°C for six weeks. In the study of Feddern et al.[30] the HU value decreased from 95.75 to 88.19 in the eggs they kept in the cold chain (0-5°C) for 3 weeks, whereas in the warm environments (20-30°C) the values were reduced from 98.60 to 51.92. According to our research results, HU values were found to be statistically significant between the groups kept at fridge versus at room temperature ($P<0.05$). The HU value in the group stored at the fridge temperature dropped to 79.48 from the initial value of 80.95 in 28 days. The changes in this period are not statistically significant in the fridge group ($P>0.05$). In the group stored at room temperature, the HU value decreased from 89.94 to 73.52 at the end of the 8th day. However, the HU parameter value could not be calculated since the quality of albumen was very low in our measurements since the 18th day. The HU value on the 28th day of the eggs stored in the fridge was found to be higher than the values on the 8th day of the group kept at room temperature. The preservation of eggs in the cold chain positively affects the quality of the HU value.

Albumen height is another important parameter in determining egg freshness. This parameter is also a critical value in the calculation of albumen index and HU values. In our study, the room temperature group's albumen height was initially 9.20 mm and then was calculated as 5.58 mm on the 8th day. In the room temperature group, no measurement could be obtained in the albumen height parameter from day 18. Even at the end of the 28th day in the fridge conditions, albumen height was measured and determined as 6.54 mm. Jones and Musgrove [28] found that albumen height in eggs were 7.05 mm on day 0 and 4.85 mm at the end of 10th week. Whereas Jones et al.[29] detected that the height of albumen falls from 7.21 mm to 4.80 mm after a 12 weeks of cold storage conditions. Şamlı et al.[26] found that the values of albumen height decreased from 8.56 mm to 6.18 mm (5°C) and 2.81 mm (29°C) after storing the eggs for 10 days (5, 21, 29°C). We observed that the albumen height values of the groups kept in the fridge were compatible with the results of the other researchers, however, the fact that we could not get the measurement from the room temperature group due to the increased albumen fluidity starting from day 18, limits our ability to compare.

As the albumen index parameter is a parameter associated with albumen height, the quality-related changes also affect these values. In our study, albumen index values are statistically significant between room temperature and fridge temperature groups ($P<0.05$). The fridge temperature was not found to be statistically significant when evaluated within the group ($P>0.05$) *(Table 1)*. In the group kept at room temperature, the albumen index value was statistically significant depending on the duration ($P<0.05$). However, albumen index values could not be detected after day 18 in this group. The reason for this is that albumen height could not be obtained due to increased albumen fluidity. In the research conducted by Artan and Durmus [31], it was found that the albumen index value was 4.94-5.87. These values are consistent with the findings of our study.

When egg yolk index parameter was evaluated, the egg yolk index values of the eggs at room temperature decreased significantly since 8th day, but the decrease in those kept at the fridge temperature was at a more reasonable level. When the egg yolk index results belonging to the day 28 were compared, it was seen that the egg yolk index of the eggs kept at the fridge temperature was in a better condition than the eggs kept at room temperature. The changes in egg yolk index were not statistically significant in the eggs stored in the fridge, but were found to be statistically significant in the eggs kept at room temperature ($P<0.05$). Şamlı et al.[26] study determined that the egg yolk index was 44.09 in fresh eggs; 40.77 (5°C) and 32.73 (29°C) at the end of 10 days. In our study, it was seen that the value of fridge group egg yolk index obtained from day 28 was compatible with the value taken from Şamlı et al.'s [30] fridge group (5°C) on 10th day.

In our study, there were significant differences between the two groups in terms of egg yolk height values ($P<0.05$). Egg yolk height decreased to 9.98 mm on the 28th day of the eggs kept at room temperature and 14.87 mm on the 28th day of the eggs kept at fridge temperature. It was determined that the 28th day value of the egg yolk height of the eggs that were kept in the fridge and the 8th day value of the eggs kept at room temperature were close to each other.

In our study, there were no statistically significant differences between the eggs stored in the room and fridge temperature

in terms of egg shape index, albumen ratio, egg yolk ratio, eggshell percentage, egg weight, albumen weight, egg yolk weight, eggshell thickness parameters (P>0.05).

The other parameter of the egg that can show changes due to storage is the pH value. In our study, there was no significant difference in pH between groups. Current differences are thought to be caused by individual differences in eggs. The pH of albumen in fresh eggs is between 7.55-8.5 [8]. In our study, pH values varied in the range of 7.52 to 8.90 in the eggs kept at room temperature while it varied in the range of 7.55 to 8.50 in the eggs kept in the fridge. Giampietro-Ganeco et al.[32] examined the quality differences of the eggs stored in the inner shelf and domestic fridge door and it was found that the quality characteristics of the eggs stored in the inner shelf were better protected. The same researchers stated that the pH of egg yolk and egg white did not show any significant change in this study. Şamlı et al.[26] specified that the pH of the albümin, which was initially recorded as 7.47, increased to 8.26 at 5°C and to 9.11 at 29°C degrees after 10 days. However, they added that the changes in egg yolk pH did not differ as much as the changes in the albumen. In Caner et al.[7] research where eggs were kept for 6 weeks at 24°C, the pH of the albumen in the first three weeks increased from 7.5 to 9.27 and the egg yolk pH increased from 5.86 to 6.32. Akyürek and Okur [4] stated that time (14 days) and temperature (4 and 22°C) significantly increased albumen and egg yolk pH.

In the microbiological investigations of inside and outside of the eggs, no coliform bacteria, *E. coli* and *Salmonella* spp. were detected in any of the samples. Total aerobic mesophilic bacteria and mold yeasts were detected in some eggs. Microbiological analyses are considered to be valuable in terms of giving some first insights only, rather than providing definite results results due to the individual differences of the analyzed eggs. Although the same conditions were provided, the fact that the same egg could not be used in the next analysis caused inconsistency between the results. Therefore, the analyzes were evaluated on one egg. At maximum, a total of 600 cfu (colony forming units) of total mesophilic aerobic bacteria and intense yeast were found in the interior of some eggs. The total number of mesophilic aerobic bacteria that can be obtained at maximum level in the microbiological analysis of the eggs' outer area stored at both storage temperatures was 1200 cfu and also 144 cfu mold colonies have been detected at maximum level. Various researchers have conducted studies to determine the microbiological quality of eggs. In the study of Eke et al.[4] the total mesophilic aerobic bacteria level was found to be $5x10^3$ CFU/mL and the mold-yeast level was $9x10^2$ CFU/mL at the ambient temperature of week zero. They stored these eggs at ambient (32+2°C) and fridge temperature for four weeks. As a result of the analyses, they found a total of $2.8x10^7$ and $1.1x10^4$ CFU/mL total mesophilic aerobic bacteria respectively. They stated that they had detected $1.2x10^5$ CFU/mL mold-yeast at the end of the fourth week in the group they kept in ambient conditions (32°C). The reason why the numbers are considered to be particularly high is that the cuticle on the surface of the eggs stored at ambient temperature dried faster and began to shrink. This causes an increase in pore size and ease of the penetration of microorganisms into the eggshell. It was stated that the mold-yeast population in the eggs stored at ambient temperature may be due to the humidity condition of the medium. In the study of Park et al.[6] the groups were set by treating the eggs with mineral oil, washing and without any process, and then they were evaluated them microbiologically. The researchers determined the initial microflora in eggs (day 0. at 30°C) as $2.8x10^2$ CFU/mL. In our study, we obtained similar results from some eggs, but our results were generally below the detection limits.

The effects of temperature and duration are evaluated in most of the studies related to the quality change of the egg. The importance of temperature in sustainability of egg quality is very important. In the study of Yenilmez et al.[9] where they investigated the quality characteristics of the eggs kept in hot and cold conditions during summer and winter, it was stated that the values obtained from the eggs kept at 4°C were better. The researchers reported that the eggs kept in summer (33°C) can be stored safely for one week and those kept in 18°C can be stored for two weeks. Eke et al.[24] stated that HU, yolk index and pH values of eggs stored at 32°C are affected more than eggs kept under fridge conditions. Akter et al.[5] stated that in both fridge and room conditions egg weight loss, the percentage of egg yolk weight, egg yolk pH value and albumen pH value increased but Haugh units and the percentage of weight of albumen decreased. These researchers have stated that eggs maintain their quality for 28 days at room temperature and 14 days at room temperature. In the study conducted by Tabidi [12], it was stated that the eggs kept at 37°C lost their consumable properties on the 15th day and the eggs kept their freshness at 4°C. In our study, for the eggs stored at room temperature, especially after the 18th day, the albumen index, albumen height and Haugh unit values could not be obtained. As a result, it is predicted that the storage temperature and duration play an important role in maintaining the freshness of the eggs and also there is a necessity the eggs should be kept in the cold chain after 8 days from the date of laying. Lee et al.[33] stated that the storage temperature and duration are major factors affecting egg quality. When the storage temperature and duration are compared, it is emphasized that storage temperature is a more sensitive determinant. This finding supports the results of our study. Feddern et al.[30] stated that there was a rapid deterioration in the eggs stored at room temperature in 1 to 5 weeks, and recommended that these eggs should be consumed in 2 weeks to maintain their internal quality until they reach the consumer from the farm or stored in the refrigerator for up to 8 weeks.

In this study, the effects of the storage time and the

temperature on the quality parameters of the eggs kept at room and fridge temperature were evaluated. It was determined that preservation of the eggs in the cold environment was important for the quality criteria of the egg and that the ambient temperature adversely affected the egg quality in terms of freshness criteria. As a result, it is predicted that the storage temperature and duration play an important role in preserving the freshness of the eggs and the eggs should be kept under the cold chain. At the latest from day 8 onwards after the egg laying date. It is thought that this study will shed light on the studies for the preservation of eggs for a longer time, while preserving its quality characteristics.

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Conflict of Interest

There is no conflict of interest in the present study.

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