Kafkas Universitesi Veteriner Fakultesi Dergisi
ISSN: 1300-6045 e-ISSN: 1309-2251
Journal Home-Page: http://vetdergikafkas.org

Kafkas Univ Vet Fak Derg
28 (3): 363-370, 2022
DOI: 10.9775/kvfd.2022.27077

Research Article

Effects of Prestorage Application of Gum Arabic Coating on the Quality of Table Eggs During Storage

Vahdettin SARIYEL [1,a] Ali AYGUN [2,b (*)] Hacer COKLAR [3,c] Dogan NARINC [4,d] Mehmet AKBULUT [3,e]

[1] Karapınar Vocational School , Selcuk University, Karapinar, TR-42130 Konya - TÜRKİYE
[2] Faculty of Agriculture, Department of Animal Science, Selcuk University, TR-42130 Konya - TÜRKİYE
[3] Faculty of Agriculture, Department of Food Science, Selcuk University, TR-42130 Konya - TÜRKİYE
[4] Faculty of Agriculture, Department of Animal Science, Akdeniz University, TR-07070 Antalya - TÜRKİYE
ORCIDs: [a] 0000-0002-3937-4849; [b] 0000-0002-0546-3034; [c] 0000-0002-4948-0960; [d] 0000-0001-8850-3806; [e] 0000-0001-5621-8293

Article ID: KVFD-2022-27077 Received: 07.01.2022 Accepted: 05.04.2022 Published Online: 06.04.2022

Abstract: The aim of this study was to investigate the effect of gum arabic coating on the quality characteristics of table eggs during 28 days of storage at 4°C and 25°C. Treatments were compared in a 2 x 4 factorial design with two different storage temperatures (4°C and 25°C) and five prestorage coating applications (control, 1% gum arabic (G1), 5% gum arabic (G5), and 10% gum arabic (G10) solution). Egg quality characteristics that were measured included weight loss, specific gravity, shell strength, Haugh unit, yolk index, and albumen pH. The eggs coated with 10% gum arabic solution had the lowest egg weight loss (2.71%), and albumen pH (9.18), and the highest egg specific gravity (1.057 g/cm3) at the end of storage (P<0.05). During the storage period, there were no significant differences between gum arabic coated and control eggs for shell strength, Haugh unit or yolk index. Eggs stored at 4°C for 28 days had a lower weight loss (1.86 %) and albumen pH (9.15), and higher egg specific gravity (1.068 g/cm^3), Haugh unit (69.96) and yolk index (0.41) than eggs stored at 25°C. The results suggest that applying a 10% gum arabic coating to eggs before they are stored might be a simple and effective way to keep them fresh.

Keywords: *Coating, Egg quality, Gum arabic, Storage, Table eggs*

Sofralık Yumurtalarda Depolama Öncesi Gam Arabik Kaplama Uygulamasının Yumurta Kalitesine Etkileri

Öz: Bu çalışmanın amacı gam arabik kaplaması uygulanmış sofralık yumurtların 4°C ve 25°C'de 28 günlük depolama süresince yumurta kalite özelliklerine etkisini araştırmaktır. Muameleler, iki farklı depolama sıcaklığı (4°C ve 25°C) ve beş adet depolama öncesi uygulama (kontrol, %1 gam arabik (G1), %5 gam arabik (G5) ve %10 gam arabik (G10)) ile 2 x 4 faktöriyel deneme deseninde karşılaştırılmıştır. Yumurta kalite özellikleri olarak yumurta ağırlık kaybı, özgül ağırlık, kabuk mukavemeti, Haugh birimi, yumurta sarısı indeksi ve ak pH'sı incelenmiştir. Depolama sonunda en düşük yumurta ağırlığı kaybı (%2.71) ve ak pH'sı (9.18) ve en yüksek yumurta özgül ağırlığı (1.057 g/cm3) değerleri %10 gam arabik solusyonu ile kaplanmış yumurtalarda tespit edilmiştir (P<0.05). Depolama süresince gam arabik kaplı yumurtalar ve kontrol yumurtaları arasında yumurta kabuğu mukavemeti, Haugh birimi ve yumurta sarısı indeksi bakımından önemli bir fark bulunmamıştır. 4°C'de 28 gün süre ile depolanan yumurtaların yumurta ağırlık kaybı (%1.86) ve ak pH (9.15)'ı 25°C'de depolanan yumurtalara göre daha düşük, yumurta özgül ağırlığı (1.068 g/cm^3), Haugh birimi (69.96) ve yumurta sarısı indeksi (0.41) değerlerinin ise daha yüksek olduğu tespit edilmiştir (P<0.05). Sonuç olarak, %10 gam arabik kaplama uygulamasının, depolama süresince yumurta kalitesini korumanın basit ve etkili bir yolu olabileceği düşünülmektedir.

Anahtar sözcükler: *Kaplama materyali, Yumurta kalitesi, Gam arabik, Depolama, Sofralık yumurta*

Introduction

Eggs are an important source of animal protein and also contain various nutritional compounds such as unsaturated fatty acids, vitamins, and minerals [1]. The quality of an egg is the highest when it is laid, and deterioration occurs depending on both environmental conditions and the duration of storage [2]. Depending on the storage conditions, a loss in egg weight [3], decreases in albumen height and Haugh unit [4-6], egg yolk index [6,7] and an increase in albumen pH [4-6,8] may be observed. After eggs are collected from the egg production system, they must

How to cite this article?
Sariyel V, Aygun A, Coklar H, Narinc D, Akbulut M: Effects of prestorage application of gum arabic coating on the quality of table eggs during storage. *Kafkas Univ Vet Fak Derg,* 28 (3): 363-370, 2022.
DOI: 10.9775/kvfd.2022.27077

(*) Corresponding Author
Tel: +90 332 223 2905 Cellular phone: +90 505 547 0821 Fax: +90 332 241 0108
E-mail: aaygun@selcuk.edu.tr (A. Aygün)

be stored under appropriate conditions. On the other hand, eggs can be exposed to unexpected and undesired conditions at all the stages through farm to retail. Nowadays, both researchers and producers have focused on new technologies such as pulsed light, sonication, high hydrostatic pressure, ozonation, ultraviolet light, and coating to extend the shelf life of eggs and minimize the negative effects of environmental conditions to which they are exposed [9,10].

Various coating materials, such as propolis [7,11], chitosan [12-14], proteins [15], oils [16] and starch [17] have been used to eliminate or reduce the aforementioned problems during storage. Some coating materials extend the shelf-life of eggs. These materials prevent the penetration of microorganisms through the shell and the evaporation of albumen water from the shell, thereby reducing economic losses [17,18]. Gums are widely used as thickening, gelling and stabilizing agents [19,20] in many different areas including foods, creams and lotions, adhesives, inks, paper coating and ceramics. Due to the film forming feature, gum arabic has been used as an edible coating directly or in combination with different materials in recent years to extend the shelf life of fruits and vegetables as well as meat products such as meatballs [21-23]. Such long-term preservation is possible as the gum arabic film minimizes contact between the external environment and the coated material. Gum arabic films have been widely used in recent years as a coating material because they are natural, water soluble, can be easily removed and do not have negative effects on human health when consumed [24,25]. Upadhyaya et al.[26] investigated the efficacy of gum arabic-based coating materials for reducing *Salmonella enteritidis* on egg shell, and found that gum arabic-based coating significantly reduced the *Salmonella enteritidis* in the egg shell. Zhang et al.[27] evaluated the effects of pullulan with added glycerin, gum arabic, lysozyme, and chitinase on egg shell microbial activity and egg quality during storage, and reported that the composite pullulan coating could effectively inhibit the growth of *Escherichia coli, Staphylococcus aureus, Salmonella* sp., *Mucor* sp., and *Aspergillus* sp. and therefore have a good preservative effect.

According to the literature survey, there is a lack of knowledge about the usability of gum arabic as an egg coating material. So this study aimed to determine the changes in some quality parameters in table eggs stored at 4 and 25°C for 28 days after coated with different concentrations of gum arabic solution.

Material and Methods

Materials

A total of four hundred table eggs were obtained from H&N Nick-Chick laying hens (40 weeks old) reared on a commercial poultry farm (Konya, Turkey). The hens were fed a layer diet containing 2800 kcal of ME/kg and 17% crude protein.

Preparation of Solutions

Three different gum arabic solutions at concentrations of 1, 5, and 10% were used in this study. Briefly, 10, 50, and 100 g of gum arabic were weighed into separate flasks, and each flask was filled to 1000 ml with ultra pure water. To obtain homogeneous solutions, each gum arabic: water mixture was stirred using a magnetic stirrer (MSH-20D, Wisestir, Daihan) at 500 rpm and room temperature for 10 hours, and then kept in a fridge at +4°C without stirring overnight. The gum arabic solutions were prepared the day before use.

Application of Gum Arabic Solutions

Four hundred eggs were randomly divided into four equal groups. The eggs in the first group (one hundred) weren't treated with any gum arabic solutions and were used as a control group (C). The eggs in the second, third, and fourth groups were treated with gum arabic solution containing 1%, 5%, and 10%, respectively, and these experimental groups were named as G1, G5, and G10, in the same order. The solutions (1000 mL of each solution) were sprayed onto the eggs, using a hand sprayer (Mertcan, Turkey) to cover the whole surface. After application, 20 eggs were taken away from each group to make experiments at the beginning of the storage, and the rest of the eggs in the groups were also splitted into eight groups. The subdivided groups were stored at 4°C or 25°C for 7, 14, 21, or 28 days. Ten eggs were analyzed from each group (control, G1, G5, and G10) at every period and storage temperature. Eggs were collected daily and stored in ambient conditions for one day before the application of gum arabic. The air flow of the storage cabinets (Qualitec, Gc-1000, Turkey) was measured at 0.15 m/sn.

Egg Quality Analysis

After the eggs were coated, they were numbered and weighed, so that the egg weight loss during storage could be calculated. The egg weight loss, specific gravity, eggshell breaking strength, Haugh unit, yolk index, and albumen pH of ten eggs from each group were measured at the end of storage periods of 7, 14, 21, and 28 days, respectively. Egg weight was measured using a balance and recorded to the nearest 0.01 g. Specific gravity was estimated by the Archimedes' method, using the following formula: Specific gravity = Egg weight (g)/(Egg weight – Egg weight in water) [28]. Eggshell strength (kg) was measured with a device for measuring eggshell resistance (Egg Force Reader, 06-UM-001, Version B, Orka Food Tech. Ltd., Hong Kong, China). The height of the albumen was measured using a digital height gauge (Egg Analyser, 05-UM-001, Version B, Orka Food Tech. Ltd., Hong

Kong, China). The Haugh unit was calculated using the following formula: Haugh unit = 100 log $(H + 7.57 - 1.7W^{0.37})$, where H is albumen height in millimeters and W is egg weight in grams [29]. After the eggs had been broken, the yolk was separated from the albumen and placed on a flat glass surface. The height of the yolk was measured using a digimatic height gauge (Tresna, IP54, USA), and the width of the yolk was measured using a micrometer caliper (Mitutoyo, Japan). The yolk index was calculated using the following formula: Yolk index = Yolk height/Yolk diameter [30]. Albumen pH was measured using a pH meter (Mettler Toledo, Switzerland).

Statistical Analysis

The study was organized as a randomized plot of trials, with three covering materials (1%, 5%, and 10% gum arabic), and a control group. At each measurement period, egg quality analyses were carried out in 10 replicates for each group. Variance homogeneity and Gaussian distribution, which are parametric test assumptions, were checked by Levene's test and the Shapiro Wilks test, respectively. The parametric test conditions were satisfied by various transformations of non-normally distributed data. The data on egg weight, egg weight loss, specific gravity, shell strength, Haugh unit, yolk index, and albumen pH were analyzed using one way analysis of variance (ANOVA) followed by a post hoc Tukey's multiple comparison test for comparison between different treatment groups. A value of $P<0.05$ was considered statistically significant (Minitab 16).

Results

Egg Weight Loss (%)

Table 1 shows the effects of storage temperature, gum coating, and storage x gum coating interaction on egg weight loss (%). Storage x gum coating interaction had a significant effect on egg weight loss only at 21 and 28 days of storage ($P<0.05$). The lowest egg weight loss was recorded in G10 after 21 and 28 days of storage at 25°C. However, there was no significant difference in egg weight loss among treatment groups at 4°C after 28 days of storage. Egg weight loss was 3.23% higher in the eggs stored at 25°C than in the eggs stored at 4°C after 28 days of storage.

Egg Specific Gravity (g/cm³)

Egg specific gravity values are given in *Table 2*. The effect of storage temperature x gum coating interaction on the specific gravity of eggs was significant only on day 28 of the storage period ($P<0.05$). No significant differences in egg specific gravity were found among treatment groups at 4°C after 28 days of storage, while the highest egg specific gravity was found in G10 after 28 days of storage at 25°C. Egg specific weight was affected by storage temperature in all storage periods ($P<0.05$). The specific gravity of eggs stored at 4°C was higher than those stored at 25°C in all periods.

Egg Shell Strength (kg)

Table 3 presents eggshell strength values and the effects

***Table 1.** The effect of storage temperature, gum coating and their interaction on egg weight loss*

Treatment		n	Fresh Egg Weight (g)	Egg Weight Loss (%)			
				7 days	14 days	21 days	28 days
Storage Temperature (°C)	25	40	53.10	1.38	2.56	3.83	5.09
	4	40	54.68	0.65	0.82	1.30	1.86
	SEM		0.578	0.107	0.046	0.066	0.104
	P-value		>0.05	<0.05	<0.05	<0.05	<0.05
Gum Arabic [1]	C	20	54.48	0.82	1.73	2.48^{b}	3.82^{a}
	G1	20	54.90	1.28	1.80	2.92^{a}	3.56^{b}
	G5	20	52.88	1.03	1.70	2.64^{ab}	3.80^{ab}
	G10	20	53.32	0.92	1.54	2.21^{c}	2.71^{c}
	SEM		0.817	0.151	0.065	0.093	0.147
	P-value		>0.05	>0.05	>0.05	<0.05	<0.05
Storage Temperature (°C) x Gum Arabic	25 x C	10	52.92	1.23	2.60	3.82^{b}	5.52^{a}
	25 x G1	10	53.63	1.41	2.70	4.37^{a}	5.36^{a}
	25 x G5	10	52.21	1.37	2.57	3.75^{b}	5.60^{a}
	25 x G10	10	53.64	1.50	2.40	3.37^{c}	3.90^{b}
	4 x C	10	56.03	0.41	0.85	1.14^{ef}	2.12^{c}
	4 x G1	10	56.16	1.16	0.91	1.48^{de}	1.77^{c}
	4 x G5	10	53.54	0.69	0.83	1.53^{d}	2.01^{c}
	4 x G10	10	53.00	0.34	0.67	1.05^{f}	1.52^{c}
	SEM		1.156	0.213	0.092	0.131	0.207
	P-value		>0.05	>0.05	>0.05	<0.05	<0.05

*$^{a-f}$ Means within a column with different superscripts differ significantly ($P<0.05$); [1] **C:** Control (with no application); **G1:** 1% gum arabic coating; **G5:** 5% gum arabic coating; **G10:** 10% gum arabic coating; **SEM:** Standard Error Mean*

***Table 2.** The effect of storage temperature, gum coating and their interaction on egg specific gravity*

Treatment		n	Fresh Egg Specific Gravity (g/cm³)	Egg Specific Gravity (g/cm³)			
				7 days	14 days	21 days	28 days
Storage Temperature (°C)	25	40	1.089	1.071	1.059	1.046	1.031
	4	40	1.089	1.081	1.077	1.073	1.068
	SEM		0.001	0.001	0.001	0.001	0.001
	P-value		>0.05	<0.05	<0.05	<0.05	<0.05
Gum Arabic[1]	C	20	1.088	1.077	1.069	1.062[ab]	1.047[b]
	G1	20	1.089	1.075	1.066	1.055[c]	1.048[b]
	G5	20	1.089	1.075	1.068	1.058[bc]	1.046[b]
	G10	20	1.088	1.079	1.069	1.064[a]	1.057[a]
	SEM		0.001	0.001	0.001	0.001	0.002
	P-value		>0.05	>0.05	>0.05	<0.05	<0.05
Storage Temperature x Gum Arabic	25 x C	10	1.086	1.072	1.058	1.048	1.027[c]
	25 x G1	10	1.089	1.071	1.058	1.041	1.027[c]
	25 x G5	10	1.091	1.068	1.058	1.045	1.026[c]
	25 x G10	10	1.089	1.074	1.061	1.051	1.045[b]
	4 x C	10	1.090	1.082	1.079	1.075	1.066[a]
	4 x G1	10	1.089	1.079	1.074	1.069	1.069[a]
	4 x G5	10	1.088	1.081	1.077	1.070	1.066[a]
	4 x G10	10	1.088	1.083	1.077	1.077	1.070[a]
	SEM		0.002	0.002	0.002	0.002	0.002
	P-value		>0.05	>0.05	>0.05	>0.05	<0.05

*[a-c] Means within a column with different superscripts differ significantly (P<0.05); [1] **C:** Control (with no application); **G1:** 1% gum arabic coating, **G5:** 5% gum arabic coating; **G10:** 10% gum arabic coating; **SEM:** Standard Error Mean*

of storage temperature, gum coating, and storage x gum coating interaction. The effect of storage temperature on eggshell strength was only significant on day 14 of storage (P<0.05). The egg shell strength of eggs stored at 25°C was higher than those stored at 4°C on the 14th day of storage.

Haugh Unit

In *Table 4*, the effects of storage temperature, gum coating, and their interaction on the Haugh unit are presented. Storage temperature had a significant effect on the Haugh unit at 14, 21, and 28 days of storage (P<0.05). The Haugh unit of eggs stored at 4°C was higher than that of eggs stored at 25°C on the 14th, 21st, and 28th days of storage. There were no effects of gum treatments and their interaction on the Haugh unit in any of the storage periods.

Yolk Index

The effects of storage temperature, gum coating, and their interaction on the yolk index are shown in *Table 5*. Storage temperature x gum coating interaction had a statistically significant effect on the yolk index only on day 21 of storage (P<0.05). The lowest yolk index was recorded in G1 after 21 days of storage at 25°C, while the highest yolk index was obtained for C after 21 days of storage at 4°C.

Albumen pH

In *Table 6*, the effects of storage temperature, gum coating, and their interaction on albumen pH are presented. Storage temperature x gum coating interaction effects on the albumen pH of eggs were significant only on the 7th, 14th, and 21st days of storage (P<0.05). The lowest albumen pH was obtained in G10 after 14 and 21 days of storage at 4°C.

The effect of storage temperature on albumen pH was significant at 14, 21, and 28 days of storage (P<0.05). The albumen pH of eggs stored at 4°C was lower than the albumen pH of eggs stored at 25°C on the 14th, 14th, and 21st days of storage.

Discussion

As can be seen from *Table 1*, the effect of gum arabic coating on egg weight loss (%) was significant only on the 21st and 28th days (P<0.05). The lowest egg weight loss was found in G10 after 21 and 28 days of storage (P<0.05). No significant differences in egg weight loss were found between the C and G5 after 21 and 28 days of storage. Similar results were observed in eggs coated with oils [31], chitosan [32] and proteins [33]. Ideally, egg weight loss should be low during storage. Egg weight loss during the storage period occurs as water in the albumen evaporates through the eggshell pores [34-37]. This study found that when gum is applied to eggs, especially 10% gum, it makes a protective layer that stops water from evaporating through the egg shell pores, which reduces egg weight loss while they are in storage.

The effect of gum arabic coating on egg specific gravity was significant on the 21st and 28th days of storage (P<0.05). The highest egg specific gravity was detected in G10 after 28 days of storage. Egg specific gravity is considered an

Table 3. *The effect of storage temperature, gum coating and their interaction on egg shell strength*

Treatment		n	Fresh Egg Shell Strength (kg)	Egg Shell Strength (kg)			
				7 days	14 days	21 days	28 days
Storage Temperature (°C)	25	40	3.916	3.678	4.322	4.620	4.681
	4	40	4.219	3.811	4.665	4.529	4.611
	SEM		0.163	0.122	0.111	0.081	0.099
	P-value		>0.05	>0.05	<0.05	>0.05	>0.05
Gum Arabic[1]	C	20	4.213	3.845	4.348	4.637	4.778
	G1	20	4.126	3.650	4.608	4.376	4.617
	G5	20	3.955	3.568	4.681	4.511	4.531
	G10	20	3.977	3.914	4.336	4.772	4.659
	SEM		0.213	0.172	0.156	0.114	0.139
	P-value		>0.05	>0.05	>0.05	>0.05	>0.05
Storage Temperature (°C) x Gum Arabic	25 x C	10	4.147	3.868	3.901	4.738	4.899
	25 x G1	10	3.841	3.767	4.536	4.409	4.573
	25 x G5	10	3.963	3.224	4.572	4.543	4.344
	25 x G10	10	3.715	3.851	4.278	4.788	4.910
	4 x C	10	4.278	3.822	4.795	4.535	4.657
	4 x G1	10	4.411	3.534	4.680	4.344	4.661
	4 x G5	10	3.947	3.912	4.789	4.479	4.718
	4 x G10	10	4.239	3.976	4.394	4.756	4.409
	SEM		0.302	0.243	0.221	0.161	0.197
	P-value		>0.05	>0.05	>0.05	>0.05	>0.05

[1] ***C:*** *Control (with no application);* ***G1:*** *1% gum arabic coating;* ***G5:*** *5% gum arabic coating;* ***G10:*** *10% gum arabic coating;* ***SEM:*** *Standard Error Mean*

Table 4. *The effect of storage temperature, gum coating and their interaction on Haugh unit*

Treatment		n	Fresh Egg Haugh Unit	Haugh Unit			
				7 days	14 days	21 days	28 days
Storage Temperature (°C)	25	40	82.03	73.79	61.70	64.11	62.99
	4	40	77.56	76.22	75.72	78.29	69.96
	SEM		1.937	1.461	1.752	0.869	1.410
	P-value		>0.05	>0.05	<0.05	<0.05	<0.05
Gum Arabic[1]	C	20	82.84	71.91	69.45	69.25	67.31
	G1	20	80.38	77.29	66.35	71.59	64.93
	G5	20	80.14	73.73	67.50	70.77	67.19
	G10	20	75.82	77.09	71.52	73.19	66.48
	SEM		2.737	2.066	2.422	1.229	1.994
	P-value		>0.05	>0.05	>0.05	>0.05	>0.05
Storage Temperature (°C) x Gum Arabic	25 x C	10	85.10	74.81	59.88	63.70	61.87
	25 x G1	10	80.17	73.19	58.12	63.48	63.25
	25 x G5	10	83.71	70.81	62.70	63.11	64.72
	25 x G10	10	79.13	76.35	66.10	66.16	62.13
	4 x C	10	80.59	69.01	79.01	74.80	72.74
	4 x G1	10	80.58	81.38	74.59	79.70	66.61
	4 x G5	10	76.56	76.65	72.32	78.43	69.66
	4 x G10	10	72.51	77.83	76.95	80.22	70.83
	SEM		3.868	2.921	3.351	1.737	2.816
	P-value		>0.05	>0.05	>0.05	>0.05	>0.05

[1] ***C:*** *Control (with no application);* ***G1:*** *1% gum arabic coating;* ***G5:*** *5% gum arabic coating;* ***G10:*** *10% gum arabic coating;* ***SEM:*** *Standard Error Mean*

important indicator of egg shell quality [38] Eggs with a higher specific gravity have a stronger eggshell, which is good for the egg industry [39].

The effects of gum coating and storage temperature x gum coating interaction on egg shell strength were not significant in any of the storage periods *(Table 3)*. Yuceer and Caner [40] stated that there were no significant differences in shell strength between coated and uncoated eggs during storage. On the other hand, the shell of uncoated (control) eggs exhibited significantly lower puncture strength at both the top and bottom than chitosan-coated eggs [41]. Similarly, Yüceer and Caner [42] reported that coating with

***Table 5.** The effect of storage temperature, gum coating and their interaction on egg yolk index*

Treatment		n	Fresh Egg Yolk Index	Yolk Index			
				7 days	14 days	21 days	28 days
Storage Temperature (°C)	25	40	0.43	0.38	0.37	0.38	0.27
	4	40	0.44	0.43	0.45	0.53	0.41
	SEM		0.004	0.003	0.005	0.005	0.006
	P-value		>0.05	<0.05	<0.05	<0.05	<0.05
Gum Arabic[1]	C	20	0.43	0.40	0.41[a]	0.47	0.33[ab]
	G1	20	0.43	0.41	0.41[a]	0.45	0.32[b]
	G5	20	0.43	0.40	0.41[a]	0.46	0.35[ab]
	G10	20	0.43	0.41	0.40[b]	0.46	0.36[a]
	SEM		0.006	0.005	0.007	0.007	0.009
	P-value		>0.05	>0.05	<0.05	>0.05	<0.05
Storage Temperature (°C) x Gum Arabic	25 x C	10	0.42	0.37	0.38	0.38[dc]	0.28
	25 x G1	10	0.43	0.38	0.37	0.36[d]	0.24
	25 x G5	10	0.44	0.38	0.36	0.39[dc]	0.28
	25 x G10	10	0.43	0.39	0.35	0.39[c]	0.29
	4 x K	10	0.45	0.43	0.45	0.55[a]	0.38
	4 x G1	10	0.44	0.43	0.45	0.54[ab]	0.41
	4 x G5	10	0.43	0.42	0.46	0.53[ab]	0.42
	4 x G10	10	0.43	0.42	0.43	0.52[b]	0.42
	SEM		0.009	0.007	0.010	0.010	0.012
	P-value		>0.05	>0.05	>0.05	<0.05	>0.05

*[a-d] Means within a column with different superscripts differ significantly (P<0.05); [1] **C:** Control (with no application); **G1:** 1% gum arabic coating; **G5:** 5% gum arabic coating; **G10:** 10% gum arabic coating; **SEM:** Standard Error Mean*

***Table 6.** The effect of storage temperature, gum coating and their interaction on albumen pH*

Treatment		n	Fresh Albumen pH	Albumen pH			
				7 days	14 days	21 days	28 days
Storage Temperature (°C)	25	40	8.80	9.19	9.41	9.34	9.37
	4	40	8.79	9.19	9.12	9.03	9.15
	SEM		0.024	0.039	0.011	0.011	0.012
	P-value		>0.05	>0.05	<0.05	<0.05	<0.05
Gum Arabic[1]	C	20	8.79	9.21	9.27[b]	9.25[a]	9.28[a]
	G1	20	8.78	9.19	9.33[a]	9.24[a]	9.30[a]
	G5	20	8.79	9.13	9.31[a]	9.20[a]	9.29[a]
	G10	20	8.81	9.25	9.16[c]	9.07[b]	9.18[b]
	SEM		0.033	0.055	0.015	0.016	0.017
	P-value		>0.05	>0.05	<0.05	<0.05	<0.05
Storage Temperature (°C) x Gum Arabic	25 x C	10	8.82	9.11[ab]	9.47[a]	9.40[a]	9.40
	25 x G1	10	8.76	9.29[a]	9.49[a]	9.40[a]	9.40
	25 x G5	10	8.81	9.22[ab]	9.44[a]	9.31[b]	9.39
	25 x G10	10	8.80	9.16[ab]	9.26[b]	9.26[b]	9.30
	4 x C	10	8.76	9.30[a]	9.08[d]	9.10[c]	9.16
	4 x G1	10	8.80	9.10[ab]	9.16[c]	9.07[c]	9.19
	4 x G5	10	8.78	9.03[b]	9.18[c]	9.08[c]	9.19
	4 x G10	10	8.81	9.33[a]	9.07[d]	8.89[d]	9.07
	SEM		0.047	0.077	0.022	0.022	0.024
	P-value		>0.05	<0.05	<0.05	<0.05	>0.05

*[a-d] Means within a column with different superscripts differ significantly (P<0.05); [1] **C:** Control (with no application); **G1:** 1% gum arabic coating; **G5:** 5% gum arabic coating; **G10:** 10% gum arabic coating; **SEM:** Standard Error Mean*

shellac and lysozyme-chitosan significantly increased egg shell strength. The shell strength of a table egg is an important economic issue for egg producers. The higher the breaking strength, the fewer losses due to breakage during the collection, transportation, and storage of the egg, which will provide an economic gain.

The fact that coating eggs with gum arabic did not affect the Haugh unit in any storage period *(Table 4)* was found to be consistent with the results reported by Xu et al.[32] who found no significant difference in the Haugh unit between chitosan coated and control eggs after 31 and 36 days of storage at 25°C. Similarly, there were no significant differences in the Haugh unit between control and eggs coated with whey protein concentrate and rice bran oil for 28 days at room temperature [43]. On the other hand, the Haugh unit of coated eggs was significantly higher than that of control eggs during storage [13]. The Haugh unit is the primary indicator of quality in the egg industry [33] and the higher the Haugh unit, the better the albumen quality of the egg. The Haugh unit decreases with the decrease of the albumen height during storage as a result of the increase in clusterin and ovoinhibitory concentrations in albumen and the disordering of the ovalbumin structure [44].

The effect of storage temperature on the yolk index was significant in all storage periods ($P<0.05$). The yolk index of eggs stored at 4°C was higher than the yolk index of eggs stored at 25°C on the 7th, 14th, 21st, and 28th days of storage. This result seems to be in agreement with studies showing that the yolk index decreases significantly with increasing storage temperature [45-48]. The effect of the gum treatment on yolk index was significant at 14 and 28 days of storage ($P<0.05$). The lowest yolk index was in G10 on the 14th day of storage, but the yolk index of G10 did not significantly differ from control on the 28th day of storage. These results conflict with the findings of Caner and Cansiz [13], Xu et al.[32], Safavi and Javanmard [43] who found that coated eggs exhibited a significantly higher yolk index than un-coated eggs during storage. The egg yolk index is a measure of the strength of the yolk vitelline membrane and can be used to indicate freshness. The higher the egg yolk index, the better the yolk quality [49]. As a result of the weakening of the egg yolk vitelline membrane, the water in the egg white diffuses into the egg yolk and the egg yolk index decreases [45,48].

The effect of gum treatment on albumen pH was significant at 14, 21, and 28 days of storage ($P<0.05$). After 14, 21, and 28 days, G10 had a lower albumen pH than the other treatment groups ($P<0.05$). These results are consistent with the studies of Biladeau and Keener [33], and Caner and Cansiz [41] in which eggs were coated using chitosan and whey protein, respectively. As the storage period increases, albumen pH increases due to the removal of CO_2 through pores in the eggshell [36,48,50]. According to our results, the gum arabic coating acts as a barrier against CO_2 loss from the albumen through the eggshell pores.

As a result, coating the eggs with gum arabic had no effect on eggshell strength, Haugh unit, or yolk index. In addition, it was determined that the eggs coated with 10% gum arabic had better results in terms of egg weight, specific gravity, and white pH compared to the eggs in the other experimental groups. It is thought that 10% gum arabic coating on table eggs will be effective in maintaining freshness. Similarly, as the storage temperature increased, most of the egg quality characteristics decreased. This study may contribute to the preservation of egg quality characteristics for a longer period of time during storage in the egg industry. Future research should focus on combining gum arabic with different coating materials to enhance its physical barrier properties.

Availability of Data and Materials

The datasets used and/or analyzed during the present study are available from the corresponding author (a. Aygün) on reasonable request.

Funding Support

This study was supported financially by Selcuk University Scientific Research Projects Coordinator (SUBAP) under project number 17401140.

Competing Interests

The authors have no competing interests to declare that are relevant to the content of this article.

Authors' Contributions

VS: Conceptualization, Investigation; AA: Conceptualization, Validation, Supervision, Writing - review & editing; HC: Methodology; DN: Methodology; MA: Methodology

References

1. Chambers JR, Zaheer K, Akhtar H, Abdel-Aal E-SM: Chicken eggs. **In,** Hater P (Ed): Egg Innovations and Strategies for Improvementsed. 1-9, Elsevier, 2017.

2. Usaga J, Acosta O, Sullivan EK, Padilla-Zakour OI: Pickling eggs. **In,** Hater P (Ed): Egg Innovations and Strategies for Improvementsed., 405-413, Elsevier, 2017.

3. Akyurek H, Okur AA: Effect of storage time, temperature and hen age on egg quality in free-range layer hens. *J Anim Vet Adv,* 8 (10): 1953-1958, 2009.

4. Scott T, Silversides FG: The effect of storage and strain of hen on egg quality. *Poult Sci,* 79 (12): 1725-1729, 2000. DOI: 10.1093/ps/79.12.1725

5. Aktan S: Effects of age and storage duration on relationships among albumen quality traits and egg weight in Japanese quails. *J Anim Vet Adv,* 10 (Suppl.): 3340-3344, 2011. DOI: 10.3923/javaa.2011.3340.3344

6. Baylan M, Canogullari S, Ayasan T, Copur G: Effects of dietary selenium source, storage time, and temperature on the quality of quail eggs. *Biol Trace Elem Res,* 143 (2): 957-964, 2011. DOI: 10.1007/s12011-010-8912-x

7. Copur G, Camci O, Sahinler N, Gul A: The effect of propolis egg shell coatings on interior egg quality. *Arch Geflugelkd,* 72 (1): 35-40, 2008.

8. Silversides FG, Budgell K: The relationships among measures of egg albumen height, pH, and whipping volume. *Poult Sci,* 83 (10): 1619-1623, 2004. DOI: 10.1093/ps/83.10.1619

9. Agregán R, Munekata PES, Putnik P, Pateiro M, Bursać Kovačević D, Zavadlav S, Lorenzo JM: The use of novel technologies in egg processing. *Food Rev Int,* 1-21, 2021. DOI: 10.1080/87559129.2021.1980887

10. Yüceer M, Caner C: The impact of coatings and novel processing techniques on the functionality of table eggs during extended storage period at ambient temperature. *J Food Process Preserv,* 45 (3):e15261, 2021. DOI:

10.1111/JFPP.15261

11. Sahinler N, Gul A, Copur G: Chemical composition and preservative effect of Turkish propolis on egg quality durig storage. *Asian J Chem,* 21 (3): 1877-1886, 2009.

12. Bhale S, No HK, Prinyawiwatkul W, Farr AJ, Nadarajah K, Meyers SP: Chitosan coating improves shelf life of eggs. *J Food Sci,* 68 (7): 2378-2383, 2003. DOI: 10.1111/j.1365-2621.2003.tb05776.x

13. Caner C, Cansiz O: Effectiveness of chitosan-based coating in improving shelf-life of eggs. *J Sci Food Agric,* 87 (2): 227-232, 2007. DOI: 10.1002/jsfa.2698

14. Yi SZ, Liu Q, Xu D, Li DM: Preservation effects of chitosan/nano-montmorillonite coating on clean eggs. *Packag Eng,* 7:12, 2017.

15. Caner C, Yuceer M: Maintaining functional properties of shell eggs by ultrasound treatment. *J Sci Food Agric,* 95 (14): 2880-2891, 2015. DOI: 10.1002/jsfa.7029

16. Jones DR, Ward GE, Regmi P, Karcher DM: Impact of egg handling and conditions during extended storage on egg quality. *Poult Sci,* 97 (2): 716-723, 2018. DOI: 10.3382/ps/pex351

17. Eddin AS, Ibrahim SA, Tahergorabi R: Egg quality and safety with an overview of edible coating application for egg preservation. *Food Chem,* 296, 29-39, 2019. DOI: 10.1016/j.foodchem.2019.05.182

18. Aygun A: The eggshell microbial activity. **In,** Hester P (Ed): Egg Innovation and Strategies for Improvemented. 135-144, Academic Press, Elsevier, Oxford, United Kingdom, 2017.

19. Saha D, Bhattacharya S: Hydrocolloids as thickening and gelling agents in food: A critical review. *J Food Sci Tchnol,* 47 (6): 587-597, 2010. DOI: 10.1007/s13197-010-0162-6

20. Cong L, Zou B, Palacios A, Navarro ME, Qiao G, Ding Y: Thickening and gelling agents for formulation of thermal energy storage materials - A critical review. *Renew Sust Energ Rev*, 155:111906, 2022. DOI: 10.1016/j.rser.2021.111906

21. Ali A, Maqbool M, Ramachandran S, Alderson PG: Gum arabic as a novel edible coating for enhancing shelf-life and improving postharvest quality of tomato *(Solanum lycopersicum* L.) fruit. *Postharvest Biol Technol,* 58 (1): 42-47, 2010. DOI: 10.1016/j.postharvbio.2010.05.005

22. Salehi F: Edible coating of fruits and vegetables using natural gums: A review. *Int J Fruit Sci,* 20 (Supppl. 2): S570-S589, 2020. DOI: 10.1080/15538362.2020.1746730

23. Zhou X, Zong X, Zhang M, Ge Q, Qi J, Liang J, Xu X, Xiong G: Effect of konjac glucomannan/carrageenan-based edible emulsion coatings with camellia oil on quality and shelf-life of chicken meat. *Int J Biol Macromol,* 183, 331-339, 2021. DOI: 10.1016/j.ijbiomac.2021.04.165

24. Ali BH, Ziada A, Blunden G: Biological effects of gum arabic: A review of some recent research. *Food Chem Toxicol,* 47 (1): 1-8, 2009. DOI: 10.1016/j.fct.2008.07.001

25. Xu T, Gao C, Feng X, Yang Y, Shen X, Tang X: Structure, physical and antioxidant properties of chitosan-gum arabic edible films incorporated with cinnamon essential oil. *Int J Biol Macromol,* 134, 230-236, 2019. DOI: 10.1016/j.ijbiomac.2019.04.189

26. Upadhyaya I, Yin HB, Nair MS, Chen CH, Lang R, Darre MJ, Venkitanarayanan K: Inactivation of *Salmonella enteritidis* on shell eggs by coating with phytochemicals. *Poult Sci,* 95 (9): 2106-2111, 2016. DOI: 10.3382/ps/pew152

27. Zhang Y, Guo S, Zhang B, Ma M, Cai Z, Huang X, Fu X: Preparation and application of composite antibacterial pullulan coating in the preservation of eggs. *Food Sci,* 40 (11): 213-219, 2019. DOI: 10.7506/spkx1002-6630-20180315-188

28. Wells R: A study of the hen's egg. *British Egg Marketing Board Symposium,* Edinburgh. 207-249, 1968.

29. Haugh RR: The Haugh unit for measuring egg quality. *US Egg Poult Mag,* 43, 522-573, 1937.

30. Funk E: The relation of the yolk index determined in natural position to the yolk index as determined after separating the yolk from the albumen. *Poult Sci,* 27 (3): 367-367, 1948.

31. Homsaard N, Kodsangma A, Jantrawut P, Rachtanapun P, Leksawasdi N, Phimolsiripol Y, Seesuriyachan P, Chaiyaso T, Sommano SR, Rohindra D, Jantanasakulwong K: Efficacy of cassava starch blending with gelling agents and palm oil coating in improving egg shelf life. *Int J Food Sci Technol*, 56, 3655-3661, 2020. DOI: 10.1111/ijfs.14675

32. Xu D, Wang J, Ren D, Wu X: Effects of chitosan coating structure and changes during storage on their egg preservation performance. *Coatings,* 8 (9): 317, 2018. DOI: 10.3390/coatings8090317

33. Biladeau A, Keener KM: The effects of edible coatings on chicken egg quality under refrigerated storage. *Poult Sci,* 88 (6): 1266-1274, 2009. DOI: 10.3382/ps.2008-00295

34. Vlčková J, Tůmová E, Míková K, Englmaierová M, Okrouhlá M, Chodová D: Changes in the quality of eggs during storage depending on the housing system and the age of hens. *Poult Sci*, 98, 6187-6193, 2019. DOI: 10.3382/ps/pez401

35. Pires PGS, Leuven AFR, Franceschi CH, Machado GS, Pires PDS, Moraes PO, Kindlein L, Andretta I: Effects of rice protein coating enriched with essential oils on internal quality and shelf life of eggs during room temperature storage. *Poult Sci,* 99 (1): 604-611, 2020. DOI: 10.3382/ps/pez546

36. Eroglu M, Baykalir Y, Erisir Z: The effect of different storage period on some egg quality characteristics and ovalbumin levels in goose eggs. *Emir J Food Agr,* 33 (8): 699-703, 2021. DOI: 10.9755/ejfa.2021.v33.i8.2741

37. Drabik K, Próchniak T, Kasperek K, Batkowska J: The use of the dynamics of changes in table eggs during storage to predict the age of eggs based on selected quality traits. *Animals,* 11 (11): 3192, 2021. DOI: 10.3390/ani11113192

38. Ingram DR, Hatten III LF, Homan KD: A study on the relationship between eggshell color and eggshell quality in commercial broiler breeders. *Int J Poult Sci,* 7, 700-703, 2008. DOI: 10.3923/IJPS.2008.700.703

39. De Ketelaere B, Govaerts T, Coucke P, Dewil E, Visscher J, Decuypere E, De Baerdemaeker J: Measuring the eggshell strength of 6 different genetic strains of laying hens: Techniques and comparisons. *Br Poult Sci,* 43 (2): 238-244, 2002. DOI: 10.1080/00071660120121454

40. Yuceer M, Caner C: Antimicrobial lysozyme–chitosan coatings affect functional properties and shelf life of chicken eggs during storage. *J Sci Food Agric,* 94 (1): 153-162, 2014. DOI: 10.1002/jsfa.6322

41. Caner C, Cansız Ö: Chitosan coating minimises eggshell breakage and improves egg quality. *J Sci Food Agric,* 88 (1): 56-61, 2008. DOI: 10.1002/jsfa.2962

42. Yüceer M, Caner C: The effects of ozone, ultrasound and coating with shellac and lysozyme-chitosan on fresh egg during storage at ambient temperature. Part II: Microbial quality, eggshell breaking strength and FT-NIR spectral analysis. *Int J Food Sci Technol,* 55 (4): 1629-1636, 2020. DOI: 10.1111/ijfs.14422

43. Safavi M, Javanmard M: Effect of whey protein-rice bran oil incorporated *Zataria multiflora* extract edible coating on chemical, physical and microbial quality of chicken egg. *Iran Food Sci Tech Res J,* 11, 738-746, 2016. DOI: 10.22067/IFSTRJ.V1394I6.50003

44. Sheng L, Huang M, Wang J, Xu Q, Hammad HHM, Ma M: A study of storage impact on ovalbumin structure of chicken egg. *J Food Eng,* 219, 1-7, 2018. DOI: 10.1016/j.jfoodeng.2017.08.028

45. Samli HE, Agma A, Senkoylu N: Effects of storage time and temperature on egg quality in old laying hens. *J Appl Poult Res,* 14 (3): 548-553, 2005. DOI: 10.1093/japr/14.3.548

46. Akarca G, Istek Ö, Tomar O: The effect of resin coating on the quality characteristics of chicken eggs during storage. *J Food Sci,* 86 (4): 1243-1257, 2021. DOI: 10.1111/1750-3841.15686

47. Güler G, Şen A, Korkmaz Turgud F, Tahtabiçen E, Ağma Okur A, Samli HE: Serbest gezen tavuklardan elde edilen yumurtaların propolis ekstraktı ile kaplanmasının raf ömrü ve kalite parametrelerine etkileri. *J Tekirdag Agric Fac,* 19 (1): 89-100, 2022. DOI: 10.33462/jotaf.893121

48. Didar Z: Effects of coatings with pectin and *Cinnamomum verum* hydrosol ıncluded pectin on physical characteristics and shelf life of chicken eggs stored at 30°C. *Nutr Food Sci Res,* 6 (4): 39-45, 2019. DOI: 10.29252/nfsr.6.4.39

49. Stadelman W: The preservation of quality in shell eggs. **In,** Stadelman W, Cotterill OJ (Eds): Egg Science and Technologyed. 67-79, Food Products Press, New York, London, 1995.

50. Mathew AO, Olufemi AM, Foluke A, Oguntunji A: Relationship of temperature and length of storage on pH of internal contents of chicken table egg in humid tropics. *Biotechnol Anim Husb,* 32 (3): 285-296, 2016. DOI: 10.2298/BAH1603285M