The use of propolis extract for the storage of quail eggs

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Primary Audience: Poultry Reseachers

SUMMARY

This study was carried out to evaluate the use of propolis extract on egg storage time of table quail *(Coturnix coturnix Japonica*) eggs. Propolis is a sticky, resinous, dark-colored material that honey bees collect from young plants. In the experiment, 600 quail eggs were used and eggs were coated with various concentrations of propolis extract (0%: group I, 5%: group II, 10%: group III, 15%: group IV) and treated with 70% ethyl alcohol (group V). A 5-week storage period was implemented, and 120 eggs were used for each group. Consequently, the effects of storage time and shell treatments on storage time and the effects of treatments on the interior quality of eggs were determined. The results of the study confirmed highly significant differences between weekly changes in egg weight loss, albumen-yellow indexes, and Haugh units ($P < 0.001$). While the difference in yolk index between groups was insignificant, the difference between groups with respect to albumen index ($P < 0.001$), Haugh units ($P < 0.001$) albumen pH ($P < 0.001$), and egg weight loss ($P < 0.001$) were significant. The significance of the overall difference with regard to Haugh units varied among groups; for example, group IV showed the highest value of 87.73%, followed by group III (87.69%), group II (86.97%), group V (85.53%), and group I (85.21%). Albumen pH levels were increased with increasing storage time for each treatment group. The best egg protection results in terms of interior quality were obtained in eggs coated with 10% and 15% propolis extract during storage.

Key words: egg quality, propolis, quail egg, storage time.

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DESCRIPTION OF PROBLEM

Eggs are naturally protected against microbial spoilage to some extent thanks to their biochemical structure and composition. However, significant quality losses may occur depending on the interval between egg collection time and consumption time if necessary measures are not taken [1].

Albumen height and albumen pH are important characteristics in the determination of the internal quality of commercial eggs. Of these

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properties, albumen height decreases, whereas albumen pH value increases with an increase in storage time [2–4]. The albumen pH value is between 7.6 and 7.9 following oviposition and may rise to 9.7 during storage time [5–9]. This happens because of the increased carbon dioxide loss from albumen through the shell [1,5–8].

Measures taken to prolong the egg storage time are usually based on a limitation of gas permeability due to coating of the pores at the shell surface [8,10]. Coating the egg shell protects the natural structure of the egg by reducing CO_2 and water loss from the albumen. For this reason some conservation methods, including oil coating, storing at low temperatures, freezing, storing, and drying, have been used for the prolonged protection of shell life, along with other methods [11].

In addition, some natural and risk-free products in terms of human health have been used in the coating of egg shells, such as chitosan, whey protein, shellac [12], and propolis [9].

Propolis is a sticky, gummy, resinous substance with a strange odor, which is collected by worker honeybees (*Apis mellifera*) from the young shoots and buds of certain trees and shrubs [13,14]. Propolis has immunostimulating, antibacterial, antioxidant, antimicrobial, and antiparasitic properties [15–21], and it is normally used by honeybees (*Apis mellifera*) to repair the slits and cracks inside hives and to embalm dead honeybees or other dead bugs that could not be removed from hives. Additionally, use of propolis during the brood period prevents water loss by evaporation through cracks and crevices [13,14]

Propolis is also used for the protection of various agricultural products during storage because of its antimicrobial and embalming properties. Torre et al. [22] and Ozdemir et al. [23], covered strawberry and mandarin with propolis to inhibit *Botrytis cinerae* Pers development and to prevent weight loss during storage. Owing to its antimicrobial effects, propolis has also been used to disinfect quail hatching eggs [24,25].

In this study, we aimed to determine the effects of coating quail table eggs with propolis, a natural product, on the interior egg quality characteristics during storage.

MATERIALS AND METHODS

This study was conducted at the Mustafa Kemal University Samandag Two-Year College in 2012. A total of 600 eggs were obtained from 12-wk-old Japonica quail (*Coturnix coturnix japonica*), which reached 90% egg production. Upon oviposition eggs were collected and brought to the laboratory for coating with various dosages of propolis extract.

The following treatments were included: control without any treatment (group I), coating with 5% (group II), 10% (group III), 15% (group IV) propolis extract, and coating with ethyl alcohol (group V).

The eggs in each treatment group were individually weighed in order to determine the egg weight loss along storage time. Before storage 20 fresh eggs (0 day storage) from each group were collected and analyzed within 2 h of being laid to determine the basic internal egg quality parameters. Following treatment, eggs were stored for 5 wk at room temperature (25°C). Every week, 20 eggs from each group were used to determine albumen pH, albumen height, albumen width, albumen length, yolk height, yolk length, and egg weight loss during storage.

Preparation of Propolis Solution

Propolis was collected from honey bees in Hatay Province, Turkey, in 2011 and extracted according to the method suggested by Krell [26; 25]. A 5% propolis solution was prepared by mixing 1,950 mL 70% ethanol and 50 g propolis, the 10% propolis solution was 1,900 mL 70% ethanol and 100 g propolis, and the 15% propolis solution was 1,850 mL 70% ethanol and 150 g of propolis. Solutions were kept in a sealed container and shaken twice daily for 2 wk.

Coating of Egg with Coating Solution and Alcohol

Eggs were immersed in the 5%, 10%, 15% propolis solutions and ethanol by hand for 1 min, and this process was repeated once more after 10 min. Following the second immersion the eggs were dried for 24 h at ambient temperature.

pH Measurement

After measurements for the albumen and yolk index parameters, the albumen was separated from the yolk. The volumes of thick and thin albumen were mixed with a spatula by hand before measuring the pH value. The pH of the albumen was measured using a pH 210 meter (Hanna Instruments, Woonsocket, RI).

Egg Weight Loss

Egg weight loss (EWL) during storage was calculated by individual measurement of initial and weekly weight changes in each group as follows:

$$\text{EWL}\,(\%) = (\text{W}_0 - \text{W}_1/\text{W}_0) \times 100$$

$$\text{W}_0 = \text{Initial Egg Weight}$$

$$\text{W}_1 = \text{Egg Weight During Measurement Day}$$

Albumen Index

Eggs from each treatment group were broken on a flat surface where the height of the albumen was measured in millimeters, halfway between the yolk and edge of the inner thick albumen, using a standard tripod micrometer. Measurements were taken from 3 points on the inner thick albumen at intervals of 10 mm from each other.

Measurement of albumen width was to 0.1 mm using a steel Vernier caliper. The albumen index (AI) was calculated as follows [27]:

$$\text{AI}\,(\%) = [\text{Albumen Height}/((\text{Albumen Length} + \text{Albumen Width})/2)] \times 100$$

Haugh Unit

Haugh unit (HU) values were calculated using the following formula [28]:

$$\text{HU} = 100\,\text{Log}(\text{H} + 7.57 - 1.7 \times \text{W}^{0.37})$$

where H is the albumen height (millimeters) and W is the egg weight (grams).

Yolk Index

The yolk index (YI) was calculated as follows [29]:

$$\text{YI}\,(\%) = (\text{Yolk Height}/\text{Yolk Width}) \times 100$$

Data Analysis

In this study, the combined effect of propolis and storage time on internal egg qualities was evaluated. The data were subjected to a GLM using the *SPSS (SPSS for Windows release 13)* software package, with treatments and storage time as the main effects. When the main effects were significant at $P < 0.05$, differences between means were tested using Duncan's multiple range test.

RESULTS AND DISCUSSION

Albumen pH

To determine the changes in albumen pH during storage, it was necessary to measure the initial albumen pH immediately after oviposition time. Albumen quality was determined by albumen height and albumen pH. Initial albumen pH levels in each group increased with increasing storage time, but this increase in the control group and the groups coated with ethyl alcohol was higher than the increase in the other treatment groups coated with different concentrations of propolis (Table 1). The initial albumen pH level of the control group was 8.28, and that of the group coated with ethyl alcohol was 8.90. These values increased to 9.45 at the end of the fifth week (Table 1).

The difference in pH values at the beginning and end of the storage time in groups I, V, II, IV, and III were 0.55, 1.17, 0.30, 0.26, and 0.23, respectively (Table 1). The observed values supported previous studies by Caner [12] and Copur et al. [9], who found lower pH values at the end of storage when eggs were coated with chitosan, shellac, and propolis compared to uncoated eggs. In this study the albumen pH values recorded after the fifth week of storage were close to the pH value of quail eggs reported by Baylan [30], who found it to be 9.52 at 20°C after 30 d of storage,

Table 1. Effect of propolis coating on albumen pH during 5 wk of storage.

	Weeks							
Group	0	1	2	3	4	5	F	P
I	8.28 ± 0.12^{d}	9.00 ± 0.02^{c}	$9.31 \pm 0.03^{a,b}$	$9.32 \pm 0.01^{a,b}$	9.21 ± 0.01^{b}	9.45 ± 0.02^{a}	68.933	0.000
II	9.01 ± 0.02^{c}	8.98 ± 0.02^{c}	$9.29 \pm 0.01^{a,b}$	$9.29 \pm 0.01^{a,b}$	9.25 ± 0.01^{b}	9.31 ± 0.01^{a}	109.207	0.000
III	9.05 ± 0.01^{d}	8.97 ± 0.01^{e}	9.31 ± 0.01^{b}	9.35 ± 0.01^{a}	9.24 ± 0.01^{c}	9.28 ± 0.01^{b}	237.838	0.000
IV	9.01 ± 0.02^{d}	9.22 ± 0.01^{c}	9.31 ± 0.01^{a}	9.34 ± 0.01^{a}	9.19 ± 0.02^{c}	9.27 ± 0.02^{b}	68.381	0.000
V	8.90 ± 0.02^{e}	9.04 ± 0.01^{d}	9.24 ± 0.01^{c}	9.27 ± 0.01^{b}	9.22 ± 0.01^{c}	9.45 ± 0.01^{a}	172.272	0.000

I: Control group; II: 5% propolis; III: 10% propolis; IV: 15% propolis; V: alcohol.

[a–e]Means with different superscripts within rows are significantly different ($P < 0.001$).

and by Aktan [31], who reported a pH of 9.78 after 7 d of storage.

Some researchers [3,5,7] have reported that the starting value of albumen pH for chicken egg was between 7.6 and 7.9. In the present experiment the basic albumen pH in quail egg was 8.84 (Table 6). This value is similar to that of previous studies, in which the initial albumen pH of quail egg was determined to be between 8.56 and 9.17 [30,32–33]. The pH of albumen increased with increasing storage time from 8.84 to 9.35 ($P < 0.001$) (Table 6). These results are in agreement with previous studies conducted by Silversides and Scott [3], Samli et al. [34], Caner [12], Akyürek and Okur [35], Aktan [31], Baylan et al. [30], Hristakieva et al. [36], and Jin et al. [37], who found an increase in the initial albumen pH level depending on storage time.

Egg Weight Loss

Internal egg quality characteristics are affected by factors such as egg surface coating with different materials and storage time. The egg weight loss of each treatment group increased significantly with storage time ($P < 0.001$) (Table 2) (Table 6). The egg weight loss of groups I, II, III, IV, and V was 6.09, 5.72, 5.01, 4.67, and 5.81%, respectively. The highest egg weight loss values were obtained from the control group and samples coated with ethyl alcohol. While the egg weight loss in the first week was 1.16%, it reached 5.46% after the fifth week (Table 6). In the present experiment, egg weight loss differed significantly between all treatment groups ($P < 0.001$) (Table 7). The highest average egg weight loss was 3.57% in group I, followed by groups V (3.44%), II (3.27%), III (2.97%), and IV (2.17%).

These results are in agreement with those of Romao et al. [38], who reported egg weight losses of 2.72 and 2.39% during 2 wk of storage at 20°C in meat and laying type quails, respectively. Lacin et al. [39] also reported similar egg weight loss (2.56% during 2 wk of storage). In this study, the determined egg weight loss following 2 wk of storage was 2.18%, which was similar to the results given previously (Table 6). While in other studies the egg weight loss was 2.07% (32°C ambient temperature) [40] and 2.8% (at 32°C ambient temperature) [41] after 1 wk of storage, in the present experiment, the same losses were observed after 2 wk. Garip and Dere [42] also reported similar weight losses in quail eggs with 10 d of storage at 11°C, 21°C, and

Table 2. Effect of propolis coating on egg weight loss during 5 wk of storage (%).

	Weeks						
Group	1	2	3	4	5	F	P
I	1.28 ± 0.10^{a}	2.32 ± 0.14^{a}	3.64 ± 0.34^{b}	4.53 ± 0.56^{b}	6.09 ± 0.76^{c}	16.969	0.000
II	1.14 ± 0.06^{d}	2.30 ± 0.14^{c}	3.03 ± 0.21^{c}	4.29 ± 0.27^{b}	5.73 ± 0.46^{a}	46.002	0.000
III	1.08 ± 0.10^{d}	$1.95 \pm 0.13^{c,d}$	2.75 ± 0.10^{c}	4.00 ± 0.59^{b}	5.01 ± 0.34^{a}	25.514	0.000
IV	1.05 ± 0.09^{d}	1.80 ± 0.11^{c}	2.47 ± 0.17^{c}	3.48 ± 0.33^{b}	4.68 ± 0.43^{a}	30.449	0.000
V	1.29 ± 0.12^{d}	2.54 ± 0.12^{c}	3.24 ± 0.32^{c}	4.35 ± 0.42^{b}	5.81 ± 0.32^{a}	35.700	0.000

I: Control group; II: 5% propolis; III: 10% propolis; IV: 15% propolis; V: alcohol.

[a–d]Means with different superscripts within rows are significantly different ($P < 0.001$).

Table 3. Effect of propolis coating on value of albumen index during 5 wk of storage (%).

	Weeks							
Group	0	1	2	3	4	5	F	P
I	13.18 ± 0.54[a]	10.40 ± 0.27[b]	8.14 ± 0.43[c]	7.20 ± 0.34[c,d]	6.45 ± 0.29[d,e]	5.65 ± 0.23[e]	59.283	0.000
II	14.28 ± 0.38[a]	10.72 ± 0.27[b]	9.18 ± 0.29[c]	7.53 ± 0.30[d]	7.23 ± 0.30[d]	6.34 ± 0.29[e]	90.676	0.000
III	14.44 ± 0.39[a]	10.40 ± 0.42[b]	8.69 ± 0.33[c]	7.87 ± 0.23[c,d]	8.04 ± 0.26[c,d]	7.29 ± 0.34[d]	64.717	0.000
IV	14.29 ± 0.65[a]	9.93 ± 0.32[b]	9.03 ± 0.36[b,c]	8.03 ± 0.29[c,d]	7.89 ± 0.37[c,d]	7.38 ± 0.21[d]	42.128	0.000
V	14.05 ± 0.47[a]	10.11 ± 0.42[b]	8.04 ± 0.34[c]	7.32 ± 0.28[c,d]	6.67 ± 0.18[d,e]	6.04 ± 0.15[e]	82.932	0.000

I: Control group; II: 5% propolis; III: 10% propolis; IV: 15% propolis; V: alcohol.

[a–e]Means with different superscripts within rows are significantly different ($P < 0.001$).

27°C. They found egg weight losses of 1.3, 3.1, and 3.7%, which were similar to the results of this study. In other experiments, egg weight losses of 1.58% were found in duck eggs stored for 11 d at 17°C [43], 1.66% in chicken eggs stored for 10 d at 21°C [34], and 2.60% in Fayumi chicken eggs stored for 8 d at 16°C and 75–80% relative humidity [44]. Differences in egg weight loss between studies may be due to different storage times, storage temperatures, egg sizes, or shell porosities.

In this study weight loss in uncoated eggs was found to be significantly higher than that found in coated eggs ($P < 0.001$) (Table 7). The samples with 15% propolis coating had significantly lower weight loss compared to the other two propolis concentrations. This finding is in agreement with the results reported by Aygun and Sert [25]. These authors reported 1.74, 1.75, and 1.37% and 2.86, 2.55, and 2.28% weight loss over 7 and 14 d of storage respectively for quail hatching eggs coated with 5, 10, and 15% propolis. Coating eggs using various concentrations of propolis may prolong their shelf life by preventing weight loss by limiting the loss of humidity and carbon dioxide through the shell.

Albumen Index

Some undesirable physicochemical changes in egg structure arose with increased storage times [34,45].

The albumen index significantly decreased with increasing storage time in all treatment groups ($P < 0.001$) (Table 3). The highest decrease in the albumen index after storage times compared with the initial albumen index values was in group V, followed by groups II, I, III, and IV. This result agreed with those of previous studies [4,9,12,35,37,46–48], which reported that the albumen index decreased with increasing storage time.

The index values with studies on quail were reported to be 12.56% by Salman and Tabeekh [49], 8.85% by Cabuk et al. [50], 14% by Shit et al. [51]; in 8-, 13-, 18-, and 23-wk-old quail (*Pharaoh coturnix*); those values were reported to be 10.0, 9.0, 9.0, and 13.0%, respectively, by Wilkanowska and Kokoszyński [33]; in Pharaoh and Manchurian Golden genotypes Genchev reported those values as 10.6% and 10.5%, respectively [52]. The difference in the initial albumen index value may be explained by the different genotypes and ages of quails used in previous studies.

The effect of storage time on the albumen index was significant ($P < 0.001$) (Table 6). In the present experiment the albumen index differed significantly among the treatment groups (Table 7). The highest albumen index values were obtained in groups II (9.24%), III (9.45%), and IV (9.45%), which were coated with propolis extract. The albumen index values of the control group and the group coated with ethyl alcohol were 8.50% and 8.71%, respectively.

Haugh Unit

The Haugh unit (HU) is related to albumen quality and measured as a function of the inner thick albumen height and egg weight. Weekly changes in HU values of all treatment groups during storage time are given in Table 4.

The basic HU value (95.28) decreased with increasing storage time. At the end of the storage time (week 5), the HU value was found to be 82.40. The differences between weeks were statistically significant ($P < 0.001$) (Table 6).

Table 4. Effect of propolis coating on Haugh units during 5 wk of storage.

	Weeks							
Group	0	1	2	3	4	5	F	P
I	92.92 ± 0.79[a]	89.57 ± 0.46[b]	83.90 ± 0.81[c]	83.26 ± 0.72[c]	80.78 ± 1.00[d]	80.81 ± 0.56[d]	44.540	0.000
II	95.50 ± 0.58[a]	89.71 ± 0.52[b]	87.76 ± 0.59[c]	83.94 ± 0.63[d]	83.67 ± 0.57[d,e]	81.96 ± 0.80[e]	65.429	0.000
III	96.19 ± 0.62[a]	89.68 ± 0.87[b]	86.70 ± 0.57[c]	84.70 ± 0.70[d]	85.17 ± 0.55[c,d]	84.01 ± 0.67[d]	48.531	0.000
IV	95.83 ± 1.32[a,b]	89.30 ± 0.60[b]	86.68 ± 0.68[c]	85.33 ± 0.63[c,d]	84.83 ± 0.63[c,d]	84.24 ± 0.38[d]	32.459	0.000
V	95.96 ± 0.58[a]	89.76 ± 0.58[b]	84.51 ± 0.82[c]	82.63 ± 0.56[d]	81.07 ± 0.46[d]	81.00 ± 0.41[d]	103.359	0.000

I: Control group; II: 5% propolis; III: 10% propolis; IV: 15% propolis; V: alcohol.

[a–e]Means with different superscripts within rows are significantly different ($P < 0.001$).

Table 5. Effect of propolis coating on yolk index during 5 wk of storage (%).

	Weeks							
Group	0	1	2	3	4	5	F	P
I	48.01 ± 1.04[a]	40.64 ± 0.50[b]	32.40 ± 0.59[c]	32.31 ± 0.53[c]	28.81 ± 0.41[d]	26.93 ± 0.64[e]	150.361	0.000
II	48.91 ± 0.66[a]	40.79 ± 0.51[b]	35.90 ± 0.57[c]	32.74 ± 0.61[d]	32.99 ± 0.76[d]	27.00 ± 0.65[e]	144.183	0.000
III	49.31 ± 0.62[a]	41.07 ± 0.53[b]	36.33 ± 0.60[c]	33.43 ± 0.81[d]	29.85 ± 0.54[e]	27.95 ± 0.88[e]	135.164	0.000
IV	49.78 ± 0.72[a]	40.19 ± 0.48[b]	36.14 ± 0.55[c]	31.70 ± 0.56[d]	28.92 ± 0.72[e]	27.78 ± 0.69[e]	175.610	0.000
V	49.58 ± 0.745[a]	41.02 ± 0.50[b]	34.85 ± 0.40[c]	32.01 ± 0.73[d]	29.37 ± 0.52[e]	27.47 ± 0.47[f]	206.191	0.000

I: Control group; II: 5% propolis; III: 10% propolis; IV: 15% propolis; V: alcohol.

[a–f]Means with different superscripts within rows are significantly different ($P < 0.001$).

Table 6. Mean weekly changes in initial egg quality for all treatments.

	Weeks							
Properties	0	1	2	3	4	5	F	P
Egg weight loss (g)		1.16 ± 0.04[e]	2.18 ± 0.06[d]	3.02 ± 0.11[c]	4.13 ± 0.20[b]	5.46 ± 0.22[a]	128.842	0.000
Yolk index (%)	49.12 ± 0.34[a]	40.74 ± 0.22[b]	35.12 ± 0.28[c]	32.44 ± 0.30[d]	29.99 ± 0.31[e]	27.43 ± 0.30[f]	732.845	0.000
Albumen index (%)	14.05 ± 0.22[a]	10.33 ± 0.15[b]	8.61 ± 0.16[c]	7.59 ± 0.13[d]	7.25 ± 0.14[d]	6.54 ± 0.13[e]	301.661	0.000
Haugh unit	95.28 ± 0.38[a]	89.60 ± 0.27[b]	85.71 ± 0.33[c]	83.93 ± 0.30[d]	83.11 ± 0.35[d,e]	82.40 ± 0.30[e]	233.186	0.000
Albumen pH	8.84 ± 0.04[e]	9.04 ± 0.01[d]	9.29 ± 0.01[b]	9.31 ± 0.05 [a,b]	9.22 ± 0.00[c]	9.3 ± 0.01[a]	132.549	0.000

I: Control group; II: 5% propolis; III: 10% propolis; IV: 15% propolis; V: alcohol.

[a–f]Means with different superscripts within rows are significantly different ($P < 0.001$).

Table 7. Means of interior egg quality at the end of the experiment on the different treatment groups.

	Group						
Properties	I	II	III	IV	V	F	P
Egg weight loss (g)	3.57 ± 0.26[a]	3.27 ± 0.20[a,b]	2.97 ± 0.20[a,b]	2.67 ± 0.17[b]	3.44 ± 0.20[a]	3.084	0.001
Yolk index (%)	38.85 ± 0.72	36.47 ± 0.69	36.29 ± 0.72	35.82 ± 0.74	35.74 ± 0.74	0.769	0.546
Albumen index (%)	8.50 ± 0.28[b]	9.24 ± 0.28[a,b]	9.45 ± 0.26[a]	9.45 ± 0.27[a]	8.71 ± 0.29[a,b]	2.564	0.037
Haugh unit	85.21 ± 0.51[c]	86.97 ± 0.49[a,b]	87.69 ± 0.47[a]	87.73 ± 0.48[a]	85.83 ± 0.56[b,c]	5.071	0.001
Albumen pH	9.09 ± 0.03[b]	9.19 ± 0.01[a]	9.19 ± 0.01[a]	9.22 ± 0.01[a]	9.18 ± 0.02[a]	4.762	0.001

I: Control group; II: 5% propolis; III: 10% propolis; IV: 15% propolis; V: alcohol.

[a–c]Means with different superscripts within rows are significantly different ($P < 0.001$).

The HU values during 5 wk of storage were higher in groups IV (8.87) and III (87.69) than in groups II (86.97), V (85.83), and I (85.21) (Table 7). The decreasing HU values with increasing storage time were supported by previous studies [3,9,12,30,31,34–37] conducted with chicken and coturnix eggs. At the end of storage, the highest HU values were determined in groups IV and III. This result is in agreement with those of Allenoni and Antunes [53], Caner [12], and

Copur et al. [9], i.e., studies that found a higher HU value in coated eggs compared to uncoated eggs.

Yolk Index

The yolk index (YI) decreases during storage through the diffusion of water from the albumen to the yolk, resulting in changes in the vitellin membrane and in liquefaction of the yolk [3,54].

The YI decreased with increasing age of the hen eggs [55], though this trend was not confirmed in Japanese quail eggs, and the YI of quail eggs was higher than that of chicken eggs [56]. The differences in YI among treatment groups were insignificant ($P > 0.05$) (Table 7). The determined basic YI value (49.12%) was approximately similar to the values obtained by Zita et al. [57], who reported results of 49.11% for 9-wk-old quail, 47.66% for 13-wk-old quail, and 50.81% for 37-wk-old quail.

The YI values for fresh and good quality eggs were reported to be 43.67% by Kumar et al. [58] and Nowaczewski et al. [59], 45% by Dudusola [60], 46% by Canogulları et al. [61], 42.73% by Alkan et al. [62], and 47.80% by Zita et al. [57]. The effect of storage time on YI was statistically significant ($P < 0.001$) (Table 5).

The basic YI decreased significantly with increasing storage time (Table 6). The basic YI values decreased from 49.12 to 35.12, 32.44, 29.99, and 27.43% for 1-, 2-, 3-, 4-, and 5-wk storage times, respectively.

These results are in agreement with those of previous studies [4,9,12,30,44,59,63], which found a significant decrease in YI with increasing storage time in various poultry eggs.

CONCLUSIONS AND APPLICATIONS

1. Coating egg shell surfaces with propolis was found to be effective at protecting the internal egg quality parameters, and these parameters were negatively affected by storage time.
2. Coating eggs with propolis extract, a natural product, may help to ameliorate the decrease in quality during storage.

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