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Effects of Pre-Storage Gum Arabic Application on Hatch Results and Chick Performance in Hatching Quail Eggs

Mustafa Güvenc[1], Ali Aygün [1,*]

[1] Selçuk University, Agriculture Faculty, Department of Animal Science, 42250, Konya, Turkey

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***Corresponding Author**
Tel: ++905055470821
E-mail: aaygun@selcuk.edu.tr

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Abstract

In this study, the effects of pre-storage coating of different ratios of gum arabic on hatching traits and chick growth performance were investigated. Treatment groups; eggs treated with 5% gum arabic were stored for 7 days (7-5G), eggs treated with 5% gum arabic were stored for 14 days (14-5G), eggs treated with 10% gum arabic were stored for 7 days (7-10G) and 10% gum arabic applied eggs were stored for 14 days (14-10G). After the gum arabic application, the eggs were stored at 13 °C with 75% humidity for 7 or 14 days. In the study, a total of 800 hatching eggs were used, with 200 eggs in each of the four groups. Regardless of the gum arabic application, eggs stored for 7 days have less egg weight loss than eggs stored for 14 days ($P<0.05$). There were no statistically significant differences found for hatchability of set eggs (HSE). The highest hatchability of fertile eggs (HFE) were found in 7-5G (88.22%) and lowest HFE was observed in 14-10G (73.96%) ($P<0.05$). In terms of embryonic mortality, the differences between the groups at days 1-9 and 17-18 were insignificant. Embryonic mortality was highest (16.49%) in the 14-10G group in the 10-16-day period ($P<0.05$). No statistically significant differences were observed among groups for chick body weight at hatch and yolk sac ratio (YSR). The lowest relative growth was found in the 14-10 G group ($P<0.05$). As a result, 5% gum arabic application and storage for 14 days can be recommended for long-term storage of eggs since it does not have a negative effect on hatchability, embryonic mortality, or chick growth performance.

Introduction

One of the important factors affecting the hatchability of hatching eggs is the storage of eggs. During storage, water and CO_2 are lost from the egg through the pores, the albumen pH increases and the albumen height decreases (Stadelman 1995; Elibol 2014). Hatching eggs can be stored for up to 7 days without adversely affecting the hatchability. Market and hatchery conditions are effective in determining the storage period. The incubation period can be extended or shortened depending on the high or low demand for chicks (Fasenko 2007). If the storage period is longer than seven days, hatchability decreases, chick quality is adversely affected, and chick deaths increase during the rearing period (Fasenko *et al.,* 2001; Elibol *et al.,* 2002; Tona *et al.,* 2003; Ipek *et al.,* 2006; Yassin *et al.,* 2008).

Some coating materials have been used to reduce the negative effects of long term storage. These coating materials are propolis (Aygun and Sert 2013), chitosan (Köseman *et al.,* 2020b; Köseman *et al.,* 2020a), stretch (Durmuş *et al.,* 2009), and chitosan-nanoparticles (Chekh *et al.,* 2021).

Gums are food additives that are widely used as thickening, gelling, and stabilizing agents (Saha and Bhattacharya 2010; Cong *et al.,* 2021). It is also used in many different areas, including creams and lotions, adhesives, inks, paper coating, ceramics, and metal corrosion inhibitors. One of the most important features of gum arabic is its film forming feature, and it has been used as an edible coating directly or in combination with different materials in recent years, allowing the longer-

term preservation of fruits and vegetables and meat products such as meatballs (Ali et al., 2010; Salehi 2020; Zhou et al., 2021). Such long-term preservation is possible as the gum arabic film minimizes contact between the external environment and the coated material. In recent years, gum arabic films have been widely used as a coating material because they are natural, soluble in water, can be easily removed and, have no adverse effects on human health if consumed (Ali et al., 2009; Xu et al., 2019).

According to our current literature research, no study has been found on the storage of hatching eggs using gum arabic coating material. Therefore, we studied the effects of gum arabic coating on hatching traits, chick weight, yolk sac ratio and chick performance in hatching eggs during 7 or 14 days of storage.

Materials and Methods

Material

A total of 800 quail eggs obtained from a private farm in Konya were used in the research. Eggs were randomly divided into 4 treatment groups. Each group was composed from 4 replications, with 50 eggs in each replication. Treatment groups; eggs treated with 5% gum arabic were stored for 7 days (7-5G), eggs treated with 5% gum arabic were stored for 14 days (14-5G), eggs treated with 10% gum arabic were stored for 7 days (7-10G) and 10% gum arabic applied eggs were stored for 14 days (14-10G).

Preparation of solutions

Two different gum arabic solutions at the concentrations of 5, and 10% were used in this study. Briefly, 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 h, and then kept in a fridge at +4℃ without stirring overnight. The gum arabic solutions were prepared the day before use (Sariyel et al., 2022).

Application of gum arabic solutions

The first and second groups were sprayed with two different concentrations of gum arabic: 5% (G5) and 10% (G10), respectively. The solutions (1000 mL of each solution) were sprayed onto the eggshell to cover the whole shell surface. After gum arabic application, each of the 200 eggs was stored for 7 or 14 days at 13°C and 75% relative humidity before storage. Thus, 800 eggs were randomly divided into four treatments (two pre-storage applications x two storage periods). After the gum arabic application, 40 eggs from each group were weighed. Eggs were weighed again at the end of storage, and egg weight loss was determined during storage. When determining egg weight loss, infertile eggs and dead embryos were excluded.

Incubation management

This study was carried out in Selçuk University, Agriculture Faculty, Department of Animal Science. The temperature of the incubator was set at 37.0 - 37.5 °C and 50-55% relative humidity for the first 14 days of incubation, and 37.0 °C and 75% relative humidity in the hatching period, and automatic turning was applied 12 times a day.

Hatching

After the chick hatchings were completed, the non-hatched eggs were opened and the embryo death stage were determined according to Aygun et al., (2012). The following characteristics were calculated from these data.

Fertility (%) = Fertile eggs / total eggs x 100
HFE (%) = Hatched chicks/ fertile eggs x 100
HSE (%) =Hatched chicks/total eggs x 100

Chick weight and yolk sac ratio

After hatching, yolk sac weight was determined in 5 chicks from each group. For this purpose, the chicks were weighed and killed, the yolk sac was separated from the body and weighed to the nearest 0.01 g. The yolk sac weight was divided by the body weight and expressed as %.

Chick performance

In order to measure chick performance, 10 chicks (40 chicks/group) randomly selected from each subgroup were individually weighed, wing banded, and placed in brooding cages. During the 10-day of rearing period, chicks were fed a grower diet (24% CP and 2,900 kcal ME/kg) The room temperature is adjusted to be 33-35℃ and continuous light is preferred as photoperiod until the end of the rearing period. The chicks were individually weighed at the end of the 10 d rearing period and the relative growth was calculated using these data (Tona et al., 2003). Chick deaths were recorded daily.

Relative Growth (RG) = [Body weight of d 10 (g) hatch body weight (g)] / hatch body weight (g) x 100

Statistical Analysis

The data were analyzed using variance analysis, and performed by Tukey's multiple range test for comparison mean values of treatment groups.

Result and Discussion

Egg weight loss

The effect of pre- storage application of gum arabic on egg weight loss during storage is given in Table 1. Pre-storage gum arabic application did not have a statistically significant effect on pre-storage egg weight (g) or end-of-storage egg weight (g). Regardless of the gum arabic application, eggs stored for 7 days have less weight loss than eggs stored for 14 days.

The lowest egg weight loss was detected in the 7-5G group (0.95%) and the highest egg weight loss was detected in the 14-5G group (2.00%) (P<0.05). Aygun, Sert (2013) applied propolis in different doses before storage and found egg weight loss between 1.37% and 1.92% in eggs stored for 7 days and between 2.28% and 3.20% in eggs stored for 14 days, and they stated that egg weight loss was significantly affected by propolis application doses. Similarly, Köseman et al., (2020b) reported that pre-storage chitosan application significantly reduced egg weight loss compared to the control group. Egg weight loss is due to evaporation of water through the pores in the eggshell. The main purpose of egg coating is to close these pores and minimize water evaporation. It can be thought that the gum arabic material used in our research either did not close the pores well enough or it lost its coating feature quickly during the storage period.

Hatchability and embryonic mortality

The effect of pre- storage application of gum arabic on hatching traits and embryonic mortality is summarized in Table 2. There were no statistically significant differences for HSE. The highest HFE were found in 7-5G (88.22%) and the lowest HFE was observed in 14-10G (73.96%) (P<0.05). However, the difference between groups 7-5G (88.22%), 7-10G (84.27%) and 14-5G (83.42%) in terms of HFE was statistically insignificant. Köseman et al., (2020b) stated that pre-storage application of chitosan and storage for 7 and 14 days had a negative effect on hatchability. On the other hand, Aygun, Sert (2013) stated that pre-storage propolis application and storage for 7 and 14 days did not have a negative effect on hatchability. Similarly, Durmuş *et al.,* (2009) reported that pre-storage application of gelatin and stretching and storage for 13 days did not have a negative effect on hatchability. Chekh *et al.,* (2021) stated that pre-storage chitosan-nanoparticles application increased hatchability by 2.3-11.6% compared to the control.

EM between 10 and 16 days of incubation in the 14-10G group (16.49%) was higher than the 7-5G (6.45%), 7-10G (2.18%), and 14-5G (5.81%) treatments groups (P<0.05). No statistically significant differences were determined between d 1 and 9 or between d 17 and 18 of incubation periods.

Table 1. Effects of gum arabic application on egg weight loss during storage

Treatment	Pre-storage egg weight (g)	End of storage egg weight (g)	Egg weight loss during storage (%)
7-5G	12.53	12.41	0.95[b]
7-10G	12.58	12.45	1.08[b]
14-5G	12.39	12.14	2.00[a]
14-10G	12.34	12.10	1.95[a]
SEM	0.166	0.164	0.832
P value	0.704	0.318	0.000

[a,b] Differences between groups are statistically significant (P < 0.05).
7-5G: 5% gum arabic application and 7 days storage; 7-10G: 10% gum arabic application and 7 days storage; 14-5G: 5% gum arabic application and 14 days storage; 14-10G: 10% gum arabic application and 14 days storage, SEM: Standard error mean

Table 2. Effects of gum arabic application on hatching traits and embryonic mortality

Treatment	Fertility (%)	HSE (%)	HFE (%)	EM (%)		
				1 - 9 d	10 - 16 d	17 - 18 d
7-5G	94.39	83.25	88.22[a]	7.00	6.45[b]	0.52
7-10G	92.94	78.32	84.27[ab]	11.94	2.18[b]	2.70
14-5G	94.98	79.30	83.42[ab]	10.73	5.81[b]	1.62
14-10G	94.94	70.09	73.96[b]	9.07	16.49[a]	2.11
SEM	2.345	1.672	1.496	0.944	1.107	0.378
P value	0.918	0.090	0.033	0.324	0.004	0.268

[a,b] Differences between groups are statistically significant (P < 0.05).
7-5G: 5% gum arabic application and 7 days storage; 7-10G: 10% gum arabic application and 7 days storage; 14-5G: 5% gum arabic application and 14 days storage; 14-10G: 10% gum arabic application and 14 days storage, SEM: Standard error mean

This result was similar to the result that Durmuş et al., (2009) stated that pre-storage sugar water application significantly increased mid-term embryonic mortality. On the other hand, Chekh et al., (2021) stated that pre-storage chitosan-nanoparticle application reduced embryonic mortality.

Chick weight and yolk sac ratio

Table 3 summarizes the treatment groups' chick body weight at hatch, YSR (g, %). No statistically significant differences were observed among groups for chick body weight at hatch and YSR (g, %). This result is consistent with the studies of Durmuş et al., (2009) that showed pre-storage stretch and gelatin application do not affect the chick hatching weight. The weight of the yolk sac in poultry varies between 10% and 25% of the hatching body weight (Jamroz et al., 2004; Abdulqader et al., 2018). The yolk sac of an egg is extremely rich in nutrients required for embryonic development and for feeding in the early post-hatching period (Noy and Sklan 1998; Jamroz et al., 2004).

Chick performance

Pre-storage application of gum arabic on chick body weight at day 1, body weight at day 10, and relative growth are presented in Table 4.

No significant differences were determined among 7-5G (52.67 g), 7-10G (52.79 g), and 14-5G (51.18 g) treatment groups, but 14-10G (48.98 g) had a significantly lower body weight than that of 7-5G (52.67 g) and 7-10G (52.79 g) at d 10 of rearing period ($P<0.05$).

The relative growth of 14-10G (469) treatment group was lower compared with those of the 7-5G (543) and 7-10G (539) treatment groups ($P<0.05$). These results are inconsistent with Köseman *et al.,* (2020a) who found pre-storage chitosan application did not have a negative effect on chick body weight gain.

Conclusion

According to our research results, 10% gum arabic was applied and 14 days of storage negatively affected hatchability, embryo mortality, and chick performance. However, 5% gum arabic did not adversely affect hatchability or chick performance in eggs stored for 14 days. As a result, if 5% gum arabic is applied to eggs that will be stored for an extended period of time, the negative effects can be mitigated.

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Table 3. Effects of gum arabic application on chick hatching weight and yolk sac weight

Treatment	Chick hatch weight (g)	Yolk sac weight (g)	Yolk sac ratio (%)
7-5G	8.21	0.71	8.68
7-10G	8.63	1.04	11.88
14-5G	9.03	0.92	10.16
14-10G	8.24	0.76	9.15
SEM	0.323	0.136	1.305
P value	0.271	0.326	0.348

7-5G: 5% gum arabic application and 7 days storage; 7-10G: 10% gum arabic application and 7 days storage; 14-5G: 5% gum arabic application and 14 days storage; 14-10G: 10% gum arabic application and 14 days storage, SEM: Standard error mean

Table 4. Effects of gum arabic application on chick body weight and relative growth

Treatment	Body weight (1 d, g)	Body weight (10 d, g)	Relative growth
7-5G	8.21	52.67^{a}	543^{a}
7-10G	8.30	52.79^{a}	539^{a}
14-5G	8.42	51.18^{ab}	513^{ab}
14-10G	8.63	48.98^{b}	469^{b}
SEM	0.128	0,954	12.569
P value	0.116	0.017	0.000

^{a,b} Differences between groups are statistically significant ($P < 0.05$).

7-5G: 5% gum arabic application and 7 days storage; 7-10G: 10% gum arabic application and 7 days storage; 14-5G: 5% gum arabic application and 14 days storage; 14-10G: 10% gum arabic application and 14 days storage, SEM: Standard error mean

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