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Research Paper

The Potential of Chitosan and Virgin Coconut Oil as Egg Coating Materials to Maintain the Quality of Local Duck Eggs during Storage

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Abstract
Eggs can be preserved by soaking them in an antibacterial solution. Chitosan and pure coconut oil are two such materials. This study aimed to extend the shelf life of eggs while maintaining their quality. The present study applied a completely randomized design (CRD) with five treatments and four. **The eggs were stored for 14 days under room temperature (**25-30°C**) and** 70-80% **relative humidity.** The treatments in this study were: P0 = without a chitosan solution and coconut oil, P1 = soaked in a 1% chitosan solution, P2 = soaked in a 2% chitosan solution, P3 = soaked in a 3% chitosan solution, and P4 = soaked in a 100% coconut oil solution. The observed variables were egg weight loss, albumen and yolk weight. The results showed that the treatments significantly affected weight loss and albumen weight ($P<0.05$) but not yolk weight ($P>0.05$). **Soaking eggs in** 100% **coconut oil (P4) resulted in the lowest weight loss (**1.26%**), which was significantly different from chitosan treatments (**1-3%**) and the control (**2.66%**). Similarly, the highest albumen weight (**43.98%**) was found in the coconut oil treatment.** The treatments also showed no significant effect on the albumen and yolk index, as well as the pH of albumen and yolk. Treatment using coconut oil showed the best results in maintaining the internal quality of duck eggs with the smallest weight loss of 1.26% and maintaining the largest albumen weight of 43.98%. The treatment also showed no significant effect on albumen index, yolk index, pH of albumen and yolk. **In conclusion, coconut oil effectively maintained egg quality, while chitosan was less effective.**

Keywords
Chitosan; Coconut oil; Local duck; Egg quality

1. INTRODUCTION

Eggs are a perishable commodity. As the duration of storage is extended, there is a concomitant decline in egg quality (Triana et al., 2024). Eggs stored at room temperature with 80–90% humidity have a shelf life of 14 days (Ahmad et al., 2022). Conversely, eggs stored at temperatures of 4-7°C with humidity levels ranging from 60-70% have been shown to maintain their viability for a duration of 30 days, or up to one month. These shows that temperature and humidity greatly influence the shelf life of consumption eggs (Siswara et al., 2023). Yuwanta (2010) stated that at a storage temperature of 25°C with a relative humidity of 70%, there is a weekly weight loss of 0.8 grams per egg. At a temperature of 30°C, the weight loss per egg per week is 2 grams. This phenomenon is attributed to the gradual enlargement of the pores within the egg, accompanied by the loss of water and gas (Ramadhani, 2024). Furthermore, the porous nature of eggs renders them susceptible to contamination by spoilage bacteria (Fatayati et al., 2023). Consequently, egg damage occurs both externally and internally.

One strategy to mitigate egg damage is to soak or coat the eggs with substances containing tannins or antimicrobial agents. Chitosan, a natural polysaccharide derived from the deacetylation of chitin, is a white, amorphous solid that is insoluble in water but soluble in weak acids . Pure coconut oil, a natural ingredient with an odorless profile and high lauric acid content, has been shown to possess antimicrobial properties, as reported by Novarianto and Tutalo (2007). Both of these ingredients have been found to exhibit antimicrobial properties (Sahara et al., 2019). Falahudin (2015) observed that soaking broiler chicken eggs in a chitosan solution with a concentration of 1% resulted in more effective inhibition of egg microbes.

Lauric acid has been shown to possess anti-viral, antifungal, anti-protozoal, and anti-bacterial properties. As Nakatsuji et al. (2009) have indicated, lauric acid, a constituent of coconut oil, has been demonstrated to impede

the proliferation of Staphylococcus aureus bacteria. In a similar study, Rahmawati et al. (2014) reported that soaking in a combination of coconut oil, whiting lime solution, and ethanol extract of ***Hibiscus sabdariffa*** **(roselle)** petals resulted in the maintenance of egg quality. The objective of this research is to extend and maintain the shelf life of eggs by soaking them in a solution composed of chitosan and coconut oil.

2. EXPERIMENTAL SECTION

The research used a a completely randomized design (CRD) with 5 treatments and 4 replications. 40 eggs were used. Each replication consists of 2 eggs. The treatment used is pure chitosan from IPB's fisheries technology, has HACCP certificate No. 24/PP/HACCP/PK/1/2010 (*certificate of analysis of chitosan*, 2015), 1% acetic acid (chitosan solvent), 3 liters of distilled water and 1 liter of coconut oil. The experimental treatments included: P0, which was the control group and did not receive any chitosan solution or coconut oil; P1 = soaked in a 1% chitosan solution; P2 = soaked in a 2% chitosan solution; P3 = soaked in a 3% chitosan solution; and P4 = soaked in a 100% coconut oil solution. The preparation of the Chitosan solution involves the amalgamation of Chitosan in 1% acetic acid, as outlined in the work of Falahudin (2015). The procedure for the synthesis of VCO follows the method established by Aminah and Supraptini (2010). The method for soaking eggs in coconut oil follows the method of Rahmawati et al. (2014).

2.1 Soaked Duck Eggs

Fresh local duck eggs, collected within 24 hours of laying, were used in this study. The duck eggs were cleaned of dirt. Then, the eggs were candled to separate the good eggs from the cracked ones. The eggs were weighed to obtain initial weight. The chitosan and coconut oil solutions were prepared according to the treatment. The eggs were placed in a container according to the number of samples and poured with the chitosan and coconut oil solution according to each treatment. The eggs were soaked for 1 hour. After that, eggs were removed and placed in an egg tray according to the treatment, air-dried **and stored for 14 days under room temperature (25-30°C) and 70-80% relative humidity.** Then, the research variables were observed.

Observed variables

The following parameters were observed and calculated using the formulas below:

1. **Egg weight loss percentage** was calculated using the following formula:
   Weight Loss (%) = (Initial Weight - Final Weight) / Initial Weight × 100%
2. **Albumen weight percentage** was determined as follows:
   Albumen Weight (%) = (Albumen Weight / Egg Weight) × 100%
3. **Egg yolk weight percentage** was calculated using the formula:
   Yolk Weight (%) = (Yolk Weight / Egg Weight) × 100%
4. **Albumen Index** was measured according to the method described by Hartono et al. (2019) using the formula:
   Albumen Index = [Thick Albumen Height (mm) / Average Albumen Diameter (mm)] × 100%
5. **Egg Yolk Index** was determined by breaking the egg onto a flat glass plate and measuring the height and diameter of the yolk using a vernier caliper (Stadelman, 1977). The index was calculated as follows:
   Yolk Index = Yolk Height (mm) / Yolk Diameter (mm)
6. **Albumen pH** was measured by dipping the tip of the pH meter electrode into the albumen (AOAC 1995)
7. **Egg yolk pH** was measured by dipping the tip of the pH meter electrode into the yolk (AOAC 1995)

2.2 Data Analysis

Observation data were analysed using ANOVA. If the treatment has a real effect, then Duncan's multiple follow-up test is carried out (Steel and Torrie, 2002).

3. RESULTS AND DISCUSSION

3.1 The effect of soaking duck eggs with chitosan and vegetable oil on egg quality

Soaking duck eggs using a solution of chitosan and vegetable oil had a significant effect on weight loss and albumen weight ($P<0.05$). The average weight of egg yolk, albumenindex and pH of albumen and yolk did not show a significant effect ($P>0.05$). **Specifically, coconut oil treatment (P4) showed significantly lower weight loss and higher albumen weight compared to other treatments, while chitosan treatments (P1-P3) resulted in higher weight loss than the control (P0).** The effect of treatment on egg quality can be seen in Table 1.

3.2 Egg Weight Loss Percentage

The average weight loss of duck eggs soaked in chitosan and vegetable oil after 14 days of storage was 1.26-4.80%. Soaking with 100% vegetable oil (P4) gave significantly lower weight loss than all treatments. Soaking duck eggs in chitosan solution (P1, P2 and P3) showed that the average weight loss of duck eggs was significantly higher than P0 and P4 (vegetable oil). **The higher weight loss in chitosan-treated eggs compared to the control can be attributed to the acidic nature of the chitosan solution.** Chitosan was dissolved in 1% acetic acid, which may have eroded the protective cuticle layer on the eggshell surface. This erosion potentially enlarged the eggshell pores, thereby increasing the rate of water evaporation and CO_2 loss from the eggs during storage. This finding is consistent with the study by Abdullah and Imtihani (2022), which noted that acidic solvents can affect the structural integrity of chitosan solutions and potentially interact with organic surfaces like eggshells. In contrast, coconut oil (P4) formed a physical

Table 1. Effect of soaking treatments on quality parameters of duck eggs during 14 days of storage.

Parameter	Treatment				
	P0	P1	P2	P3	P4
Albumen loss (%)	2.66^{b}±0.25	4.80^{c}±0.64	4.25^{c}±0.73	4.48^{c}±0.57	1.26^{a}±0.10
Albumen weight (%)	40.87^{b}±1.32	37.87^{a}±1.07	37.45^{a}±1.76	37.81^{a}±1.87	43.98^{c}±1.05
Egg yolk weight (%)	41.63±5.29	36.96±4.23	38.64±1.88	42.09±5.06	35.58±4.30
Albumen index	0.045±0.006	0.045±0.006	0.060±0.008	0.060±0.013	0.100±0.009
pH of Albumen	7.58±0.490	7.25±0.816	7.25±0.129	7.24±0.063	7.01±0.511
pH of egg yolk	6.80±0.334	6.23±0.150	6.21±0.382	6.51±0.193	6.30±0.471

Notes:
P0 (control, without chitosan and coconut oil), P1 (1% chitosan solution), P2 (2% chitosan solution), P3 (3% chitosan solution), P4 (100% coconut oil)
Data are presented as mean values ±standard deviation (SD)
Different superscript letters within the same row indicate significant differences ($P<0.05$) according to Duncan's multiple range test

barrier that effectively sealed the eggshell pores, significantly reducing weight loss by minimizing moisture and gas exchange between the internal egg environment and the external atmosphere (Wulandari, 2004). Soaking with vegetable oil was able to coat and close the pores of the egg shell, thereby slowing down the evaporation of water and gas from inside the egg (Wulandari, 2004). Pure coconut oil was resistant to rancidity and other advantages according to (Rindawati and Kurniawan, 2020) are the smell of fresh coconut, not rancid, normal taste, typical of coconut and colourless. Coconut oil is high in lauric acid (44%) higher than other fatty acids, able to kill various types of microbes whose cell membranes originate from fatty acids and has antiviral, antifungal, antiprotozoal and antibacterial properties (Makruf and Jannah, 2024). Jazil et al. (2010) stated that the value of egg weight loss during 2 weeks of storage was 3.63±1.66%. Several studies also report that chitosan has good antimicrobial properties, so it is suspected that it can be used as a natural antibacterial (Hariyanto et al., 2023).

3.3 Albumen Weight Percentage

The average weight of duck egg whites soaked in a solution of chitosan and vegetable oil was 37.45-43.98%. Soaking in 100% vegetable oil gave the highest albumen weight (43.98%), significantly higher than all treatments ($P<0.05$). The reason for that was vegetable oil was able to close the pores of the egg, thereby protecting the contents of the egg from microbial contamination and inhibiting the evaporation of water and gas from inside the egg. Pure coconut oil contains lauric acid which can kill various types of bacteria by dissolving the bacterial plasma membrane so that the bacteria become lysed (Irmawaty et al., 2022). Soaking with chitosan solution was significantly lower than without P0 and P4 (vegetable oil) treatment ($P<0.05$). It can be assumed that the acidic chitosan solution (using acetic acid as a solvent) thins the eggshell so that the pores of the duck egg become more open. As a result, the evaporation of water and gas from inside the egg becomes greater. Chitosan is insoluble in water and dissolves well in weak organic acids (Abdullah and Imtihani, 2022). Ascorbic acid is one of the acids that can dissolve chitosan (Evelyna et al., 2020). 1% acetic acid is a good chitosan solvent (Muhlis et al., 2021).

3.4 Egg Yolk Weight Percentage

Soaking duck eggs in chitosan and vegetable oil showed that the average egg yolk weight was not significantly different during 14 days of storage ($P>0.05$). The average weight percentage of egg yolk is 35.58-42.09%. Yolk weight can be influenced by ovarian development because the ovaries are reproductive organs that function as producers of follicles. The nutritional content of the ration is also a factor that can influence yolk weight. Yolk weight is influenced by the crude fat and protein content in commercial feed of 3.0% and 18.0%. Herbal laying breed chickens at different ages (27 weeks, 45 weeks, 62 weeks, and 88 weeks) had a yolk percentage of 24.84%; 26.09%; 26.15%; and 25.53% (Surmini et al., 2024). Yolk weight is influenced by feed quality such as protein and fat content (Muhlis et al., 2021). In this study, soaking eggs using chitosan and vegetable oil gave insignificant results. Even though there had been a reduction in the weight of the egg white by immersing in the chitosan solution, it had not affected the vitelline membrane of the egg yolk, so the evaporation of water and gas was only indicated from the egg whites.

3.5 Albumen Index

The average index for duck albumen soaked in a solution of chitosan and vegetable oil for 2 weeks was 0.045-0.100. The treatment did not have a significant effect (P>0.05) on the albumen index. **The albumen index value in the P4 treatment (0.100) was within the normal range for fresh eggs (0.050-0.174) according to BSN (2008),** indicating that coconut oil coating helped maintain albumen quality. The increase in albumen index in the P4 treatment was higher than the control (without soaking). The average decrease in the albumen index (egg white) of phase two breed chicken eggs stored at room temperature is 0.010-0.095 (Masitoh et al., 2022). The albumen index increased with immersion in chitosan and vegetable oil. During the 14 days storage period, duck eggs will definitely experience a gradual decline in quality. The expectation was that soaking the eggs using a solution of chitosan and vegetable oil will slow down the decline in egg quality. The albumen index in this study by immersion in 100% vegetable oil had the potential to slow down changes in the albumen index.

3.6 Albumen pH

The chitosan and vegetable oil solution immersion treatment (14 days storage) on the pH of duck albumen did not show a significant difference (P>0.05). The average pH of research duck albumen was 7.01-7.58 or with an average of 7.27. The pH in this study was still within normal standards. The pH of albumen had not changed, presumably because there had been no damage to the ovomucin protein (a protein that maintains the viscosity of egg whites). The albumen index also had the same value for all treatments. The pH of fresh albumen in the first week was around 7 and would increase with storage time. Fresh eggs or newly laid eggs have a normal pH of 7.6-7.9 and increase to a maximum value of 9.7 (Krisnaningsih et al., 2024). However, in this study, with an egg shelf life of only 14 days, there was not much evaporation of water and gas from the egg. It was 3.7. assumed that this did not damage the albumen protein, so the pH stability remains the same.

3.7 Egg Yolk pH

The chitosan and vegetable oil solution immersion treatment (14 days storage) on the pH of duck egg yolk did not show a significant difference (P>0.05). The average pH of yolk was 6.21-6.80 or with an average of 6.41. The pH of fresh duck yolk is 6.0. The pH value of yolk in research (Suryono and Lukman, 2020) ranged from 6.9-6.11 using garlic solution injection. The pH of the egg yolk was also not significantly different because the yolk was the part that was located after the egg whites and the treatment given had not been able to reach the egg yolk due to various obstacles. To reach the egg yolk, the treatment must first penetrate the viscosity of the egg white and penetrate the membrane that coats the egg yolk. The same thing was predicted in this study. If the condition of the egg white was still normal, it was suspected that the condition of the egg yolk which was protected by the vitelline membrane would also not change. Usually, the pH value will increase as the egg ages, depending on the temperature and storage time. However, the position of the egg yolk which was in the middle and protected by the vitelline membrane slows down changes in the egg yolk. The pH value would increase if the water in the egg whites enters the egg yolk. Chitosan and vegetable oil solutions had not shown any effect on egg yolk and egg yolk pH.

4. CONCLUSION

Based on the results of this study, it can be concluded that:

1. **Coconut oil (**100%**) proved to be an effective coating material,** significantly reducing egg weight loss (1.26%) and maintaining higher albumen weight (43.98%) compared to other treatments and control.
2. **Chitosan solutions (**1-3%**) unexpectedly increased egg weight loss** compared to the control group, likely due to the effect of the acetic acid solvent damaging the eggshell cuticle.
3. The treatments had **no significant effect** on yolk weight, albumen index, yolk index, albumen pH, or yolk pH after 14 days of storage.

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