

## Chitosan-coated Eggshells Help Slow the Deterioration of Internal Egg Quality During Storage at Room Temperature under Tropical Conditions

Thanaset Thongsaklaing, Samsuree Seenamnung and Elham Wachama\*

Faculty of Agriculture, Princess of Naradhiwas University, Narathiwat, 96000, Thailand

\* Corresponding author. E-mail address: elham.w@pnu.ac.th

Received: 11 May 2026; Revised: 4 July 2026; Accepted: 10 August 2026; Available online: 1 October 2026

### Abstract

Egg deterioration during room-temperature storage is a major challenge in tropical regions lacking practical refrigeration. While chitosan coatings preserve eggs, research on how different concentrations perform under tropical ambient conditions remains limited. Therefore, this study evaluated the concentration-dependent effects of chitosan coatings on internal egg quality during extended room-temperature storage. A total of 360 freshly laid chicken eggs were randomly assigned to four treatments: non-coated eggs (NC), eggs coated with 1% acetic acid (AC), eggs coated with 1% chitosan solution (1CS), and eggs coated with 2% chitosan solution (2CS). Eggs were stored at tropical room temperature for 35 days, and egg weight loss, Haugh Unit (HU), and albumen pH were evaluated at weekly intervals. Egg weight loss increased progressively in all treatments throughout storage. Although chitosan-coated eggs tended to exhibit lower cumulative weight loss than the NC and AC groups, differences among treatments were not statistically significant ( $P > 0.05$ ). In contrast, chitosan coating significantly affected internal egg quality parameters. Chitosan-coated eggs maintained significantly higher HU values during storage than non-coated or acetic acid-treated eggs ( $P < 0.05$ ), demonstrating superior preservation of internal quality. Similarly, albumen pH increased in all treatments during storage; however, the increase was significantly slower in chitosan-coated eggs ( $P < 0.05$ ). These results suggest that chitosan coatings may act as semi-permeable barriers, reducing moisture and gas exchange to slow deterioration in internal egg quality during storage. Notably, the 2% chitosan treatment provided the greatest preservation effect, maintaining substantially higher HU values at the end of the 35-day storage period than the control treatments. Visually, eggs coated with 2% chitosan maintained Grade B quality after 40 days of storage, suggesting extended marketability under tropical ambient conditions. However, longer storage periods and quantitative evaluations are needed to confirm the exact shelf-life extension. In conclusion, chitosan coating effectively delayed the deterioration of internal egg quality during room-temperature storage, with the 2% concentration providing the greatest protective effect. This study supports using concentration-dependent chitosan coatings as an eco-friendly way to preserve egg quality in tropical areas with limited refrigeration.

**Keywords:** Chitosan, Egg quality, Edible coating, Haugh Unit, Room-temperature storage.

### Introduction

Chicken eggs are widely consumed worldwide because they are affordable, nutrient-dense foods that provide high-quality proteins, essential amino acids, vitamins, and minerals (Caffa et al., 2025). However, egg quality gradually deteriorates during storage due to moisture loss ( $H_2O$ ) and carbon dioxide ( $CO_2$ ) diffusion through eggshell pores (Pires et al., 2020). These changes lead to increased albumen pH, reduced internal egg quality, decreased Haugh Unit (HU), and lower consumer acceptability, particularly under ambient storage conditions (Duan et al., 2019; Pires et al., 2021). The deterioration process is accelerated in tropical regions, where high temperatures and limited refrigeration infrastructure can negatively affect egg quality throughout storage and distribution (Kaya et al., 2024). Edible coatings have emerged as a promising postharvest strategy for preserving egg quality by reducing moisture and gas exchange across the eggshell surface (Derelioglu et al., 2022; Alemu et al., 2025). Among available coating materials, chitosan has received considerable attention due to its

biodegradability, non-toxicity, film-forming ability, and antimicrobial properties (Muñoz-Tebar et al., 2023; Moradinezhad et al., 2025). Chitosan-based films can function as semi-permeable barriers that limit water vapor transmission and gas diffusion, thereby slowing physicochemical deterioration during storage. Previous studies have demonstrated that chitosan coatings can help maintain internal egg quality by reducing albumen pH changes and preserving HU values during storage (Pires et al., 2020). However, the effectiveness of chitosan coatings may depend on coating formulation and concentration, as higher polymer concentrations can produce thicker, more continuous protective films with improved barrier properties (Moradinezhad et al., 2025). Although several studies have reported the beneficial effects of chitosan coatings on egg preservation, direct comparisons of different chitosan concentrations under tropical ambient storage conditions remain limited (Purnawarman et al., 2025). Furthermore, practical information on the concentration-dependent performance of chitosan coatings in non-refrigerated storage systems remains insufficient. Therefore, this study evaluated the effects of different chitosan coating concentrations on egg weight loss, albumen pH, and Haugh Unit during 35 days of room-temperature storage under tropical conditions. Unlike previous studies that focused primarily on the general preservative effects of chitosan coatings, this study specifically investigates the concentration-dependent effectiveness of chitosan coatings under tropical ambient storage conditions (Purnawarman et al., 2025). The findings are expected to provide practical information for developing environmentally friendly egg preservation strategies in regions where refrigeration is limited or unavailable.

## Materials and Methods

### Preparation of Chitosan Solutions

Chitosan coating solutions were prepared using food-grade chitosan powder derived from shrimp shells (200-mesh, degree of deacetylation > 91%, molecular weight =  $5.4 \times 10^5$  Da; Sinudom Agriculture Products Co., Ltd., Surat Thani, Thailand). Chitosan solutions at concentrations of 1% and 2% (w/v) were prepared following previously reported procedures for edible chitosan coatings (Çelebi et al., 2026). Briefly, 10 g and 20 g of chitosan powder were dissolved separately in 800 mL of 1% (v/v) food-grade acetic acid to obtain 1% and 2% chitosan solutions, respectively. The mixtures were stirred continuously with a magnetic stirrer at room temperature until completely dissolved. Because the polymer solution had increased viscosity, stirring continued for 12 h to ensure complete dissolution and homogeneity. The resulting solutions were filtered to remove undissolved particles, adjusted to a final volume of 1000 mL with distilled water, and allowed to stand for 24 h to remove entrapped air bubbles before use.

### Egg Coating Procedure and Storage Conditions

Freshly laid Roman Brown chicken eggs (Betagro Group), with an average weight of 60.88 g, were obtained from the Agri-PNU layer farm in Narathiwat Province, Thailand. Eggs with cracked shells or visible defects were excluded from the study. The experiment used a completely randomized design (CRD) with four treatments (Fig.1): 1. Non-coated eggs (NC), 2. Eggs coated with 1% acetic acid (AC), 3. Eggs coated with 1% chitosan solution (1CS), 4. Eggs coated with 2% chitosan solution (2CS). Each treatment consisted of three independent replicates, with 30 eggs per replicate. Therefore, each treatment included 90 eggs, for a total of 360 eggs used throughout the experiment. Eggs were individually immersed in the respective coating solutions for 30 s and subsequently air-dried for 30 min at room temperature, following previously described egg-coating methods

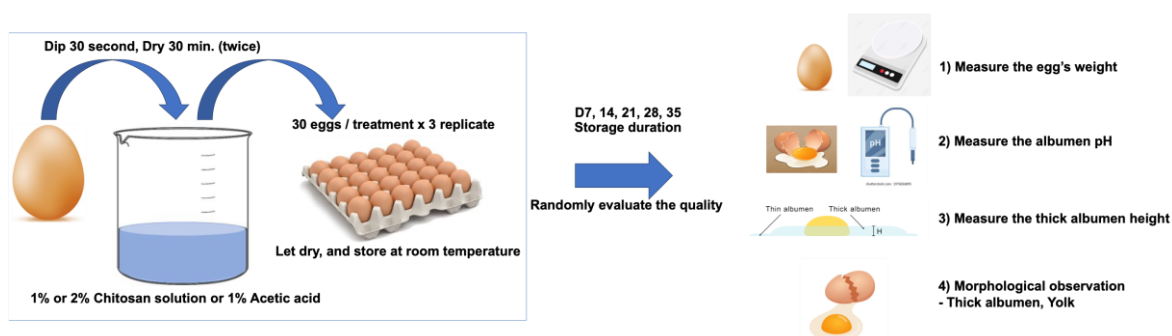
(Purnawarman et al., 2025). The immersion and drying procedures were repeated once, resulting in two consecutive coating applications per egg. Following the final drying step, the eggs were stored under ambient tropical conditions for the duration of the experiment. Two coating layers were applied to each egg. All eggs were subsequently stored under ambient tropical conditions for 35 days. Storage temperature ranged from 25 to 35°C, while relative humidity ranged from 70 to 80% throughout the storage period.

### Egg Quality Evaluation

Egg quality was evaluated on days 0, 7, 14, 21, 28, and 35 of storage. At each sampling interval, five eggs were randomly selected from each replicate (15 eggs per treatment) for destructive analysis. Different eggs were used at each sampling time point, and no egg was repeatedly measured during the experiment. This sampling procedure ensured independent observations across storage intervals. Egg weight was measured using a digital balance and used to calculate percentage weight loss. Albumen height was determined using a digital Haugh tester (Baxlo®, Spain), and Haugh Unit (HU) was calculated according to standard procedures (Purnawarman et al., 2025). Albumen pH was measured using a calibrated pH meter (Mettler Toledo SevenCompact™ S210, Switzerland).

### Statistical Analysis

Data were analyzed using R statistical software (Version 3.0). A two-way analysis of variance (ANOVA) was performed to evaluate the effects of treatment, storage time, and their interaction on egg quality parameters. When significant differences were detected, means were compared using Tukey's Honestly Significant Difference (HSD) test. Differences were considered statistically significant at  $P < 0.05$ .



**Figure 1** Schematic illustration of the experimental design. Thirty chicken eggs per replicate were coated with either 1% or 2% chitosan solution, while eggs coated with 1% acetic acid served as a comparison group, and non-coated eggs served as the control. All eggs were stored at room temperature for 35 days. At 7-day intervals throughout the storage period, five eggs from each replicate were randomly sampled to evaluate egg quality parameters

## Results

### Eggshell coating with chitosan solution and egg weight loss during storage.

Changes in egg weight during room-temperature storage are presented in Table 1. Egg weight gradually decreased in all treatments as storage duration increased. Initial egg weights ranged from 60.47 to 61.50 g on day 0 and declined to 56.20–57.33 g by day 35. Within each treatment, storage duration significantly affected egg weight ( $P < 0.05$ ), indicating progressive moisture loss during storage. However, no significant differences in egg weight were observed among treatments at any sampling interval ( $P > 0.05$ ). Although eggs coated with chitosan, particularly the 2% chitosan treatment (2CS), tended to maintain slightly higher egg weights at later

storage periods, these differences were not statistically significant. Table 2 presents the percentage of egg weight loss during storage. Egg weight loss increased progressively with storage time in all treatments. At day 35, eggs coated with 2% chitosan exhibited the lowest mean weight loss (5.67%), followed by 1CS (6.09%), NC (6.99%), and AC (7.25%). Nevertheless, treatment effects were generally not significant during most storage periods. Therefore, interpret the observed differences as trends rather than statistically confirmed treatment effects. Overall, egg weight loss was primarily influenced by storage duration rather than coating treatment.

**Table 1** The changes in egg weight (grams) during storage at room temperature

| Storage (day) | Treatment           |                     |                     |                     | CV%   | P-value  |
|---------------|---------------------|---------------------|---------------------|---------------------|-------|----------|
|               | NC                  | AC                  | 1CS                 | 2CS                 |       |          |
| 0             | 61.50 <sup>w</sup>  | 60.77 <sup>w</sup>  | 60.47 <sup>w</sup>  | 60.76 <sup>w</sup>  | 7.26  | P > 0.05 |
| 7             | 60.62 <sup>wx</sup> | 59.99 <sup>wx</sup> | 59.72 <sup>wx</sup> | 60.09 <sup>wx</sup> | 10.73 | P > 0.05 |
| 14            | 59.77 <sup>xy</sup> | 59.19 <sup>xy</sup> | 58.85 <sup>xy</sup> | 59.29 <sup>xy</sup> | 11.54 | P > 0.05 |
| 21            | 58.38 <sup>yz</sup> | 58.70 <sup>yz</sup> | 58.42 <sup>yz</sup> | 58.99 <sup>yz</sup> | 15.67 | P > 0.05 |
| 28            | 57.35 <sup>z</sup>  | 57.58 <sup>z</sup>  | 57.33 <sup>z</sup>  | 58.16 <sup>z</sup>  | 16.44 | P > 0.05 |
| 35            | 56.20 <sup>z</sup>  | 56.37 <sup>z</sup>  | 57.18 <sup>z</sup>  | 57.33 <sup>z</sup>  | 16.99 | P > 0.05 |
| P-value       | P < 0.05            | P < 0.05            | P < 0.05            | P < 0.05            | –     | –        |

Data are presented as mean  $\pm$  SEM from three independent replicates. Data were analyzed using two-way ANOVA followed by Tukey's honestly significant difference (HSD) test. Different lowercase letters (a–d) within the same row indicate significant differences among treatments at the same storage period (P < 0.05). Different lowercase letters (w–z) within the same column indicate significant differences among storage times within the same treatment (P < 0.05).

**Table 2** The percentage of egg weight loss (%) during storage at room temperature

| Storage (day) | Treatment          |                    |                    |                    | CV%   | P-value  |
|---------------|--------------------|--------------------|--------------------|--------------------|-------|----------|
|               | NC                 | AC                 | 1CS                | 2CS                |       |          |
| 0             | ND                 | ND                 | ND                 | ND                 | ND    | ND       |
| 7             | 1.42 <sup>w</sup>  | 1.30 <sup>w</sup>  | 1.24 <sup>w</sup>  | 1.10 <sup>w</sup>  | 19.73 | P > 0.05 |
| 14            | 2.81 <sup>x</sup>  | 2.60 <sup>x</sup>  | 2.69 <sup>x</sup>  | 2.42 <sup>x</sup>  | 13.54 | P > 0.05 |
| 21            | 3.44 <sup>y</sup>  | 3.41 <sup>y</sup>  | 3.38 <sup>y</sup>  | 2.91 <sup>y</sup>  | 13.73 | P > 0.05 |
| 28            | 5.12 <sup>ay</sup> | 5.26 <sup>ay</sup> | 5.19 <sup>ay</sup> | 4.27 <sup>b</sup>  | 12.39 | P < 0.05 |
| 35            | 6.99 <sup>bz</sup> | 7.25 <sup>az</sup> | 6.09 <sup>bz</sup> | 5.67 <sup>cz</sup> | 12.79 | P < 0.05 |
| P-value       | P < 0.05           | P < 0.05           | P < 0.05           | P < 0.05           | –     | –        |

Data are presented as mean  $\pm$  SEM from three independent replicates. Data were analyzed using two-way ANOVA followed by Tukey's honestly significant difference (HSD) test. Different lowercase letters (a–d) within the same row indicate significant differences among treatments at the same storage period (P < 0.05). Different lowercase letters (w–z) within the same column indicate significant differences among storage times within the same treatment (P < 0.05).

#### Chitosan solution-coated eggshell maintains internal egg quality during room-temperature storage.

Table 3 presents Haugh Unit (HU) values during storage at room temperature. At day 0, no significant differences were observed among treatments (P > 0.05), with all groups showing high initial HU values (84–86), indicating excellent internal quality. However, from day 7 onward, significant differences among treatments were detected. NC and AC exhibited a rapid decline in HU values over time, falling to 60 by day 21

and reaching markedly low values at day 35 (33.34 and 36.69, respectively), indicating substantial deterioration of internal egg quality. In contrast, 1CS and 2CS maintained significantly higher HU values throughout storage. After day 7, 2CS consistently showed the highest HU values at each sampling interval, retaining HU values above 67 even at day 35. These findings indicate that chitosan coating effectively slowed the decline in internal egg quality during storage, with the 2% chitosan treatment showing the greatest protective effect.

**Table 3** Haugh Unit changes during storage at room temperature

| Storage (day) | Treatment           |                     |                      |                     | CV%  | P-value  |
|---------------|---------------------|---------------------|----------------------|---------------------|------|----------|
|               | NC                  | AC                  | 1CS                  | 2CS                 |      |          |
| 0             | 84.00 <sup>w</sup>  | 84.52 <sup>w</sup>  | 84.40 <sup>w</sup>   | 86.12 <sup>w</sup>  | 2.41 | P > 0.05 |
| 7             | 76.42 <sup>ax</sup> | 74.76 <sup>ax</sup> | 81.60 <sup>bw</sup>  | 83.17 <sup>bw</sup> | 1.66 | P < 0.05 |
| 14            | 75.23 <sup>ax</sup> | 73.65 <sup>bx</sup> | 80.45 <sup>cwx</sup> | 82.39 <sup>dw</sup> | 0.54 | P < 0.05 |
| 21            | 60.78 <sup>ay</sup> | 63.36 <sup>ay</sup> | 73.82 <sup>by</sup>  | 78.65 <sup>cy</sup> | 2.01 | P < 0.05 |
| 28            | 56.21 <sup>ay</sup> | 57.10 <sup>ay</sup> | 69.36 <sup>by</sup>  | 72.35 <sup>cy</sup> | 2.54 | P < 0.05 |
| 35            | 33.34 <sup>az</sup> | 36.69 <sup>az</sup> | 64.61 <sup>by</sup>  | 67.10 <sup>bz</sup> | 6.63 | P < 0.05 |
| P-value       | P < 0.05            | P < 0.05            | P < 0.05             | P < 0.05            | –    | –        |

Data are presented as mean  $\pm$  SEM from three independent replicates. Data were analyzed using two-way ANOVA followed by Tukey's honestly significant difference (HSD) test. Different lowercase letters (a–d) within the same row indicate significant differences among treatments at the same storage period ( $P < 0.05$ ). Different lowercase letters (w–z) within the same column indicate significant differences among storage times within the same treatment ( $P < 0.05$ ).

#### Chitosan solution-coated eggshell reduces changes in albumen pH during storage.

Table 4 presents changes in albumen pH during storage. No significant differences among treatments were observed at day 0 ( $P > 0.05$ ). However, albumen pH increased progressively throughout storage in all treatments. From day 7 onward, significant treatment effects were detected ( $P < 0.05$ ). The NC and AC groups exhibited the highest albumen pH values during storage, whereas the 1CS and 2CS groups maintained significantly lower pH values. Among all treatments, 2CS consistently showed the lowest albumen pH values throughout the storage period. At day 35, albumen pH reached  $9.88 \pm 0.03$  in NC and  $9.66 \pm 0.06$  in AC, whereas 1CS ( $8.79 \pm 0.04$ ) and 2CS ( $8.62 \pm 0.06$ ) showed significantly lower values. These results indicate that chitosan coating effectively delayed the increase in albumen pH during storage, thereby helping preserve internal egg quality.

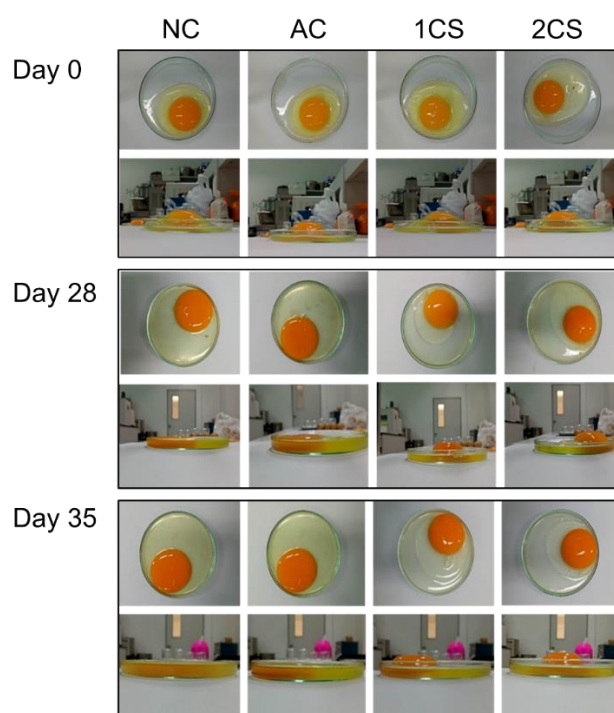
**Table 4** The pH value of the egg changes during storage at room temperature

| Storage (day) | Treatment           |                     |                     |                     | CV%  | P-value  |
|---------------|---------------------|---------------------|---------------------|---------------------|------|----------|
|               | NC                  | AC                  | 1CS                 | 2CS                 |      |          |
| 0             | 7.45 <sup>w</sup>   | 7.27 <sup>w</sup>   | 7.15 <sup>w</sup>   | 7.25 <sup>w</sup>   | 1.30 | P > 0.05 |
| 7             | 8.54 <sup>ax</sup>  | 8.24 <sup>bx</sup>  | 7.70 <sup>cw</sup>  | 7.34 <sup>dw</sup>  | 1.39 | P < 0.05 |
| 14            | 8.60 <sup>ax</sup>  | 8.47 <sup>ax</sup>  | 7.78 <sup>bw</sup>  | 7.44 <sup>cw</sup>  | 0.89 | P < 0.05 |
| 21            | 9.32 <sup>axy</sup> | 9.17 <sup>ay</sup>  | 8.53 <sup>bx</sup>  | 8.39 <sup>cx</sup>  | 0.87 | P < 0.05 |
| 28            | 9.61 <sup>ayz</sup> | 9.39 <sup>byz</sup> | 8.64 <sup>cxy</sup> | 8.54 <sup>dxy</sup> | 0.43 | P < 0.05 |
| 35            | 9.88 <sup>az</sup>  | 9.66 <sup>bz</sup>  | 8.79 <sup>cy</sup>  | 8.62 <sup>dy</sup>  | 0.89 | P < 0.05 |
| P-value       | P < 0.05            | P < 0.05            | P < 0.05            | P < 0.05            | –    | –        |

Data are presented as mean  $\pm$  SEM from three independent replicates. Data were analyzed using two-way ANOVA followed by Tukey's honestly significant difference (HSD) test. Different lowercase letters (a–d) within the same row indicate significant differences among treatments at the same storage period ( $P < 0.05$ ). Different lowercase letters (w–z) within the same column indicate significant differences among storage times within the same treatment ( $P < 0.05$ ).

## Coated Chitosan eggshell surface retains thick albumen appearance.

The visual appearance and stability of albumen and yolk after cracking were evaluated at 0, 7, 14, 21, 28, and 35 days of storage. At day 0, eggs from all treatments showed normal, viscous albumen with a well-defined, elevated thick albumen layer and minimal spreading of the thin albumen, while the yolk remained round, centrally positioned, and free from blood or meat spots. By day 7, NC and AC eggs showed early signs of quality degradation, including reduced internal egg quality and slight spreading of the thin albumen; however, yolks remained intact and centrally located. In contrast, eggs in the 1CS and 2CS groups maintained firm, thick albumen and limited albumen scattering. From days 14 to 21, deterioration became more pronounced in NC and AC groups, with visible thinning and flattening of the thick albumen and partial displacement of the yolk from the center. At 28 and 35 days, NC and AC eggs showed marked albumen spreading, loss of structural integrity, enlarged and flattened yolks, and occasional blood or meat spots. In contrast, chitosan-coated eggs, particularly at 2%, retained greater internal egg quality, maintained yolk centrality, and showed minimal structural degradation throughout the storage period, indicating improved internal quality stability under room-temperature conditions (Fig. 2).

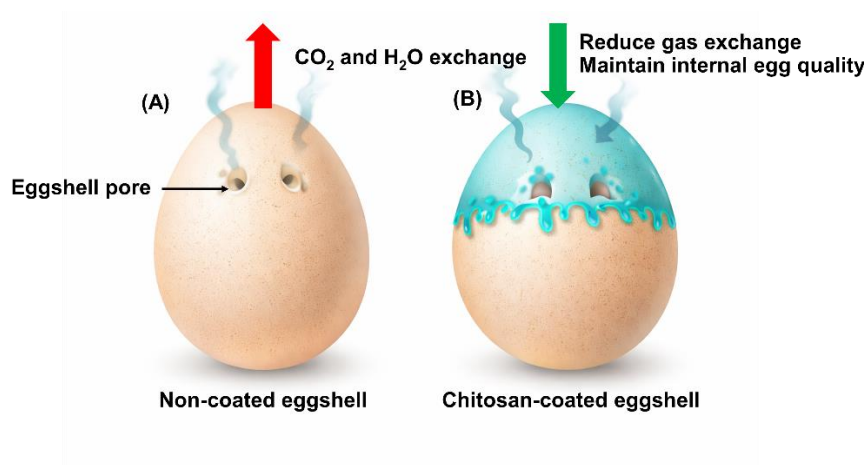


**Figure 2** The schematic representation of internal egg morphology highlighting the role of chitosan-coated eggshells in preserving thick albumen integrity and freshness during storage at room temperature (25–35 °C) at days 0, 28, and 35

## Discussion

The present study demonstrated that chitosan coating effectively delayed the deterioration of internal egg quality during room-temperature storage, with the 2% chitosan treatment providing the greatest protective effect. Egg weight decreased progressively in all treatments during storage, reflecting the continuous loss of moisture and carbon dioxide ( $\text{CO}_2$ ) through eggshell pores (Kocetkovs, 2022). Although chitosan-coated eggs tended to exhibit lower cumulative weight loss than the non-coated and acetic acid-coated groups, no significant differences among treatments were detected ( $P > 0.05$ ). Therefore, the observed reduction in weight loss should be interpreted as a tendency rather than a statistically confirmed treatment effect. Nevertheless, this trend may indicate that chitosan coatings partially reduce moisture transfer through the eggshell by forming a protective barrier on the shell surface, thereby helping to maintain a more stable internal environment during storage (Pires et al., 2021; Yaashikaa, 2023).

Chitosan coating had more pronounced effects on albumen pH and HU, both widely recognized indicators of internal egg quality. Albumen pH increased progressively in all treatments during storage, reflecting the gradual loss of  $\text{CO}_2$  through eggshell pores (Kocetkovs, 2022). However, eggs coated with chitosan maintained significantly lower albumen pH values than the non-coated and acetic acid-coated groups throughout storage. These findings suggest that chitosan coatings act as semi-permeable barriers that may reduce gas exchange and slow the physicochemical changes associated with egg aging (Fig. 3). Similar observations have been reported for edible coatings used to preserve egg quality under ambient storage conditions (Pires et al., 2021).



**Figure 3** The illustration of the proposed role of chitosan coating in preserving egg quality during storage. The schematic shows that (A) non-coated eggshells may allow  $\text{CO}_2$  and  $\text{H}_2\text{O}$  loss through pores, while (B) the application of a chitosan coating may form a barrier over the eggshell pores, thereby reducing gas exchange and helping maintain egg freshness

The maintenance of lower albumen pH was accompanied by significantly higher HU values in chitosan-coated eggs. Because HU is strongly associated with internal egg quality, the higher HU values observed in coated eggs indicate that chitosan effectively delayed quality deterioration during storage. In particular, eggs coated with 2% chitosan consistently exhibited the highest HU values throughout the experiment, demonstrating superior preservation of internal egg quality compared with the other treatments. The study also showed a concentration-dependent response. The 2% chitosan coating consistently outperformed the 1% formulation in maintaining HU values and moderating increases in albumen pH. This finding suggests that higher chitosan

concentrations may improve coating continuity and barrier performance, thereby enhancing preservation efficiency. Recent studies on chitosan-based edible coatings and other food preservation systems have reported similar concentration-dependent effects (Muñoz-Tebar et al., 2023; Moradinezhad et al., 2025). From a practical perspective, the results indicate that a 2% chitosan coating can help maintain acceptable internal egg quality under tropical ambient storage conditions. Based on the HU values observed in this study, eggs coated with 2% chitosan retained substantially higher quality scores than non-coated eggs throughout the 35-day storage period. Furthermore, visual observations conducted after 40 days of storage suggested that eggs coated with 2% chitosan still exhibited characteristics consistent with Grade B quality. However, because quantitative egg quality measurements were performed only up to day 35, the extent of shelf-life extension beyond this period cannot be definitively confirmed. Therefore, additional studies incorporating longer storage periods, microbial assessments, sensory evaluations, and economic analyses are required to establish the maximum practical shelf life achievable under commercial tropical storage conditions.

Although the present study demonstrated the effectiveness of chitosan coating in preserving internal egg quality during ambient storage, several limitations remain. The study focused primarily on physicochemical quality parameters, including egg weight loss, albumen pH, and HU, and did not evaluate microbial quality, sensory attributes, or economic feasibility. In addition, the study assessed storage performance under a specific range of ambient tropical conditions. Consequently, further validation under different environmental and commercial storage conditions is needed before recommending large-scale implementation.

Overall, the findings demonstrate that a chitosan coating, particularly at a 2% concentration, is an effective and eco-friendly strategy for slowing internal egg quality deterioration during room-temperature storage. These results provide additional evidence for the concentration-dependent effectiveness of chitosan coatings and support their potential application in egg production and distribution systems where refrigeration is limited or unavailable.

### **Conclusion and Suggestions**

This study demonstrated that chitosan coating effectively slowed the deterioration of internal egg quality during room-temperature storage. Among the treatments evaluated, the 2% chitosan coating showed the greatest preservation effect, as indicated by significantly higher HU values and lower albumen pH compared with non-coated eggs throughout the 35-day storage period. Although chitosan-coated eggs tended to exhibit lower cumulative weight loss than non-coated eggs during storage, differences among treatments were not consistently significant. In contrast, HU and albumen pH improved significantly, indicating that 2% chitosan coating effectively preserved internal egg quality during room-temperature storage. These findings suggest that a 2% chitosan coating has potential as an environmentally friendly, non-toxic preservation strategy for maintaining egg quality under tropical ambient storage conditions, particularly in areas with limited refrigeration. However, practical application should be considered cautiously because this study did not evaluate commercial-scale implementation, economic feasibility, microbial safety, or consumer acceptance. Future studies should investigate longer storage periods, microbial quality, sensory acceptance, and cost-effectiveness of chitosan-coated eggs under commercial storage and distribution conditions. In addition, further research using scanning electron microscopy is recommended to characterize eggshell surface structure and pore-sealing mechanisms, which would help clarify the protective role of chitosan coatings.

### Acknowledgments

This research was financially and academically supported by the Faculty of Agriculture, Princess of Naradhiwas University. The authors would also like to express their sincere appreciation to Dr. Malinda Hulugalla for his valuable comments, careful reading, and constructive suggestions that greatly improved the quality of this manuscript.

### Author Contributions

Tanaset Thongsaklaing : Conceptualization, methodology design, data interpretation, manuscript writing.

Samsuree Seenamnung : Conceptualization, methodology design, data collection and analysis.

Elham Waehama : Conceptualization, methodology design, data collection and interpretation, manuscript review and finalizing

### Conflict of Interests

All authors declare that they have no conflicts of interest.

### Funding

The authors received financial support for this research from the Faculty of Agriculture research fund.

### Declaration of Generative AI and AI-assisted Technologies

During preparation of this manuscript, the authors used ChatGPT for grammar checking and language refinement to improve clarity and readability for publication. Following its use, the authors thoroughly reviewed and edited the content and accept full responsibility for the final version of the publication.

### References

- Alemu, T. T., Intipunya, P., & Gebeyo, B. A. (2025). A comprehensive review of edible coatings for postharvest management of fruits and vegetables: enhancing food and nutrition security. *Discover Agriculture*, 3, 190. <https://doi.org/10.1007/s44279-025-00348-8>
- Caffa, I., Proietti, E., Turrini, F., Borgarelli, C., Ferrando, M. R., Formisano, E., de Cassya Lopes Neri, L., Martini, D., Angelino, D., Tagliabue, A., & Pisciotta, L. (2025). Nutritional Aspects of Eggs for a Healthy and Sustainable Consumption: A Narrative Review. *Food Science & Nutrition*, 13(9), e70285. <https://doi.org/10.1002/fsn3.70285>
- Çelebi, M., Tav, A., Kaya, M. A., & Özdemir, Z. Ö. (2026). Scalable Production of Low-Molecular-Weight Chitosan: Comparative Study of Conventional, Microwave, and Autoclave-Assisted Methods. *Polymers*, 18(2), 213. <https://doi.org/10.3390/polym18020213>

- Derelioglu, E., & Turgay, Ö., (2022). Effect of chitosan coatings on quality and shelf-life of chicken and quail eggs. *African Journal of Food Science*, 16(3), 63–70. <https://doi.org/10.5897/AJFS2021.2158>
- Duan, C., Meng, X., Meng, J., Khan, M. I. H., Dai, L., & Zhang, X. (2019). Chitosan as a preservative for fruits and vegetables: A review on chemistry and antimicrobial properties. *Journal of Bioresources and Bioproducts*, 4(1), 11–21. <https://doi.org/10.21967/jbb.v4i1.189>
- Kaya, S., Özdemir, H. H., & Erdem, B. G. (2024). Physical changes in hen eggs stored at different temperatures. *Food and Health*, 10(4), 253–261. <https://doi.org/10.3153/FH24024>
- Kocetkovs, V., Radenkovs, V., Juhnevica-Radenkova, K., Jakovlevs, D., & Muizniece-Brasava, S. (2022). The Impact of Eggshell Thickness on the Qualitative Characteristics of Stored Eggs Produced by Three Breeds of Laying Hens of the Cage and Cage-Free Housed Systems. *Applied Sciences*, 12(22), 11539. <https://doi.org/10.3390/app122211539>
- Moradinezhad, F., Adiba, A., Ranjbar, A., & Dorostkar, M. (2025). Edible coatings to prolong the shelf life and improve the quality of subtropical fresh/fresh-cut fruits: A Review. *Horticulturae*, 11(6), 577. <https://doi.org/10.3390/horticulturae11060577>
- Muñoz-Tebar, N., Pérez-Álvarez J. A., López, J. F., & Viuda-Martos, M. (2023). Chitosan edible films and coatings with added bioactive compounds: Antibacterial and antioxidant properties and their application to food products: A review. *Polymers*, 15(2), 396. <https://doi.org/10.3390/polym15020396>
- Pires, P. G. S., Bavaresco, C., Prato, B. S., Wirth, M. L., & Moraes, P. D. O. (2021). The relationship between egg quality and hen housing systems – A systematic review. *Livestock Science*, 250, 104597. <https://doi.org/10.1016/j.livsci.2021.104597>
- Pires, P. G. S., Cardinal, K. M., & Bavaresco, C. (2020). The use of coatings in eggs: A systematic review. *Trends in Food Science & Technology*, 106, 312–321. <https://doi.org/10.1016/j.tifs.2020.10.019>
- Purnawarman, T., Nasution, M. I. A., Soenarno, M. S., Siswanto, Yunilas., Hasanah, U., & Wahyuni, S. (2025). Effects of chitosan-stearin on quality of chicken egg storage at room temperature. *Journal of World's Poultry Research*, 15(1), 92–102, <https://dx.doi.org/10.36380/jwpr.2025.9>
- Yaashikaa, P. R., Kamalesh, R., Senthil-Kumar, P., Saravanan, A., Vijayasri, K., & Rangasamy, G. (2023). Recent advances in edible coatings and their application in food packaging. *Food Research International*, 173(2), 113366. <https://doi.org/10.1016/j.foodres.2023.113366>