

# Shelf life and Internal Quality of Eggs Coated with Chitosan-Rice bran oil during Storage

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**Abstract.** The shelf life of consumer eggs is only 7-14 days. Chitosan coating technology is one approach for increasing the shelf life of consumer eggs. To boost the hydrophobicity of the chitosan solution, oil must be added. The study sought to investigate the extension of shelf life and internal quality of fresh eggs through cleaning and coating with chitosan and rice bran oil (RBO). Treatments evaluated included controls, cleaners and non-cleaners, coating and non-coating Chitosan, and RBO. Weight loss, egg yolk index, egg white index, haugh units, and pH levels were all recorded. Observations were conducted for seven weeks. The research results showed that coating rice bran oil without sanitizer had the lowest weight loss and egg pH, which were 1.99% and 8.3, respectively. The rice bran oil coating treatment without sanitizer had the greatest egg white and HU indexes, respectively 0.04 and 62.57, while the rice bran oil coating treatment with sanitizer had the highest egg yolk index, 0.32. Without sanitizer, the chitosan and rice bran oil coating treatment outperformed the control and other treatments in terms of egg shelf-life extension.

## 1 Introduction

Eggs are a dietary product produced by livestock and one of the most commonly ingested types of animal protein. National egg consumption data in both urban and rural areas ranges between 67.4 and 82.5% [1]. Eggs offer several advantages, including being easy to procure, being relatively inexpensive, being popular, and having a balanced and full nutritional makeup. Eggs have some of the greatest protein levels. Apart from protein, eggs include 11 different vitamins, including vitamin A, vitamin B2, B5, B6, B12, vitamin E, and vitamin K. Minerals found in eggs include folate, phosphorus, selenium, calcium, and zinc. According to [2], chicken egg production in 2022 would be 5.56 million tons, while egg consumption will be 4.85 million tons, resulting in a surplus of 615 thousand tons.

Behind these advantages, eggs have a disadvantage: they have a short shelf life of 7-14 days at room temperature. Longer storage induces more fluid evaporation in the egg, increasing the size of the air sac [3]. The deterioration in egg quality includes, among other things, a decrease in the viscosity of egg whites and egg yolks, widening of the air cavity, and a loss in egg weight due to evaporation of gases such as water vapor, carbon dioxide,

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ammonia, nitrogen, and H<sub>2</sub>S. The evaporation of these gases expands the air sacs and affects the chemical composition of the egg's contents. As stated in [4], physical alterations during handling encompass an expansion of the air cell, the liquefaction of the thick albumen, and a reduction in the strength of the vitelline membrane that encases the egg yolk from the albumen.

Temperature, humidity, and storage time all affect egg quality. According to [5], the most critical factors impacting egg quality are storage period and temperature, with storage temperature being a more sensitive predictor of egg quality deterioration than storage duration. According to [6,] loss of egg quality during storage causes albumen thinning, higher pH, weakened and stretched vitelline membrane, and increased water content in egg yolk. According to [7], although the egg shell has been considered a natural egg protector, the number is very small. The pores in the egg shell, in addition to being for gas exchange, cause moisture and CO<sub>2</sub> loss in the egg as well as microbial penetration, resulting in a decrease in egg quality. Cracked eggs can also induce microbial contamination, resulting in lower egg quality.

According to [8], there are two strategies for preventing egg quality loss: killing bacteria in the egg and sealing the egg pores with a coating material. Coating methods that have been widely utilized on eggs include lime coatings, which can increase egg shelf life [9]. Lime (CaO) reacts with carbon dioxide to generate a thin layer of calcium carbonate (CaCO<sub>3</sub>), which closes the egg shell's pores and prevents the release of water and other gasses. Eggs can last up to 30 days at room temperature, although their quality deteriorates, becoming quality III. The disadvantage of treating with lime solution is that the egg's outer layer becomes white. Furthermore, it is feared that chemical coating materials like chalk could be hazardous if consumed [10].

Chitosan is an egg coating substance that has been and continues to be developed [11]. Research on egg coating using chitosan alone or in combination with other antibacterial agents such as essential oils or nanomaterials (ZnO and TiO<sub>2</sub> nanoparticles). Chitosan coating with 3% ZnO nanoparticles can extend the shelf life of eggs by 30 days, whereas the addition of oil. Basil and wax with chitosan can improve shelf life by up to 35 days. The research aimed to explore methods for prolonging the shelf life and maintaining the internal quality of fresh eggs by applying sanitation and coating techniques using chitosan and rice bran oil (RBO). As a result, this research must be conducted to develop alternative solutions for entrepreneurs and chicken breeders in order to successfully lengthen shelf life and minimize egg loss during the storage and distribution processes.

## **2 Research method**

### **2.1 Tools and materials**

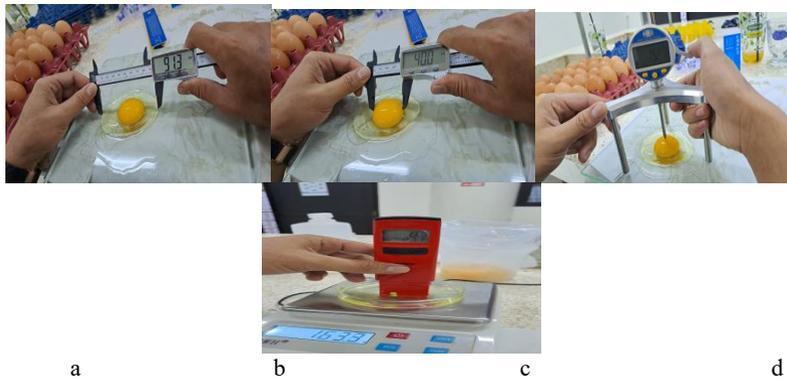
The materials utilized in this study were consumption eggs measuring 55-65 grams collected from laying hen breeders on a single farm in the Tangerang area of Banten, chitosan, acetic acid (Merck), CaCO<sub>3</sub>, glycerol, rice bran oil, sanitizer hipocloride, tween 80, and distilled water. Meanwhile, the tools used include a magnetic stirrer, pH meter, measuring flask (Iwaki), oven (Furnace Vulcan A-550), electric scale (Kenko KK-LABR), measuring cup (Iwaki), basin, thermometer, hygrometer, egg tray, Becker glass (Iwaki), egg separator, spatula, flat glass, depth micrometer, particle size analysis, scanning electron microscope, and caliper.

## 2.2 Preparation of coating solution

To produce a chitosan solution, the following process is used: A total of 1 g of chitosan is dissolved in 100 ml of 1% acetic acid and then homogenized with a magnetic stirrer at 40°C for 30 minutes. CaCO<sub>3</sub> was gradually put into the chitosan solution until the pH reached 5–5.5. CaCO<sub>3</sub> was gradually put into the chitosan solution until the pH reached 5–5.5. Then, 100 ml of chitosan solution was combined with a plasticizer, glycerol (2%), and homogenized with a magnetic stirrer before adding an antibacterial agent, rice bran oil (0.5%). Add 2% emulsifier (tween 80), and homogenize again with a magnetic stirrer at 70°C for 30 minutes. When the edible coating solution has reached a temperature of 30°C, it is ready to apply on the eggs.

## 2.3 Application of edible coating

Purebred chicken eggs are coated using the dipping procedure. The cleaned egg sample from sorting is placed/dipped in the coating solution for 1 minute. Next, the eggs are air-dried. Eggs that have been handled are then kept at room temperature (25-30°C). The parameters observed in eggs before and after coating were egg quality parameters (egg weight, egg white index, egg yolk index, pH and Haugh Unit (Figure 1). Parameter observations were carried out every 7 days for 7 weeks.



**Fig. 1.** Measurement of Egg Quality: a) egg white diameter; b) yolk diameter; c) egg yolk height and d) egg white pH

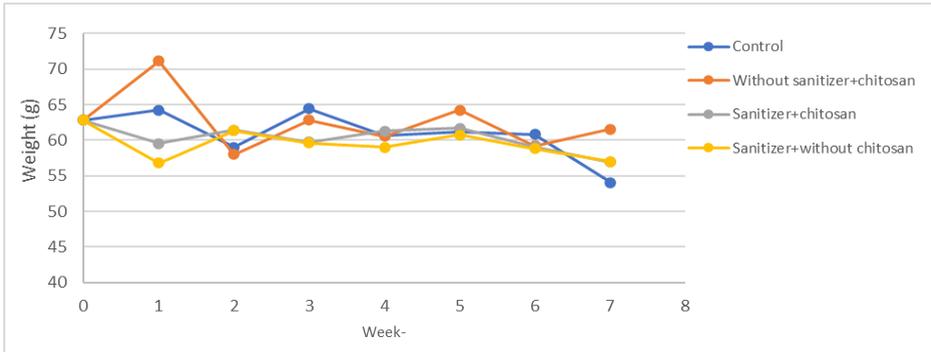
## 3 Results and discussion

### 3.1 Weight loss

Figure 2 depicts how weight loss decreases with increasing storage duration. This is caused by the evaporation of water from within the egg through the pores of the shell, resulting in weight loss. This type of coating material, which is based on proteins and polysaccharides, is impenetrable to gas yet allows water vapor to pass through. [12] found that chitosan coating with a concentration of 1-2% is impermeable to gas at RH below 70%. However, at 100% RH, O<sub>2</sub> and CO<sub>2</sub> gases penetrate at 44  $\mu\text{l}/\text{cm}^2/\text{hour}$  and 3  $\mu\text{l}/\text{cm}^2/\text{hour}$ , respectively. Water vapor can pass through at a rate of 0.8  $\text{mg}/\text{cm}^2/\text{hour}$ . The findings of this study showed a reduction in egg weight across all treatments during the storage period (Figure 2).

Weight loss is fairly high/dramatic in the first week, then it slopes somewhat in weeks 2 and 3 before drastically decreasing near the end of storage. This is consistent with [13], who found that prolonging the shelf life of eggs resulted in a continuing decline in egg weight,

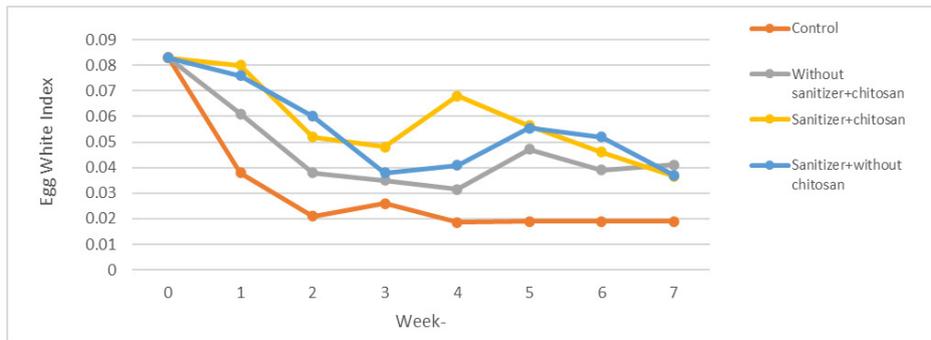
with the decrease in egg weight being greater in the first week compared to the following storage periods. After seven (7) weeks of storage, the control (uncoated) eggs lost the most weight, 13.99%, while the treated eggs coated without sanitizer lost the least, 2.01%. Coated eggs lose a small amount of weight due to the coating material's great resistance to water vapor and slow evaporation rate [13].



**Fig. 2.** Weight loss of controlled and coated eggs during 7 weeks of storage

### 3.2 Egg White Index

The shelf life of eggs causes dilution of the egg white. Water can diffuse from the egg white into the egg yolk. The average diameter of egg whites will increase with the length of time the eggs are stored. This can be seen in Figure 3 that the egg white index value is increasing. This is caused by the high evaporation of CO<sub>2</sub> gas, which results in an increase in pH and subsequently speeds up the breakdown of ovomucin. Changes in the physicochemical qualities of eggs cause the egg white to become runny.



**Fig. 3.** Egg white index of controlled and coated eggs during 7 weeks of storage

The egg white index value at week 7 ranges between 0.019 and 0.041. The egg white index fell at the seventh week. The greatest drop occurred in eggs that were not coated (control), at 0.064, while the smallest decrease happened in eggs covered with chitosan without sanitizer, at 0.042. The analysis of variance also indicates distinctions between eggs that are uncoated and those that are coated. Because chitosan possesses impermeable qualities to CO<sub>2</sub> and O<sub>2</sub> gasses, the coating's usefulness as an artificial barrier in producing an atmosphere matches its potential for slowing down quality degradation. Chitosan can form a semipermeable layer, slowing the evaporation of water and CO<sub>2</sub> gas [14]. Changes in internal gases, respiration rate, and material properties can all be used to assess the efficiency of edible coatings [15].

### 3.3 Egg Yellow Index

The storage of eggs produces changes in index values. The storage period for eggs allows fluid to migrate from the egg white to the egg yolk, increasing the size of the egg yolk. This weakens the egg yolk's firmness and flexibility [16]. After several weeks of storage, the vitelline membrane easily breaks, resulting in a drop in the egg yolk index [17]. The egg yolk index declines as the chicken ages, and is also affected by the duration and temperature of storage. The evaporation of water results in widening the diameter of the egg white so that the yolk is not strong enough to hold water from the egg white and results in a decrease in the quality of the yolk. While the evaporation of CO<sub>2</sub> caused by the decomposition of NaHCO<sub>3</sub> compounds from purebred chicken eggs into NaOH and CO<sub>2</sub>. The NaOH formed will be decomposed into Na<sup>+</sup> and OH<sup>-</sup> while the CO<sub>2</sub> formed will evaporate, so that the quality of egg whites decreases [18].

Fresh eggs' yolk index ranges from 0.33 to 0.50, with an average of 0.42. The initial yolk index value for the eggs utilized in the study was rather high, 0.462; however, by the end of week 7, it was 0.11 in coated eggs, while the control was 0.057 (Figure 4). The egg yolk index value falls with increasing storage time. The decrease in the egg yolk index value during the coating treatment was due to the coating material used being unable to inhibit the process of evaporation of water and CO<sub>2</sub> from purebred chicken eggs and the destruction of the ovomucin-lysozyme complex bond, which functions as the structure of the egg white, causing the egg white to become watery.

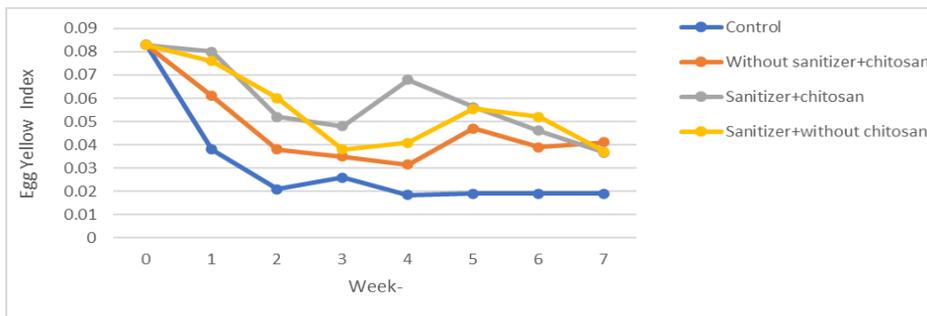


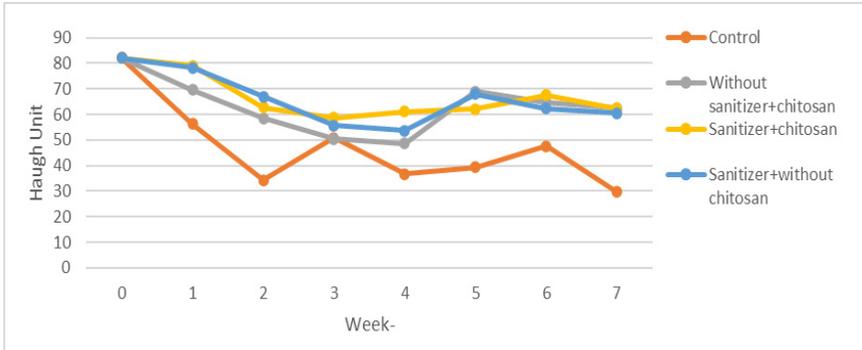
Fig. 4. Egg yellow index of controlled and coated eggs during 7 weeks of storage

### 3.4 Haugh Unit

The Haugh value symbolizes the close link between egg white height and egg weight [19]. The egg white's viscosity is directly related to the HU value; a higher HU value indicates thicker egg white, while a lower HU value signifies thinner egg white and, consequently, poorer quality. Research shows that fresh eggs have a HU value of 95.74, indicating good quality (Grade AA: HU value < 72) (USDA) or grade 1 [20]. The HU value of the control (no coating) is significantly lower than that of the coated eggs. After week 7, the HU value of coated eggs ranges from 62.34-62.57, indicating quality A (Quality II), whereas the control egg has a HU value of 29.75 (Quality C) (Figure 5).

The findings indicated that storage time and temperature had a negative impact on HU. According to [21], a drop in HU is caused by albumen-induced degradation to the ovomucin fibers (which create a thick texture), resulting in a loss of CO<sub>2</sub> gas and a pH increase. [22] reported that after 21 days of storage, the HU ranged from 51.5 to 52.7. The decomposition of carbonic acid in egg whites produces carbon dioxide and water, leading to a decrease in Haugh Unit values in eggs over the storage period. The loss of carbon dioxide from egg whites, as well as changes in pH owing to alkaline circumstances, cause the mucin fibers that

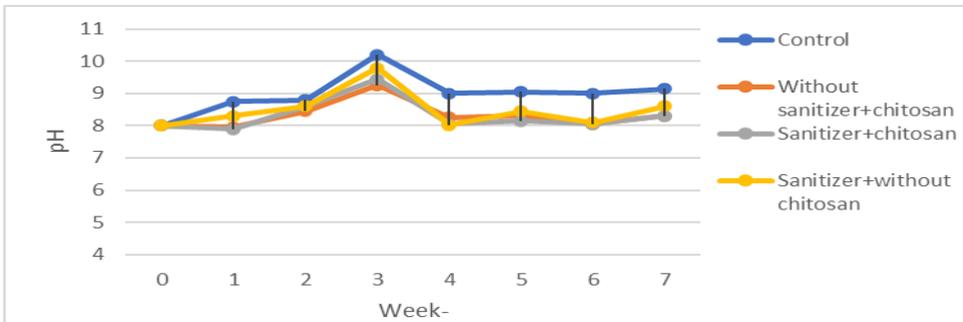
give egg whites their gel structure to weaken and lose structure, causing the egg whites to become runny and resulting in a decrease in the HU value during storage.



**Fig. 5.** Haugh unit of controlled and coated eggs during 7 weeks of storage

### 3.5 pH

Eggs will undergo metabolic alterations while in storage. The pH value of albumin or egg white fluctuates and is a significant criterion in determining egg quality [23]. The albumen pH value is a measure of egg freshness. The pH value of egg white from fresh eggs typically ranges between 7.6 and 7.9. Figure 6 depicts the findings of observations made on fresh chicken eggs after 7 weeks of storage at room temperature. The average pH of egg whites at the start of storage is around 7.2, and it gradually increases until the seventh week. At 7 weeks of storage, all treatments, including the control, had albumin pH values ranging from 8.3 to 9.15. According to other research, albumin's pH rises to 9.27 for up to 6 weeks of storage [24]. The lower amount of CO<sub>2</sub> resulting from the breakdown of carbonic acid in albumen during storage allows the albumin pH to be determined by the balance of dissolved CO<sub>2</sub>.



**Fig. 6.** pH of controlled and coated eggs during 7 weeks of storage.

Coating fresh eggs seeks to enhance their shelf life. The covering is believed to impede biological activities by inhibiting the release of water and other gasses from the egg's contents. According to the results in Figure, the coating functions as a barrier to gas diffusion through the shell and CO<sub>2</sub> release, so helping to control albumen pH and maintain albumin quality. This can be attributed to an increase in the gas barrier to O<sub>2</sub> and CO<sub>2</sub> in the layer, resulting in a drop in pH [25].

## 4 Conclusion and recommendation

At the seventh week of storage, eggs coated with chitosan without sanitizer are the best treatment in terms of egg quality parameters (reduction in weight loss, egg white index, egg yolk index, haugh index, and pH). Chitosan and rice bran oil coating treatment without sanitizer was more effective in extending the shelf life of eggs than the control or other treatments. Future studies can focus on the economic aspects of implementing chitosan oil and rice bran coating on a large scale. This includes a cost-benefit analysis, scalability of the coating process, and potential impacts on the overall supply chain.

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