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Combination of Chitosan from Black Soldier Fly Exuviae and Palm Oil Stearin as Coating on Chicken Eggs

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ABSTRACT

Consumption chicken eggs have perishable properties, the quality of eggs will decline faster and the shelf life of eggs is very short at room temperature compared to cold temperatures. The purpose of this study is to test and evaluate the use of chitosan derived from black soldier fly exuviae and palm oil stearin as a coating on the quality of consumption chicken eggs at room temperature storage. Study design was a Completely Randomized Design (CRD) 4 x 5 factorial pattern with three replications. Each replicate consisted of 6 fresh chicken eggs, resulting in 360 eggs. Factor I was formula dosage (CS0 = Without Coating; CS1 = Virgin Coconut Oil; CS2 = 1.5% Chitosan + 1% Stearin; CS3 = 3% Chitosan + 1% Stearin) and Factor II was storage duration (ST0 = 0 Days; ST14 = 14 Days; ST28 = 28 Days; ST42 = 42 Days; ST56 = 56 Days). The results of the study indicate that the formula dose and storage time had a very significant effect (P<0.01) on the Haugh unit, albumen index, and yolk index of consumption chicken eggs. There was an interaction between the formula dose and storage time (P<0.01) on the Haugh unit, albumen index, and yolk index. Coating combination of chitosan BSF exuviae and palm oil stearin can maintain the quality of consumption chicken eggs during the storage period up to 56 days. The use of a coating formula with a treatment level of 3% chitosan + 1% stearin showed the best results in maintaining the quality of consumption chicken eggs during storage at room temperature and was still in quality category III according to SNI No.3926:2023, namely haugh unit 60.54%, albumen index 0.06% and yolk index 0.33%.

Keyword: Chitosan, Coating, Consumption Chicken Eggs, Room Temperature, Stearin

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1. Introduction

Consumption chicken eggs are eggs produced by poultry (chickens) that are safe and suitable for consumption to meet the public's need for animal protein. One type of chicken egg for consumption is the commercial chicken egg, which is widely favored by the public due to its high quality, wide availability in the market, and relatively affordable price. Consumption of commercial chicken eggs in Indonesia has shown an upward trend over the past five years, reaching 6.47 kg per capita per year in 2019 and increasing to 6.69 kg per capita per year in 2023 [1].

The government's "free nutritious meals" program features eggs as a source of protein. However, distribution to eastern Indonesia takes time, so careful planning of the transportation supply chain for table eggs is essential to ensure a smooth supply of consumption chicken eggs. Given the perishable nature of

consumption chicken eggs which are prone to breaking if left at room temperature, they can only last 10–14 days after this period, the eggs will deteriorate and eventually rot. Furthermore, if the load is too heavy and the vehicle transporting the eggs travels on damaged roads, the eggs may be damaged before reaching retailers at the market and ultimately consumers [2]. Consumption chicken eggs must also reach their destination on time if they are not available when needed, incalculable losses will occur, such as lost sales, customer dissatisfaction, and production delays ultimately leading to the greatest loss of all: a loss of consumer trust. During storage, eggs undergo quality changes, including a decrease in Haugh units, albumen index, and yolk index. Therefore, an alternative is needed for handling eggs to enable longer storage by sealing the pores of the eggshell specifically, a coating capable of controlling the exchange of moisture, O_2, and CO_2 and inhibiting microbial growth [3-4]. Various coating materials have been extensively studied, but few have utilized a combination of chitosan from BSF exuviae and palm oil stearin.

Chitosan can be isolated from black soldier fly (BSF) exuviae, which account for 12.46% of the insect's biomass [5]. Chitosan also possesses biodegradable, antimicrobial, and non-toxic properties, and acts as a barrier against water vapor and gas in a product due to the strong polysaccharide layer of chitosan [6]. Chitosan is the product of chitin deacetylation obtained through extraction [7]. Chitosan extraction involves the stages of demineralization, deproteinization, depigmentation, and deacetylation, and chitosan is soluble in acetic acid at a concentration of 1–2%, and chitosan extraction yields diverse products due to the variety of sources and the concentration of materials used in the extraction process, and chitosan is also highly multifunctional [8].

In addition, stearin is a byproduct of palm oil, accounting for 20–30% of the total, yet its use as a coating remains very limited. Stearin is produced through a series of steps including purification, bleaching, deodorization, and cooling [9]. Stearin contains palmitic acid, which functions as an antimicrobial [10]. Stearin is also used as a coating to improve water vapor permeability and flexibility, impart a glossy finish, and maintain the structure and shape of products storage time [11].

Numerous studies have been conducted on the production and use of crustacean-based chitosan derived from shrimp shells, crab shells, and mud crab shells for various applications, including coatings. However, to date, no studies have utilized a combination of chitosan from black soldier fly (BSF) exuviae and palm oil stearin applied to fresh consumption chicken eggs. Based on this, the author conducted research on the application of chitosan derived from BSF exuviae and palm oil stearin as a coating to assess its effect on the quality of fresh consumption chicken eggs storage time at room temperature.

2. Materials and Methods

2.1. Material

Materials used in this study were BSF exuviae chitosan DD 75% and palm stearin from the Palm Oil Research Center Bogor Unit, freshly harvested chicken eggs at 50–60 weeks of age (after peak production) with the Lohmann Brown strain and sorted with a weight of 60–65 g from PT Global Buwana Farm, virgin coconut oil, acetic acid 2%, tween 80, gloves, alcohol, masks, distilled water and label paper.

Tools used in this study were haugh digital micrometer, hygrometer, caliper, digital scale, glass table, filter paper, plastic, knife, basin, rubber binder, brush, egg yolk separator and mica tray.

2.2. Method

The method used in this research is an experimental method using a completely randomized design (CRD) 4 x 5 factorial pattern with three replications. Each replicate consisted of 6 fresh consumption chicken eggs, resulting in 360 eggs. Factor I was the formula dosage (CS0 = Without Coating; CS1 = Virgin Coconut Oil; CS2 = 1.5% Chitosan + 1% Stearin; CS3 = 3% Chitosan + 1% Stearin) and Factor II was the storage time (ST0 = 0 Days; ST14 = 14 Days; ST28 = 28 Days; ST42 = 42 Days; ST56 = 56 Days).

2.3. Coating formula

The preparation of the coating formula refers to [12], chitosan from crab shells is dissolved using 2% acetic acid at 40 ºC while palm stearin is melted at 60 ºC. Then the chitosan solution of the crab shell was mixed with the palm stearin solution and 2% Tween 80 was added according to the variation of the ratio. Then the solution was stirred for 4 minutes with a magnetic stirrer.

2.4. Coating application

Fresh consumption chicken eggs are cleaned by dry cleaning using a sponge. Coating on eggs is done by dipping technique, namely by dipping the egg sample into the coating solution for 15 minutes, then lifted and

placed on a mica tray and aerated until the coating solution sticks to fresh chicken eggs, then stored at an average room temperature of 28 °C and an average humidity of 56%. Each 1 consumption chicken egg requires 1 mL of coating formula solution.

2.5. Variables

Consumption chicken egg quality testing was conducted at the Poultry Nutrition Laboratory, Department of Nutrition and Feed Technology, Faculty of Animal Science, IPB University, Indonesia. The chicken egg quality tests specifically the Haugh Unit, albumen index, and yolk index were performed in accordance with [2].

2.6. Data Analysis

Data on egg quality were statistically analyzed using Analysis of Variance (ANOVA). If significant or highly significant results were obtained, a Duncan Multiple Range Test (DMRT) was conducted at a significance level of P>0.05. Data were processed using the Statistical Analysis System (SAS) software and Microsoft Excel [13].

3. Results and Discussion

The results of the study on the quality of consumption chicken eggs, as measured by Haugh units, the albumen index, and the yolk index, are presented in Tables 1–3.

3.1. Haugh Unit

The Haugh units of consumption chicken eggs that had been coated with various formula doses and stored for varying time ranged from 12.11% to 91.71%. Analysis of variance results indicate that formula dosage and storage time have a very significant effect (P<0.01) on the Haugh units of consumption chicken eggs, and there is an interaction between formula dosage and storage time (P < 0.01). The Haugh unit results from this study are presented in Table 1.

Table 1. Haugh unit for coating of consumption chicken eggs

Treatment (CS)	Storage Time (ST)				
	ST0	**ST14**	**ST28**	**ST42**	**ST56**
CS0	90.27^{A}	45.71^{A}	37.01^{A}	22.59^{A}	12.11^{A}
CS1	90.64^{CD}	77.84^{CD}	70.40^{CD}	66.75^{CD}	57.08^{CD}
CS2	91.22^{B}	70.50^{B}	65.21^{B}	60.89^{B}	53.78^{B}
CS3	91.71^{CD}	76.43^{CD}	68.07^{CD}	65.02^{CD}	60.54^{CD}

Egg Quality Categories

Treatment (CS)	Storage Time (ST)				
	ST0	**ST14**	**ST28**	**ST42**	**ST56**
CS0	Grade I	Grade III	Grade III	Loss	Loss
CS1	Grade I	Grade I	Grade II	Grade II	Grade III
CS2	Grade I	Grade II	Grade II	Grade II	Grade III
CS3	Grade I	Grade I	Grade II	Grade II	Grade III

Note: The same superscript in the same row and column indicates a very significant difference (P<0.01); CS0: uncoated; CS1: virgin coconut oil; CS2: 1.5% chitosan + 1% stearin; CS3: 3% chitosan + 1% stearin; ST0: 0 days; ST14: 14 days; ST28: 28 days; ST42: 42 days; ST56: 56 days; egg quality categories (BSN 2023)

In this study, from day 0 to day 56, the uncoated group (CS0) showed a significant decrease in egg Haugh units of 12.11% compared to the groups coated with coconut oil (CS1) at 57.08%, chitosan 1.5% + 1% stearin (CS2) at 53.78%, and chitosan 3% + 1% stearin (CS3) at 60.54%. Other ongoing research using chitosan derived from rajungan and stearin for 56 days has yielded egg Haugh units comparable to those in this study. [12] conducted a study using chitosan derived from mud crab shells and stearin with a storage time of 56 days, resulting in an egg Haugh unit of 61.27%.

The Haugh units of the eggs in this study indicate that egg treatment using coating can prevent a significant decrease in Haugh units, as seen in the CS2 and CS3 treatments. The longer the eggs are stored, the lower the Haugh unit value becomes (decreasing). Haugh units also correlate with egg weight and egg albumen height.

The higher the egg albumen height, the higher the Haugh unit value. Conversely, if the egg albumen height decreases, the Haugh unit value also decreases. Additionally, a low Haugh unit value occurs due to an increase in water content in the egg yolk. According to Gogo *et al*. [14], eggs will not maintain good quality if stored for an extended period, as they are prone to spoilage and the Haugh unit value decreases with prolonged storage.

3.2. Albumen Index

The egg albumen index of consumption chicken eggs coated with various formula doses and stored for varying time ranged from 0.02% to 0.10%. Analysis of variance results indicated that formula dose and storage time had a very significant effect (P<0.01) on the egg albumen index of consumption chicken eggs, and there was an interaction between formula dose and storage duration (P<0.01). The egg albumen index results from this study are presented in Table 2.

Tabel 2. Albumen index for coating of consumption chicken eggs

Treatment (CS)	Storage Time (ST)				
	LP0	**LP14**	**LP28**	**LP42**	**LP56**
DF0	0.08^{A}	0.06^{A}	0.04^{A}	0.03^{A}	0.02^{A}
DF1	0.09^{C}	0.07^{D}	0.07^{C}	0.06^{C}	0.05^{C}
DF2	0.09^{B}	0.08^{B}	0.07^{B}	0.04^{B}	0.03^{B}
DF3	0.10^{D}	0.08^{D}	0.08^{D}	0.07^{D}	0.06^{D}

Egg Quality Categories					
Treatment (CS)	**Storage Time (ST)**				
	ST0	**ST14**	**ST28**	**ST42**	**ST56**
CS0	Grade II	Grade III	Loss	Loss	Loss
CS1	Grade II	Grade III	Grade III	Grade III	Grade III
CS2	Grade II	Grade III	Grade III	Loss	Loss
CS3	Grade II	Grade III	Grade III	Grade III	Grade III

Note: The same superscript in the same row and column indicates a very significant difference (P<0.01); CS0: uncoated; CS1: virgin coconut oil; CS2: 1.5% chitosan + 1% stearin; CS3: 3% chitosan + 1% stearin; ST0: 0 days; ST14: 14 days; ST28: 28 days; ST42: 42 days; ST56: 56 days; egg quality categories (BSN 2023)

In this study, from day 0 to day 56, the uncoated group (CS0) showed a higher decrease in the egg albumen index of 0.02% compared to the group coated with coconut oil (CS1) at 0.05%, 1.5% chitosan + 1% stearin (CS2) at 0.03%, and 3% chitosan + 1% stearin (CS3) at 0.06%. Other ongoing research using chitosan derived from mud crab shells and stearin over 56 days has yielded egg albumen indices comparable to those in this study. [12] conducted a study using chitosan derived from mud crab shells and stearin with a storage time of 56 days, resulting in an egg albumen index of 0.05%.

The egg albumen index in this study indicates that treating eggs with a coating can prevent a significant decrease in the egg albumen index, as seen in the CS2 and CS3 treatments. The longer the eggs are stored, the lower the egg albumen index value becomes (it decreases). Storage time, the egg albumen is the part that deteriorates most rapidly due to the loss of water vapor from the ovomucin network, which serves as the structural framework of the egg albumen. Additionally, the water content in egg albumen is higher than in other parts, so damage to the egg albumen occurs more rapidly. Egg albumen stored without coating is more prone to damage compared to coated egg albumen, as evidenced by the thinning of the egg albumen the thinner the egg albumen becomes, the lower the egg albumen index will be. According to Adriaensen *et al*. [15], the egg albumen index tends to decrease with prolonged storage, resulting in a lower index value.

3.3. Yolk Index

The yolk index of consumption chicken eggs coated with various formula doses and stored for different time ranged from 0.24% to 0.40%. Analysis of variance results indicate that formula dosage and storage time have a very significant effect (P<0.01) on the egg yolk index of consumption chicken eggs, and there is an interaction between formula dosage and storage time (P<0.01). The egg yolk index results from this study are presented in Table 3.

Tabel 3. Yolk index for coating of consumption chicken eggs

Treatment (CS)	Storage Time (ST)				
	LP0	**LP14**	**LP28**	**LP42**	**LP56**
DF0	0.40^{A}	0.35^{A}	0.33^{A}	0.27^{A}	0.24^{A}
DF1	0.40^{C}	0.39^{C}	0.36^{C}	0.35^{C}	0.32^{C}
DF2	0.40^{B}	0.39^{B}	0.35^{B}	0.33^{B}	0.31^{B}
DF3	0.40^{D}	0.39^{D}	0.38^{D}	0.35^{D}	0.33^{D}

Egg Quality Categories

Treatment (CS)	Storage Time (ST)				
	ST0	**ST14**	**ST28**	**ST42**	**ST56**
CS0	Grade II	Grade III	Grade III	Loss	Loss
CS1	Grade II	Grade II	Grade III	Grade III	Grade III
CS2	Grade II	Grade II	Grade III	Grade III	Grade III
CS3	Grade II	Grade II	Grade III	Grade III	Grade III

Note: The same superscript in the same row and column indicates a very significant difference ($P<0.01$); CS0: uncoated; CS1: virgin coconut oil; CS2: 1.5% chitosan + 1% stearin; CS3: 3% chitosan + 1% stearin; ST0: 0 days; ST14: 14 days; ST28: 28 days; ST42: 42 days; ST56: 56 days; egg quality categories (BSN 2023)

In this study, from day 0 to day 56, the group without coating (CS0) showed a higher decrease in egg yolk index of 0.24% compared to the group coated with coconut oil (CS1) at 0.32%, chitosan 1.5% + 1% stearin (CS2) at 0.31%, and chitosan 3% + 1% stearin (CS3) at 0.33%. Other ongoing research using chitosan derived from mud crab shells and stearin for 56 days has yielded egg yolk indices comparable to those in this study. [12] conducted a study using chitosan derived from mud crab shells and stearin with a storage period of 56 days, resulting in an egg yolk index of 0.34%.

The egg yolk index in this study indicates that egg treatment using a coating can prevent a significant decrease in the egg yolk index, as observed in the CS2 and CS3 treatments. The longer the eggs are stored, the lower the egg yolk index value will be. The progressively decreasing egg yolk index value is caused by the egg yolk's vitelline membrane becoming weakened due to water migration from the egg albumen that has entered the yolk via diffusion, resulting in yolk enlargement. Additionally, prolonged egg storage causes the yolk to become soft, indicating that the egg yolk index has already been damaged, resulting in a low egg yolk index value. According to Biesiada-Drzazga *et al*. [16], a low egg yolk index storage time is caused by the of storage time extremely long storage periods result in a low egg yolk index.

4. Conclusion

Coating combination of chitosan BSF exuviae and palm oil stearin can maintain the quality of consumption chicken eggs during the storage period up to 56 days. The use of a coating formula with a treatment level of 3% chitosan + 1% stearin showed the best results in maintaining the quality of consumption chicken eggs during storage at room temperature and was still in quality category III according to SNI No.3926:2023, namely haugh unit 60.54%, albumen index 0.06% and yolk index 0.33%.

5. Conflict of Interest

All researchers involved in writing this manuscript have no conflicts of interest.

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