The Effect of Chitosan-based Edible Coating on the Shelf Life of Steamed Shrimp Based on Moisture Content and Color Measurement

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ABSTRACT

Steamed shrimp is one of the processed fishery products that is popular with the public, mainly because it has high protein content, attractive color, has a distinctive taste and can be eaten immediately. To minimize the quality degradation process in steamed shrimp, such as discoloration and microorganism activity, chitosan was added as an edible coating. This study aims to inhibit the damage of steamed shrimp which are given chitosan edible coating during the storage period. The method used in this study is an experimental method. Steamed shrimp soaked in edible coating added with chitosan treatment of 0%, 1.5%, 2%, 2.5%, and 3% for 3 minutes, and stored at low temperature (5-10 ^{o}C). Observations were made on day-1, 3, 4, 5, 7, 8, 9, 10, 11, 12, and day-13. The parameters observed included moisture content and color test. The results showed that the 2% chitosan concentration was the optimal concentration for storing steamed shrimp at low temperature on the 12th day, with a water content of 68.34% and the steamed shrimp sample had a white color with a slightly yellowish red color.

Keyword: *antibacterial, chitosan, low temperature, microbe, steamed shrimp*

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1. INTRODUCTION

Steamed shrimp will experience physical, chemical and microbiological degradation during storage. The decline in the quality of cooked prawns is caused by, among others, discoloration, fat oxidation, protein denaturation, and the discharge of liquid containing solid shrimp meat or drip [1]. The main attractive characteristic of cooked shrimp is the appearance of a red color due to changes in the carotenoid astaxanthin pigment. During storage, the red color tends to fade and gradually turns yellow. According to [2], this change was caused by photo oxidation of astaxanthin. [3] stated that the process of this change could be accelerated by increasing the concentration of oxygen. In addition, biological quality degradation can occur due to the activity of microorganisms present in these fish, for example, caused by bacteria or fungi.

Giving edible coating to boiled shrimp after the cooking process shows the resulting texture is smoother and more compact [4]. The use of edible coating reduces the rate of damage during the process, improves the texture and appearance of the product [5]. When viewed microscopically, boiled shrimp that are not coated with edible coating have a duller surface of steamed shrimp compared to steamed shrimp coated with edible coating. All surfaces of boiled shrimp that are given an edible coating have a transparent, bright and shiny appearance [4].

[6] states that chitosan is an antibacterial material because it has the ability to inhibit the growth of destructive microorganisms and coat products to protect them from environmental contamination. The mechanism of action in general is to damage the main structures of the microbial cell. The positive charge of the NH_3^+ group on chitosan can interact with the negative charge on the surface of the bacterial cell [7]. The damage to the bacterial cell wall results in weakening of the strength of the cell wall, the shape of the cell wall becomes abnormal, and the cell

pores are enlarged so that the bacterial cell is unable to regulate the exchange of substances from outside into the cell. The cell membrane becomes damaged so that bacterial activity is inhibited and the bacteria will experience death [8].

Based on the results of research conducted by [9], the addition of 2% chitosan as an edible coating gave the best results on the organoleptic characteristics and the number of red tilapia filet bacterial colonies at low temperature storage with acceptance limits until the 13th day. [10] also conducted research on chitosan, the results of which showed that the 2% chitosan concentration added by 0.4% α-tocophenol antioxidants was able to inhibit the hydrolysis and oxidation of fish fat stored at low temperatures.

According to [11], the addition of 1.5% chitosan and vacuum packaging on presto mackerel showed the best value. The product can still be received by the panelists until the 14^{th} day of storage. [12] stated that the application of 2% chitosan as an edible coating showed antimicrobial, antioxidant, and fat oxidation barrier effects that could extend the shelf life of rainbow salmon at low temperatures until the 11^{th} day of storage. Based on research conducted by [13], chitosan with a concentration of 2% is the optimal concentration for storing catfish fillets at low temperatures until the 11^{th} day. Based on research conducted by [14], the optimal chitosan concentration is 3% which can extend the shelf life of tilapia until the 14^{th} day of storage or 4 days longer than control sausages in inhibiting microbial growth. The purpose of this study is to identify the best percentage of chitosan concentration so as to extend the shelf life of steamed shrimp at low temperature storage based on water content and color changes.

2. MATERIALS AND METHODS

2.1 Preparation

Initially, chitosan had to be produced as one of the main treatment in this research. The process of producing chitosan were carried out based on [15] study and was produced through several stages, namely as follows:

a. Deproteination. This process is carried out at a temperature of 60-70° C using 1 M NaOH solution with a ratio of shrimp powder to NaOH = 1:10 (g powder/ml NaOH) while stirring for 60 minutes. Then the mixture is separated by filtering and the precipitate is taken.
b. Washing and drying. Washing of sediment was carried out using aquadest until the pH was neutral. Then filtered to take the precipitate and proceed with drying
c. Demineralization. Mineral removal was carried out at a temperature of 25-30°C using 1 M HCl solution with a ratio of the sample to HCl = 1:10 (g powder/ml HCl) while stirring for 120 minutes. Then the mixture is separated by filtering and the precipitate is taken.
d. Color removal. The demineralized precipitate was extracted with acetone and blended with 0.315% NaOCl (w/v) for 5 minutes at room temperature. The ratio between solid and solvent used is 1:10 (w/v).
e. Washing and drying. Washing of sediment was carried out using aquadest until the pH was neutral. Then filtering is carried out and the precipitate is dried.
f. Deacetylation of chitin to chitosan. The chitin that has been produced in the above process is put in a 50% NaOH solution at a temperature of 90-100^{o}C while stirring at a constant speed for 60 minutes. The results obtained are in the form of slurry then filtered and the precipitate is washed with aquadest then aqueous HCl solution is added so that the pH is neutral then dried.

This study consist of several treatments based on chitosan coating addition percentage. The coating solution is made by dissolving the ingredients listed in the formulation (Table 1.). The formulation for making the edible coating were selected according to [16] study.

Table – 1: Chitosan edible coating formulation based on treatments

Material	Concentration (%)				
	A	B	C	D	E
Chitosan	0	1.5	2	2.5	3
Acetic Acid	0	1	1	1	1
Aquadest	0	2	2	2	2
Glycerol	0	1	1	1	1

The raw material used for this research was Vanname shrimp (*Litopenaeus vannamei*) in the form of PUD (peeled undevine). The size of the shrimp used was 60-70/kg in the form of PUD. Fresh peeled PUD shrimp initially washed using cold water and then steamed at a temperature of 100^{o}C for 5 minutes [18]. Afterwards, the shrimp were drained and subsequently dipped in an edible coating solution, then finally packed and stored at low temperature. The chitosan-based edible coating were then be applied to the drained steamed shrimp as a coating by dipping the steamed shrimp for as long as 3 minutes time. The immersion time is determined based on [18].

Steamed shrimp that have been coated with edible coating will be packed using Styrofoam dish (12 x 12 square centimeters) and plastic wrap is used to cover the top surface, therefore the surrounding air does not easily in contact with the packed materials. Packaged steamed shrimp are put in the refrigerator and are not stored in stacked position to avoid physical contact between packaged steamed shrimp and other parts. The storage temperature used was 5-10^{o}C and observed for a minimum of 12 days of storage. All of the research data derived from analysis parameters were discussed descriptively.

2.2 Moisture Content

The analysis was carried out according [19]. The water content of the material shows the amount of water content per unit weight of the material. In this case, there are two methods to determine the moisture content of the material, namely based on the dry weight (dry basis) and based on the wet weight (wet basis). First of all, the empty plates to be used are dried in the oven for 15 minutes or until a fixed weight is obtained, then cooled in a desiccator for 30 minutes and then weighed. A sample of approximately 2 g was weighed and then placed in a cup then heated in an oven for 3-4 hours at a temperature of 105-110ºC. The plate containing the sample is then cooled in a desiccator and after cooling it is weighed again. The procedure is repeated until a constant weight is obtained. The calculation is as follows:

$$water\ content\ (\%) = \frac{B_1 - B_2}{B}\ x\ 100\%$$

Where B is sample weight (grams); B_1 is weight (sample + plate) before drying (grams) and B_2 is weight (sample + plate) after drying (grams).

2.2 Moisture Content

According to the [20]- SNI 01-2345-1991, an objective color measurements were carried out using a Chroma meter CR200 with the Hunter notation system (L * a * b). Shrimp coloring level is indicated by the notation [21], [22], as follows:

a. L: brightness parameter, where this notation represents the reflected light that produces white, gray and black achromatic colors. L values range from 0 (black) to 100 (white).
b. a: chromatic color gradation of red green, where this notation has a value of + (plus) from 0 to 100 for red and a value of 0 to -80 for green
c. b: chromatic color gradation of blue yellow, where this notation has a value of + (plus) b from 0 to 70 for yellow and a value of b from 0 to -80 for blue

3. RESULT AND DISCUSSION

3.1 Moisture Content

The amount of moisture content in a product will affect the resistance of the material to microbial attack [23]. Water is the main component in food. The water content in food ingredients determines the acceptability, freshness and shelf life of the food material [24]. The water content in steamed shrimp will decrease during the storage period. Steamed shrimp that are not coated with chitosan edible coating will experience a very rapid decrease compared to steamed shrimp coated with chitosan edible coating. The moisture content of steamed shrimp that was not coated with chitosan edible coating ranged from 68.43% to 65.3%, while the moisture content of steamed shrimp coated with chitosan edible coating with an additional concentration of 1.5% ranged from 70.53% to 67.31%, for the addition of 2% concentration ranged from 70.63% to 68.34%, the addition of 2.5% concentration ranged from 70.85% to 67.92%, and the water content concentration of 3% added ranged from 70.00% up to 67.83%. According to observations, the water content of steamed shrimp tends to decrease during the storage period. The decrease is caused by the loss of part of the water from a product.

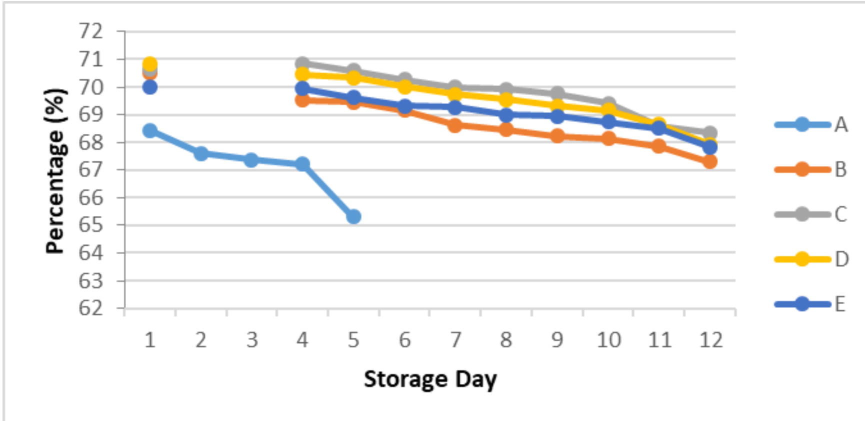

Chart -1: Water content in steamed shrimp during low temperature storage period

The decrease in water content is thought to be caused by a decrease in the water binding capacity of the protein, causing denaturation or a change in internal forces due to pressure on the connective tissue connectivity. Bacteria on steamed shrimp will remodel the connective tissue which functions to hold water in the meat. A higher number of bacteria causes more breakdown and the amount of water drip that comes out will also be more. [25] further reported that the water content in shrimp decreased almost during the cooking process. The decrease in water content in steamed shrimp can be minimized by adding chitosan to the edible coating. The relatively high water content of boiled shrimp coated with edible coating is due to the ability of the edible coating to inhibit the rate of water vapor transmission [17]. Edible coating functions as a barrier (barrier) to moisture, oxygen, flavor, aroma and / or oil to improve food quality, in addition to providing mechanical protection for foodstuffs, reducing damage and improving food integrity [26].

3.1 Color Analysis

Color measurements were carried out objectively using a CR200 Chroma meter with the Hunter notation system (L * a * b *). The degree of coloring is indicated by the notation L *, a * and b *. The L * notation is a brightness parameter, representing reflected light that produces white, gray and black achromatic colors. The L * value ranges from 0 to 100 (black and white). The a * notation is a chromatic color gradation from red to green with positive (+) values from 0 to 80 for red and negative (-) from 0 to -80 for green. The b * notation is a chromatic yellow-blue grading, with positive (+) values from 0 to 70 for yellow and negative (-) from 0 to -80 for blue [4].

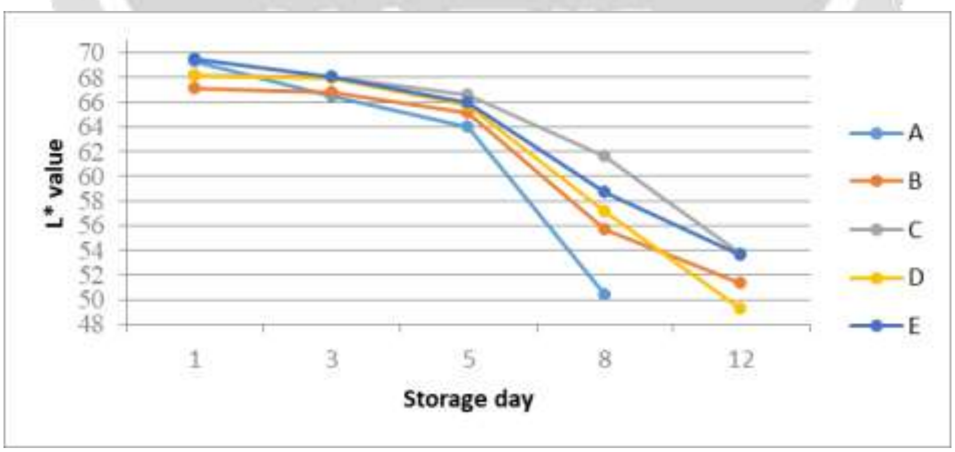

Chart -2: L* values in steamed shrimp during low temperature storage period.

Based on the research results, the brightness level of steamed shrimp during storage tends to decrease. The brightness level of steamed shrimp that was not coated with chitosan edible coating tended to decrease rapidly compared to samples of steamed shrimp using chitosan edible coating. The L * value in steamed shrimp without chitosan edible coating was 69.39 and changed to 50.33, while the steamed shrimp coated with chitosan edible coating with a concentration of 1.5%, the initial value was 67.09 changed to 51.32, the sample with addition of edible coating with 2% concentration of chitosan, the initial value was 68.17, changed to 53.65, samples with a concentration of 2.5% added chitosan had the value 68.09 changed to 49.19, and the addition of chitosan with a concentration of 3% had the value from 69.49 which then changed to 53.58. The brightness level of steamed shrimp coated with chitosan edible coating during storage was slightly brighter than the steamed shrimp samples without chitosan edible coating.

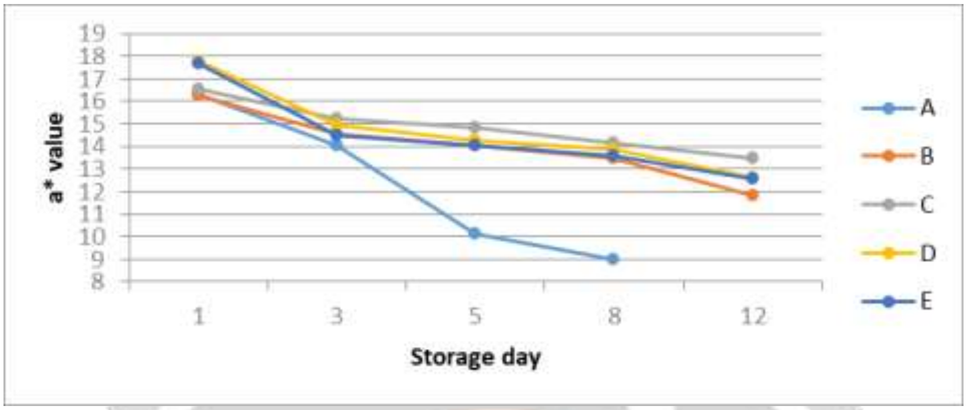

Chart -3: Value of a * in steamed shrimp during low temperature storage period.

The a* value in steamed shrimp during storage tended to decrease. Steamed shrimp samples that were not coated with chitosan edible coating tended to decrease in value very rapidly compared to samples of steamed shrimp coated with chitosan edible coating. The a* value of steamed shrimp without chitosan edible coating changed from 16.34 to 8.99, while the sample of steamed shrimp coated with chitosan edible coating with a concentration of 1.5% changed its value from 16.26 to 11.85, the sample of edible coating with the addition of a 2% concentration of chitosan changed its value from 16.54 to 13.46, the sample with the addition of a chitosan concentration of 2.5% the a value changed from 17.79 to 12.61, and the sample coated with an edible coating with an additional concentration of 3 % changed from 17.69 to 12.58. The value of a* will decrease with the length of storage. The color of steamed shrimp coated with chitosan is redder than steamed shrimp without chitosan coating.

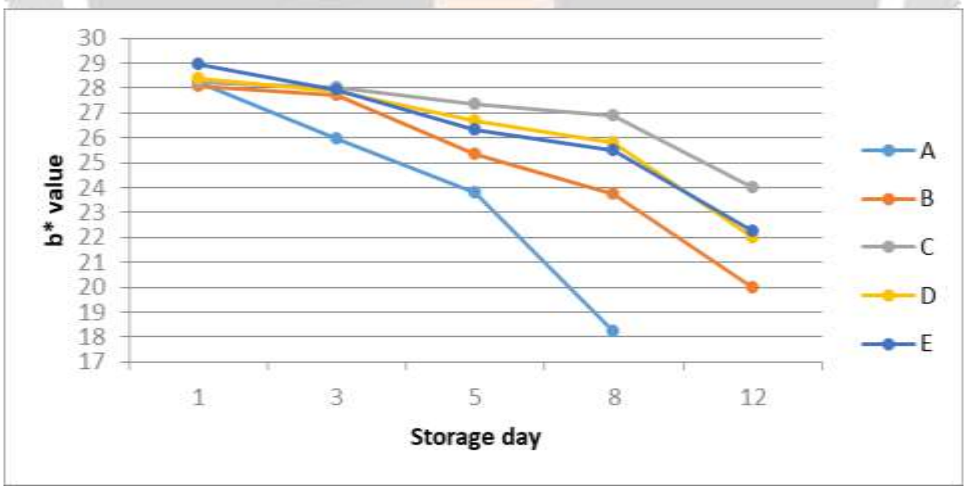

Chart -4: Value of b * in steamed shrimp during low temperature storage period

The value of b * in the steamed shrimp sample during storage tended to decrease. The value of steamed shrimp samples that were not coated with chitosan edible coating tended to decrease very rapidly compared to steamed shrimp coated with chitosan edible coating. The b * value of the sample of steamed shrimp without chitosan edible coating changed from 28.24 to 18.22, while the sample of steamed shrimp coated with chitosan edible coating with an added concentration of 1.5% changed from 28.07 to 19.98, the concentration of addition The value of 2% chitosan changed from 28.25 to 24.02, the concentration of 2.5% chitosan addition changed from 28.39 to 21.99, and the sample of steamed shrimp coated with edible coating with the concentration of adding 3% chitosan changed from 28 , 97 becomes 22.23. The value of b * will decrease with the length of storage. The color of steamed shrimp coated with chitosan is yellow compared to steamed shrimp without chitosan coating.

Based on the L *, a *, and b * values, the samples of steamed shrimp that were not coated with chitosan edible coating had lower values compared to samples coated with chitosan edible coating. The color of the steamed shrimp will decrease during the storage period and the spoilage process occurs. The spoilage process that occurs during the storage time makes the steamed shrimp color from bright red to pale red due to dehydration. According to [27], this is due to the oxidation of astaxanthin (red pigment) so that the red color which is a characteristic of astaxanthin disappears. In addition, according to [2], this change was caused by photo oxidation of astaxanthin. [3] stated that the process of this change could be accelerated by increasing the concentration of oxygen. Steamed shrimp that are not coated with chitosan edible coating will experience a very rapid color decline. This is due to the astaxanthin oxidation process because the surface of the steamed shrimp is not protected, while the steamed shrimp is coated with an edible coating of chitosan, although it still changes color by oxidation of astaxanthin but the process takes place slower because the surface is protected by an edible coating layer.

4. CONCLUSIONS

Based on the results of the research that has been done, it can be concluded that the addition of 2% chitosan as an edible coating on steamed shrimp samples can provide the best results during low temperature storage. Steamed shrimp coated with 2% chitosan edible coating reached the acceptance limit until the 12th day with a water content of 67.41% and a bright yellowish red color with an L * of 53.65, a * of 13.46 and b * of 24.02.

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