Quality of gelatin from tilapia (*Oreochromis niloticus*) by-products and its effects as edible coating on fish sausage during chilled storage

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**Abstract.** Gelatin is a hydrolysed collagen that can be used as raw material for edible coatings to protect perishable foods such as fish sausage. This study aims to examine the quality of gelatin from tilapia by products (skin, scale, bone) and determine the best source of fish gelatin as edible coating on quality of tilapia sausage during chilled storage. The process of made skin gelatin was demineralized with acetic acid while scale and bone were demineralized by hydrochloric acid. Gelatin was examined for yield, gel strength, and viscosity. After edible coatings were applied to the sausages by dipping method, the sausages were stored in the refrigerator at ±5°C for 21 days. Quality deterioration of sausages during storage were measured by sensory value, moisture content, TPC, gel strength and color. The results showed that the highest gelatin yield was obtained from tilapia scales, which was 6.87% while the yield of skin and bone were 4.33% and 1.47% respectively. The best material for edible coating was bone gelatin with gel strength and viscosity which were 325 bloom and 7.10 cP respectively. The application of sausage, where the appearance and texture of sensory value were still acceptable until 21st days of storage. Sausages with edible coating from tilapia bone also showed the highest gel strength about 2514.99-3716.05 g.cm.

1. **Introduction**

Tilapia (*Oreochromis niloticus*) is one of the freshwater fish that is widely cultivated in Indonesia. The production of tilapia has increased every year until in 2018 it reached 1,546,675 tons, which was higher than the production of catfish and gourami which were only 1,339,795 tons and 269,098 tons [1]. The increasing number of tilapia production also increases the by-products such as skin, bones and scales. The by-product contains collagen which has the potential to be processed into gelatin.

The increase in tilapia production is also followed by an increase in its processing which is increasingly diverse to meet consumer demand. One of the processed products of tilapia is made into sausages. Fish sausage products are made from mashed meat added with fillers and spices in a cylindrical shape with a chewy texture. Sausage from fish raw materials has a weakness that is easily damaged during storage. According to [2], fish sausages are prone to spoilage where at refrigerator temperature storage (10-13°C), fish sausages are not suitable for consumption on the 4th day based on the TPC value of 16.7 x 106. Meanwhile, sausages with edible coating are still suitable for consumption on the 4th day.
Edible coating is a thin layer that can be eaten, and has biological and chemical functions as a food coating. The source of edible coatings comes from biopolymers such as lipids, polysaccharide and proteins which are extracted using a method that is suitable for the raw material. The function of edible coating is to inhibit the effects of moisture, oxygen and microorganisms [3]. Gelatin is the result of hydrolysis of collagen from bone, skin and connective tissue of animals such as fish which consists of a heterogeneous mixture of polypeptides consisting of -chain (one polymer/single chain), -chain (two covalently crosslinked -chains) and chains (three covalently crosslinked -chains). covalently bonded chains). Its composition consists of typical amino acids, namely glycine, proline and hydroxyproline. This protein derivative can be used as raw material for edible coatings. Utilization of gelatin with the addition of plasticizers or crosslinking can improve the functional properties of gelatin and the shelf life of coated food products [4].

2. Materials and methods

2.1. Materials
The raw materials used for the manufacture of gelatin are skin, bones and scales of tilapia obtained from PT Aqua Farm Nusantara Semarang. Fish sausage is made from tilapia, tapioca flour, salt, garlic, pepper, eggs, milk and spices. While the materials used in the manufacture of edible coatings are gelatin, glycerol, CMC and aquades.

2.2. Methods
The method used in this research is an experimental laboratory with Split Plot in Time design, where the different types of edible coating are used as the main plot and storage time as a subplot. The treatments were sausage without edible coating (C), sausage with edible coating gelatin skin (K), scale gelatin (S) and bone gelatin (T), stored at a chilled temperature of ±5°C and tested on day 0, 7, 14 and 21. Each treatment combination was repeated three times.

2.2.1. Gelatin manufacturers.
Making fish skin gelatin refers to the method [5], tilapia skin was cleaned of adhering dirt. Furthermore, the degreasing process was carried out by soaking in hot water at 70°C for 2 minutes. Then the skin was soaked in 4% acetic acid solution with a ratio of fish skin to 1:4 solution for 12 hours, then neutralized with running water before being extracted with distilled water, the ratio of skin to distilled water was 1:3, for 3 hours, temperature 800°C. Making gelatin Fish scales referred to method [6] with modification of pretreatment by [7], scales were cleaned of adhering dirt and then soaked in 1% NaOH solution, the ratio of scales to a solution of 1:3 for 3 hours. The next step was neutralization with running water followed by soaked in a 4% HCl solution at a ratio of 1:10 for 24 hours. The last stage was extraction using aquades in a ratio of 1:10, for 6 hours at a temperature of 600°C. The preparation of fish bone gelatin refers to the method [8] with modified pretreatment by [9], the bones are boiled with water at 700°C for 15 minutes. Furthermore, washed and soaked with 4% HCl ratio of bone with a solution of 1:4 for 48 hours. Then the extraction was carried out using aquades in a ratio of 1:3 for 6 hours at a temperature of 850°C.

2.2.2. Making fish sausage.
Making fish sausage refers to the preliminary research that has been done. Tilapia fillets were ground using a grinding machine and then leached 2 times using ice water. The mashed fish meat was then mixed with tapioca flour, spices and additional ingredients until smooth. The finished dough was put in a plastic sleeve and tied with a size of ±10 cm. The last step was to boil the sausages with water at 700°C for 25 minutes.

2.2.3. Manufacture and application of edible coatings.
The manufacture of edible coating refers to the method [10], with slight modifications to the type and concentration of gelatin. The manufacture of edible coatings begins with dissolving 2% each of gelatin from the skin, scales and bones of tilapia into 100 ml of distilled water in an erlenmeyer. Then 1%
CMC and 2 ml of glycerol were added to the solution and heated using a hot plate magnetic stirrer at 90°C for 5 minutes. The application of edible coating was used as a dipping method. Fish sausage was removed from the casing and then dipped in edible coating solution for 2 minutes with 2 repetitions so that it can stick well.

2.2.4. Testing the characteristics of gelatin.

Gelatin yield [11]

Yield is the quotient of the weight of the resulting product divided by the weight of the raw material multiplied by 100%. Yield can be formulated as follows:

\[
\text{Yield (\% w/w) = \frac{\text{Weight of extract (gelatin powder)} (g)}{\text{Weight of extracted materials (g)}} \times 100%}
\]

Description of extracted:
- Fish skin material is fresh tilapia skin that has been washed and air dried.
- Fish scales material is fresh tilapia fish scales that have been washed and air dried.
- Fish bone material is fresh tilapia bone which has been washed until clean.

Gelatin Gel Strength [12]

The test was carried out by weighing 6.67 grams of gelatin dissolved in 100 ml of distilled water at 60°C for 30 minutes. The solution was then cooled in the refrigerator at 7°C for 16-18 hours. Gel strength was measured using a texture analyzer equipped with a 0.5 inch cylinder probe. The speed used is 0.5 mm/s with a trigger of 0.1 kgf.

Viscosity [13]

Gelatin samples were weighed as much as 6.67 in 100 ml distilled water and placed into an erlenmeyer. The sample was left at room temperature for 30 minutes. Then placed in a water bath at 60°C until dissolved. The sample solution was transferred from the erlenmeyer into a beaker glass. The viscosity of the sample solution was used a Brookfield viscometer with a speed of 60 rpm. The measurement results were multiplied by the conversion factor on the spindle, which is 64 referring to the Brookfield manual (2002). The viscosity value is expressed in units (cP).

2.2.5. Testing the characteristics of fish sausages.

Sensory Value [14]

The test was carried out on fish sausage after being treated. Sensory testing was carried out using the fish sausage sensory scoresheet SNI 7755:2013 with the criteria of number 1 as the lowest value and 9 as the highest value.

Gel Strength of Sausage [15]

The sample was cut into cubes of length, width and height of 2.5 cm. Samples placed on the texture analyzer plate tool Lloyd brand, just below the probe type boleprobe. 0.5 inch diameter. Furthermore, the probe was operated with texture analyzer software at a speed of 100 mm/s. The results will appear on the computer screen in the form of a graph from the zero position to the peak. The peak point is used to determine the value of F and D. The calculation is carried out by the formula:

\[
\text{Gel strength} = F \times D \text{ (g.cm)}
\]

Moisture Content [16]

The procedure is to condition the oven at a temperature of 105°C until it reaches a stable condition. Next, put the empty cup into the oven for at least 2 hours and then transfer it to a desiccator for about 30 minutes until it reaches room temperature and weigh the empty weight (A). The fine sample was weighed as much as ±2g into a cup (B) which was then placed in an oven at a temperature of 105°C for 16-24 hours. The cup was transferred using wooden tongs into a desiccator for ± 30 minutes and then weighed (C) to a constant weight. Moisture content is determined by the formula:
Moisture content (%) = \frac{\text{BC}}{\text{BA}} \times 100\%

Color [17]
Color testing was carried out using the digital image analysis method by first preparing a box image equipped with a webcam and lamp. Samples were placed in a box with a distance setting webcam with the sample was always consistent. Image capture was done with the help of a laptop equipped with the application Capture. The results obtained cropped images to obtain the object image only. Processing of the results was carried out using the Matlab R2017a application.

Total Plate Count [18]
The test was carried out by weighing 10 grams of the sample aseptically and put into sterile plastic. Addition of KH$_2$PO$_4$ (1:9 w/v). Furthermore, making PCA media by dissolving 11.25 grams of KH$_2$PO$_4$ dissolved in distilled water. 90 ml of homogeneous sample solution (dilution 10-1), was used to make a dilution of 10-2, 10-3, 10-4 by adding 1 ml of the 10-1 dilution into the 10dilution-2 continued until the 10 dilution-4. 1 ml of the solution was poured into a petri dish. Furthermore, 10 ml PCA media was poured into a petri dish, homogenized by sliding like number 8 and waited for it to harden. Petri dishes containing samples were incubated at 37°C for 48 hours. The last step is to calculate the number of bacteria using a colony counter.

3. Results and discussion

3.1. Characteristics of gelatin
The results of the yield test, gel strength and viscosity of tilapia by product gelatin are presented in Table 1.

| No | Type of gelatin | Yield (%) | Gel strength (bloom) | Viscosity (cP) |
|----|----------------|-----------|---------------------|---------------|
| 1. | GK             | 4.33      | 122.81              | 3.50          |
| 2. | GS             | 6.87      | 79.01               | 3.15          |
| 3. | GT             | 1.47      | 325                 | 7.10          |

The highest gelatin yield value was obtained from the extraction of raw material for scales (GS) and the lowest was obtained from bone (GT). The difference in yield value of each gelatin is influenced by several factors such as the type of fish, the type of raw material and the extraction method. Materials with hollow structures such as bone contain marrow that is not composed of collagen so that it can reduce the yield value obtained [19]. The type of solution used can affect the ability of the solution to break down collagen into gelatin. The process of soaking leather raw materials is better using weak acids because it includes soft tissue so it is easy to hydrolyze, while harder tissues can use strong acids or use alkaline solutions. The use of NaOH solution in soaking the scales is able to break down collagen more strongly so that more gelatin is extracted. According to [20], soak using an alkaline solution such as sodium hydroxide will convert collagen more maximally than acetic acid. As a result, the yield is higher, but the gel strength is lower.

The gel strength values of tilapia skin, scales and bone gelatin ranged from 79.01 to 325 blooms. The value of gel strength produced on skin and scale gelatin meets the gelatin quality standard, which is in the range of values of 50-300 bloom [12]. The strength of the tilapia bone gelatin gel in this study was 325 blooms and higher than the research conducted by [21], where the strength of the tilapia bone gelatin gel produced ranged from 78.12 to 86.47 blooms from each treatment given. According to [22], a gelatin gel strength value below 50 blooms can make gelatin difficult to form a gel, whereas if the gelatin gel strength value is more than 300 blooms it will make the gelatin stiffer and harder.
The tilapia gelatin with the highest viscosity value was obtained from bone gelatin, which was 7.10 cP, while the skin gelatin viscosity was 3.50 cP and the lowest viscosity was scale gelatin, which was 3.15 cP. The order of viscosity values from highest to lowest is directly proportional to the gel strength value. This is because both parameters are closely related to the length of the amino acid chain produced during gelatin extraction. According to [23], gelatin viscosity is influenced by hydrodynamic interactions between gelatin molecules, temperature, pH and concentration. The viscosity value is directly proportional to the gel strength value, which can be determined from the length of the amino acid chain that breaks down during the collagen hydrolysis process.

3.2. Fish sausage characteristics

3.2.1. Sensory value. The sensory test results for each parameter in tilapia fish sausage are presented in the following graph.

*Figure 1. Appearance value of tilapia sausage.*

*Figure 2. Aroma value of tilapia sausage.*

*Figure 3. Taste value of tilapia sausage.*

*Figure 4. Texture value of tilapia sausage.*

Appearance

The appearance value in Figure 1, the control sample decreased faster than fish sausage with application treatment of edible coating gelatin skin, scales and bones which tended to have almost the same decrease. This happened because the control fish sausage was not coated with edible coating gelatin so that the surface of the sausage was in direct contact with air or light. Edible coating gelatin provides protection in the form of a layer that forms on the surface of the sausage. This layer can block the entry of air and light that can affect the appearance of the sausage surface. According to [24], gelatin is used as a coating because it is stable, viscous, transparent and colorless. The formation of a
layer can protect food from drying, light and oxygen so that it can be used as food packaging. The coating properties vary depending on the gelatin source used.

**Odor**
The odor value of tilapia sausage in Figure 2 decreased during storage. The decrease in odor in sausages treated with edible coating skin and bone gelatin was slower than the control and coating scale gelatin. Factors that affect the decrease in odor value during storage is the result of the activity of microorganisms that cause rancid odor in tilapia sausage. This is in line with research [25], that the interaction between packaging method and storage time has an effect on odor. During storage, there was a decrease in the smell of milkfish satay due to the decomposition of the chemical components of the milkfish satay. The odor caused by fishery products is caused by the presence of enzymes and microorganisms that break down protein compounds into simple compounds such as polypeptides, amino acids, indole and skatole. Another factor is the influence of lipolytic enzymes and oxygen.

**Taste**
The change in taste value in Figure 3 occurs because the tilapia sausage has deteriorated in quality caused by damage to the fat and protein content in it. The damage is caused by the increased activity of microorganisms during storage. According to [26], taste is an important parameter that determines acceptance by consumers. Each product has a specific taste depending on the constituent ingredients. The taste parameter is closely related to the protein reshuffle process by microbes that produce free amino acid compounds and volatile bases that can reduce the taste value.

**Texture**
Tilapia sausage without edible coating in Figure 4 decreased faster than fish sausage with edible coating of skin, scales and bones gelatin. Texture test values of all sausages with edible coating gelatin were acceptable until the end of storage, while sausages without edible coating were only up to the 7th day. The difference in the value of the texture test during storage is influenced by the treatment given, where the edible coating gelatin can maintain the cohesiveness of tilapia sausage. This is also influenced by the material edible coating used, namely gelatin which is able to increase the gel strength of a product. According to [27], the type of sausage casing affects the texture of the sausage. The use of sleeves made from protein such as collagen is able to form a chewy texture. This is related to the ability of protein to absorb and retain water which has an important role in the formation of the texture of a food.

3.2.2. **Moisture content.**
The results of the water content test on tilapia sausage during chilled storage are presented in Table 2.

| Storage time (day) | Perlakuan | C | K | S | T |
|-------------------|-----------|---|---|---|---|
| 0                 |           | 67.81±0.19<sup>Aa</sup> | 68.07±0.29<sup>Aa</sup> | 67.85±0.20<sup>Aa</sup> | 68.14±0.36<sup>Ba</sup> |
| 7                 |           | 67.26±0.14<sup>Aa</sup> | 67.48±0.23<sup>Ab</sup> | 67.34±0.24<sup>Aa</sup> | 67.63±0.06<sup>Ba</sup> |
| 14                |           | 66.27±0.39<sup>Ab</sup> | 66.29±0.58<sup>Ab</sup> | 65.73±0.76<sup>Ab</sup> | 65.93±0.25<sup>Ab</sup> |
| 21                |           | 63.59±0.62<sup>Ac</sup> | 65.43±0.51<sup>Bac</sup> | 62.43±1.76<sup>Ac</sup> | 64.68±0.59<sup>Cc</sup> |

Note:
- The data is the average result of three repetitions of the moisture content test (%) ±standard deviation
- Superscript with the same capital letters on the same row shows no significant difference
- Superscript with the same non-capital letters in the same column shows no significant difference
Value of the moisture content of tilapia sausage during 21 days of cold storage in all treatments decreased. This happens because when stored in the refrigerator at a temperature of ±5°C, the moisture content in the sausage undergoes evaporation. The loss of moisture content in fish sausages during storage is thought to be influenced by the temperature and humidity of the surrounding air. In addition, the activity of microorganisms during storage damages the sausage protein so that the protein cannot bind water anymore. This is supported by research [28] which states that during storage, bound water turns into free water. The moisture content of fillet tuna decreased due to protein denaturation. During storage, microorganisms will damage the protein so that the structure becomes porous and can no longer bind water in the tissue.

The control tilapia sausage at the beginning of storage was lower than that of the application edible coating gelatin. This happens because the edible coating of gelatin (skin, scales and bones) of tilapia can bind water when applied to food. According to [29], gelatin can increase viscosity and is able to absorb water. This can occur due to the presence of a polypeptide chain which at the end can form hydrogen bonds with water molecules. The amino acid composition that dominates in the formation of hydrogen bonds is proline, hydroxyproline which contains hydroxyl and carbonyl groups as hydrogen bond-forming groups.

### 3.2.3. Total Plate Count (TPC).

The results of the Total Plate Count (TPC) test for tilapia sausage during storage are presented in Table 3.

| Storage time (day) | Treatment | C         | K         | S         | T         |
|-------------------|-----------|-----------|-----------|-----------|-----------|
| 0                 | 3.04±0.14 | 3.05±0.06 | 2.92±0.12 | 3.06±0.16 |
| 7                 | 4.24±0.20 | 4.17±0.18 | 4.23±0.10 | 4.04±0.32 |
| 14                | 5.44±0.10 | 5.12±0.08 | 5.37±0.03 | 4.76±0.44 |
| 21                | 7.62±0.22 | 5.28±0.07 | 5.56±0.19 | 5.49±0.25 |

Note:
- The data is the average result of three repetitions of TPC test (log colony/gram) ±standard deviation
- Superscript with the same capital letters on the same row shows no significant difference
- Superscript with the same non-capital letters in the same column shows no significant difference

The highest increase in the amount of TPC occurred in fish sausage without edible coating which was stored until the 21st day. Fish sausage without edible coating gelatin experienced a significant increase in the test results because the sausage was not protected by a layer formed from the edible coating as in the other treatments. Edible coating gelatin applied to tilapia sausage is able to protect the product from environmental influences such as air, light and humidity by forming a layer. According to [30], edible coating as a thin layer is used to coat food to increase shelf life. The function of the coating is as a limiting component for the transfer of water, oxygen or fat so as to inhibit microbial contamination of the product. Coating materials from the protein group such as gelatin are good for use as edible coatings because they have a good chemical structure as a coating.

The storage time has a significant effect on the growth of the number of bacteria in tilapia sausage. The number of bacteria in tilapia sausage at the beginning of storage was 2.92 – 3.06 log colonies/gram. All treatments from the beginning of storage continued to increase until the end of storage for 21 days. Food products such as fish sausages are very easy to experience quality deterioration caused by the activity of microorganisms. This is because the protein content and high water content in fish sausages allow microbial metabolism to increase and grow very well. According to [31], the total microbial of pempek products increased with the longer storage time. Products without treatment coating had more total number of bacteria than products with treatment coating. The increase in the number of bacteria is caused by increased metabolic activity and microbial growth.
O'Mahony [32] stated that day 0 to two weeks is the growth period for bacteria. Furthermore, storage of two weeks to four weeks of microbial activity occurs optimally.

3.2.4. *Gel strength*. The results of tilapia sausage gel strength values during storage are presented in Table 4.

| Storage time (Day) | Treatment | C         | K         | S         | T         |
|-------------------|-----------|-----------|-----------|-----------|-----------|
| 0                 |           | 3156,15±25,60<sup>Ab</sup> | 3640,55±71,06<sup>Ba</sup> | 3252,86±78,80<sup>Ca</sup> | 3716,05±63,72<sup>Ba</sup> |
| 7                 |           | 2676,80±25,10<sup>Ab</sup> | 3506,94±11,16<sup>Ch</sup> | 2777,75±54,83<sup>Db</sup> | 3561,16±45,53<sup>Cb</sup> |
| 14                |           | 1672,66±61,18<sup>Be</sup> | 3088,99±37,90<sup>Be</sup> | 2644,19±55,14<sup>Cc</sup> | 3207,47±23,00<sup>Cb</sup> |
| 21                |           | 1193,89±73,11<sup>Ad</sup> | 2224,51±62,70<sup>De</sup> | 2112,45±77,83<sup>De</sup> | 2514,99±13,00<sup>Db</sup> |

**Note:**
- The data is the average result of three repetitions of gel strength test (g.cm) ±standard deviation
- Superscript with the same capital letters on the same row shows no significant difference
- Superscript with the same non-capital letters in the same column shows no significant difference

The application of edible coating gelatin tilapia sausage was carried out by the dipping method where the sausage was dipped into the solution edible coating for a certain time. This causes the surface of the sausage to be in direct contact with the solution and allows the edible coating gelatin to seep into the sausage during the application process. Gelatin is a protein derivative compound that acts as a gelling agent when interacting with processed products such as sausages. The mechanism of gel formation is by forming a three-dimensional network by polymer molecules that trap water around it. According to [33] which states that the addition of proteins such as gelatin will affect the strength of the gel. The polypeptide chains will interact to form the protein matrix structure to be strong and dense.

Storage of tilapia sausage for 21 days decreased the value of gel strength in all treatments. Sausage coated with edible coating bone has the highest gel strength value during storage time. This is influenced by the bone gelatin used that has the highest gel strength. The lowest percentage decrease in gel strength value was in sausages with edible coating bones indicated by the percentage reduction in C, K, S and T sausages of 62.17%, 38.90%, 35.06% and 32.32%, respectively. The lowest value of gel strength during storage was in sausage without edible coating gelatin (control) with the value of gel strength at the end of storage of 1193.89±73.11 g.cm. The control sausage with the lowest gel strength value was not coated with edible coating, so it was suspected that the water in the sausage easily evaporated during storage which caused the texture to become hollow and not compact. These results are in accordance with research [34] which states that the value of gel strength continues to decrease during storage until the end of storage which is the value of the lowest gel strength. These results occur due to the process of releasing a certain amount of water from the fish paste product, which results in reduced gel strength due to the formation of pores in the fish paste product.

3.2.5. *Color*. The results of the color test on tilapia sausage during storage are presented in Table 5.

| Value | Storage time (Day) | Treatment |
|-------|--------------------|-----------|
|       | C                  | K         | S         | T         |
| L     | 0                  | 54,09±0,51<sup>Aa</sup> | 55,57±0,71<sup>Ba</sup> | 53,88±0,72<sup>Aa</sup> | 56,24±0,79<sup>Ba</sup> |
|       | 7                  | 51,04±0,65<sup>Ab</sup> | 54,52±0,30<sup>Ch</sup> | 53,40±0,56<sup>Ba</sup> | 54,61±0,83<sup>Cb</sup> |
|       | 14                 | 50,48±0,96<sup>Ab</sup> | 52,14±0,69<sup>Be</sup> | 50,88±1,11<sup>Ab</sup> | 53,21±0,87<sup>Be</sup> |
The application of edible coating gelatin has an effect on the color of the sausage so that it becomes shiny and looks lighter during storage. The viscosity of the edible coating also affects the sausage. The thicker it is, the sticking the edible coating on the sausage will be, so that it gives a shiny color during storage for a longer time. Control sausages that were not treated with coating decreased the L value lower than the other treatments. Edible coating gelatin on sausages provides color protection during cold storage, because the sausage surface is protected and cannot be in direct contact with the environment such as air and light which can reduce the brightness of the color due to the browning process because the surface dries. According to [35], curried fish sausage that was given an edible coating gave a shiny effect on the surface of the sausage so that the surface became cleaner and brighter. [36] in his research stated that the L color value of control sausages and those coated with edible coating gelatin stingray skin decreased due to the browning reaction. The L color value decreased from 68.1±0.69 to 65.8±0.64 during cold storage (4°C) for 8 weeks. The average L color value of control sausage was 66.8 ± 0.91 while sausage with edible coating gelatin was 67.0 ± 0.68.

**a* value**

As storage increases, it can be seen that the tilapia sausage during storage changes its color to become increasingly red. The color difference based on the a* value is thought to be due to differences in the treatment of the edible coating gelatin given. Tilapia sausage treated with edible coating had a lower a* value than sausage without edible coating. The color of the edible coating of gelatin is less transparent due to the addition of CMC which is white and follows the basic color of the gelatin used, so that when applied to the product it slightly covers the original color of the sausage. According to [37], CMC (Carboxymethyl Cellulose) is a hydrocolloid compound for food mixtures. CMC is in powder form, white in color and odorless. [38] in his research on the application edible coating of fish skin gelatin grass carp fillets explained that the a* value increased during storage. The increase occurred in all samples, but the increase in samples with edible coating was slower than samples without edible coating. This is possible due to the degradation of lipids and proteins that affect the color.

**b* value**

Application edible coating value of tilapia gelatin affects the b* color value in tilapia sausage during storage. Tilapia fish sausage increased the value of b* with increasing storage time. Tilapia fish sausage with the highest the b* value was fish sausage without coating (C), while the lowest value was tilapia sausage with edible coating bone gelatin(T). Edible coating gelatin applied to sausage affects the yellowness of the color because the original color of the sausage is covered by a layer formed from the edible coating as evidenced by the higher L value compared to the control. According to [39] which stated that his research on nuggets tilapia treated with coatings increased the value of b* during storage.
storage. The $b^*$ value of tilapia nuggets coated with edible coating has a less yellow or red color when compared to the control (without coating). Fish nuggets that are coated with a coating have a value of $b^*$ 16.52 – 19.92 while fish nuggets without coating have a value of $b^*$ 27.44-30.07. The difference in the value of $b^*$ is also influenced by the difference in the value of L obtained.

4. Conclusions
The highest yield of gelatin was obtained from tilapia fish scales, which was 6.87%. The highest gel strength and gelatin viscosity values were obtained from tilapia bones, namely 325 bloom and 7.10 cP. The best edible coating for tilapia sausage is the bone gelatin edible coating where the appearance and texture values are still acceptable up to the 21st day and the smallest decrease in odor and taste values. The sausage gel strength value was the highest compared to the others and the value lightness was higher than the sausage with edible coating of scales and skin. Application of edible coating on tilapia sausage during cold storage had a significant effect on the value of water content, TPC, gel strength and color value of L a* b*.

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