Original Research Article

Characterization of Surimi Based Edible Film From Mackerel Tuna Dark Muscle

ABSTRACT

This research aims to determine the concentration of dark muscle surimi of mackerel tuna to produce edible films with characteristics according to JIS (Japanese Industrial Standard) standards and to analyze the characteristics of the resulting edible films. The method used was experimental with Completely Randomized Design (CRD), the treatment of surimi concentration consisted of three treatments with three replications including 8%, 10%, and 12%. Parameters observed include thickness, tensile strength, percent elongation, and transparency. The results showed that increasing concentrations of dark muscle surimi of mackerel tuna had a significant effect on thickness and percent elongation, but had no significant effect on tensile strength and transparency. The Edible film with the addition of 8% concentration of mackerel dark muscle surimi had the best characteristics based on the Japanese Industrial Standard (JIS) and statistical analysis, with a thickness of 0.096 mm, tensile strength 486.78 kgf/cm2, percent elongation 211.67%, transparency 5, 72 and 94.28% clarity. Based on the research results, the overall treatment has met the Japanese Industrial Standard (JIS) so that the dark muscle surimi of mackerel tuna is suitable to be used as packaging material for a product

Keyword:edible film; dark muscle; mackerel tuna; surimi

1. INTRODUCTION

Mackerel tuna meat is divided into dark muscle and light muscle. Comparison of protein content in dark muscle 54.196% with light muscle 68.355%, and fat content in dark muscle 5.6%, light muscle 1.8% [1]. The difference in content makes light muscle often used in product manufacture, while dark muscle has not been widely utilized because it looks darker and causes a fishier smell. The dark muscle in fish is a layer of reddish-pigmented flesh that contains myoglobin and hemoglobin which are pro-oxidants and are rich in fat [2].The processing of mackerel tuna which often uses light muscle makes dark muscle a processed waste.

The development of food technology causes surimi to be used as edible packaging or better known in the form of edible films and protein-based edible coatings. Surimi in another sense is a myofibril protein, fibrous proteins (actin and myosin) generally can form films with good mechanical properties, while globular or pseudo-globular proteins (eg, globular-actin) need to be opened before film formation. The films produced from myofibrillar proteins have higher tensile strength than other protein-based films [3].

The edible film is a food component in the form of coatings made of edible materials or as a thin layer placed between food components, serves to inhibit the migration of moisture, oxygen, carbon dioxide, aroma, lipids, and so on [4]. Edible films and coatings are the potential to be used as packaging materials because they can affect food quality, food safety, and product shelf life [5].

The success of making edible films can be determined from the characterization of the resulting film. The flexibility of the packaging can be determined from the physical properties of the edible film, the smaller the tensile resistance value and the greater the elongation value of the edible film, the more applicable it will be [6]. Mechanical properties determine the quality of the packaging, the smaller the value of the water vapor transmission rate produced, the better the quality of the edible film [7]. Several characteristic tests of edible films based on the Japan Industrial Standard consist of thickness, tensile strength, elongation and water vapor transmission rate. Therefore, this research aims to determine the concentration of dark muscle surimi of mackerel tuna to produce edible film characteristics according to JIS (Japan Industrial Standard).

2. MATERIAL AND METHODS

2.1 Tools and Materials

The tools used are basin, knife, cutting board, calico cloth, mixer, food processor, measuring cup, scales, hot plate, magnetic stirrer, pipette, plastic mold measuring 13 cm x 22 cm x 2.5 cm, drying oven, caliper, Instron, cuvette, thermometer, ph meter, and 300 ml beaker glass. The ingredients used were dark muscle of tuna, aquades, glycerol, salt, cold water, 1 M NAOH, sorbitol and ice cubes.

2.2 Procedure

This research consists of making surimi and making edible films.

2.2.1 Making Dark Muscle Mackerel Tuna Surimi

The method of making surimi of dark muscle mackerel tuna is based on research modification by Frasisca[8], the procedures carried out include: The flesh of the mackerel tuna is separated from the bone (filled), then the dark muscle is separated from the light muscle (dark muscle is along the side of the body under the skin). pulverizing using a food processor, the results of pulverizing are washed with water 1 time washing lasts for 5 minutes at a temperature of 5-10oC and 0.3% salt solution (washing modifications based on the results of Hendrawan’s research [9]. Soaking using cold water (ratio of water: meat is 3: 1). The mashed meat is squeezed using a calico cloth to remove the water. Squeezed mashed meat was added with 2% cryoprotectan sorbitol and mixed using a food processor until homogeneous. The resulting surimi was put in polyethylene plastic and stored in a freezer at a temperature of -15oC, and then used in the manufacture of edible films.

2.2.2 Making Edible Filmfrom Dark Muscle Surimi of Mackerel Tuna

The method of making edible film from dark muscle surimi of mackerel tuna, research modification by Neviana [4], the procedures carried out include: Surimi from dark muscle of mackerel tuna which is frozen in thawing for 20 minutes. Surimi weighed as much as 8%; 10%; 12% of 150 ml of distilled water and put in a 300 ml beaker glass. Surimi was added with distilled water and 1 M NaOH until pH 11 was then stirred and heated using a hot plate at 55^{o}C for 30 minutes. Stirrer using a stirrer until the solution is homogeneous. The homogeneous solution was added with 1% glycerol plasticizer while stirring and heated until the temperature reached 70^{o}C for ±25 minutes (modification of glycerol plasticizer based on the results of Frasisca’s research [8]. The process solves surimi, after which it is filtered using nylon mesh (150 mesh), the resulting solution is taken as much as 100 ml. The solution was poured on a mold measuring 22 x 13 cm x 2.5 cm and leveled so that the same thickness was obtained. The edible film was dried and put into the oven at 50^{o}C for 18 hours. The cooled film is removed from the mould.

2.3 Research Methods

The method used is experimental with Completely Randomized Design (CRD). The treatment consists of adding surimi 8%, 10%, and 12%.

2.4 Observations Parameters

2.4.1 Edible film Thickness Test

The thickness of the edible film was measured using a micro-cal messenger with an accuracy of 0.0001 mm at 5 different points at random [10]. The measured film thickness value is the average of the 5 measurements

2.4.2 Tensile Strength and Percent Elongation

Tensile strength is the maximum stress strain of the sample before breaking [11]. The tensile strength in the edible film is the maximum tensile force that the edible film can hold until it breaks [12]. The calculation of the tensile strength using the following equation [13]:

$$\sigma = \frac{\text{Fmaks}}{A}$$

Information:
σ = Tensile Strength (kgf/cm2)
Fmaks = Maximum voltage (N)
A = Cross-sectional area (cm^2).

The percent elongation is the maximum change in length that the film can experience when stretched or pulled until it tears or breaks. The measurement of the percent elongation uses the following formula:

$$\text{Percent Elongation} = \frac{\text{break distance}}{\textit{clamp distance}} \times 100$$

2.4.3 Transparency

The transparency of the edible film was measured using a spectrophotometer at a wavelength (λ) of 546 nm. Transparency of the film was measured using the [10] method, in which the film of known thickness (x mm) was cut sufficiently and then inserted into the test cell. The absorbance (A546) was recorded using a UV-Vis spectrophotometer. Transparency test is calculated using the formula:

$$T = \frac{A_{550}}{x}$$

Information :
T = Transparency
A_{550} = Absorbance at a wavelength of 550 nm
X = Thickness

2.5 Data Analysis

The data from the thickness, tensile strength, percent elongation, and transparency of the edible film were analyzed descriptively and statistically using the F test or Analysis of Variance (ANOVA) test with a 95% confidence level. Based on the results of statistical calculations, if Fcount is significantly different or very significant from Ftable, then proceed with Duncan's multiple distance test to determine the value between differences with a 95% confidence level.

3. RESULT

3.1 Thickness

The thickness of the edible film affects the permeability to water vapor, gas, and volatile compounds as well as other physical properties such as tensile strength and elongation at break of the resulting edible film [14].

The results of the analysis of variance showed that the addition of dark muscle surimi concentration of mackerel tuna gave a significantly different effect on the thickness of the edible film produced. The higher the concentration of surimi added, the thicker the edible film produced. The results of the thickness of the edible film can be seen in Table 1.

The thickness that is formed due to the expansion or development of denatured protein molecules in surimi so that it opens the reactive groups that exist in the polypeptide chain [15]. The bonds between the reactive groups of the protein will hold all the liquid, so a gel will be formed. Meanwhile, when the liquid is separated from the coagulated protein, the protein will settle and product sheets. The formation of the film from protein occurs through 3 stages, namely protein denaturation (breaking the protein intermolecular chain by dissolving or heat treatment), interactions between protein chains to form a new three-dimensional structure, and stabilization of the formed layer (forming a cohesive and continuous matrix) [16].

Table 1. Edible Film Thickness

Surimi Concentration (%)	Average Thickness (mm)
8	0,096 ± 0,01^{a}
10	0,111 ± 0,003^{b}
12	0,151 ± 0,02^{c}

The addition of surimi concentration will increase the thickness of the resulting edible film. This is in accordance with [4], the greater the concentration of surimi added increases the amount of protein in the edible film solution so that the sediment that settles as forming the edible film increases. The thickness is influenced by the area of the mold, the volume of the solution, and the total amount of solids in the solution [15]. So with the same mold area and solution volume, the more concentration of surimi added will increase the total dissolved solids and increase the value of the thickness of the edible film [4].

The use of plasticizers in film formation does not affect thickness. The thickness of the edible film is highly dependent on the composition, properties, and polymer content of the constituents, but does not depend on the plasticizer [17].

3.2 Tensile Strength

The addition of surimi concentration will increase the resistance and ability of the edible film so that the resulting tensile strength value increases.The higher the protein concentration in the solution, the more intermolecular incorporation increases so that the bonding polar groups will increase [18]. This increase causes the absorption of water around it, which is then entangled between the three-dimensional matrix. The addition of more protein, the more matrix formed, the stronger the structure of the film matrix so that the strength given to support the load from the outside is getting bigger [10]. The incorporation of bonds will be very strong if it involves hydrogen bonds, hydrophobic and ionic interactions so that the tensile strength increases [19].

The results of the analysis showed that an increase in the concentration of dark muscle surimi of mackerel tuna did not have a significantly different effect on the strength value of the edible film produced (95% confidence level). The results of the tensile strength test of the edible film can be seen in Table 2.

Tabel 2. Edible Film Tensile Strength

Surimi Concentration (%)	Average Tensile Strength (kgf/cm^2)
8	486,78 ± 116,65^{a}
10	577,82 ± 160,34^{a}
12	665,94 ± 91,02^{a}

The addition of a greater concentration of surimi at a fixed amount of glycerol causes the ratio of protein to glycerol to be greater, as a result, the constituent components in the form of protein are more and more, resulting in greater tensile strength of the edible film. This is in accordance with the edible film of starch which states that when the glycerol added to the starch tissue is reduced, the reduction of starch bonds gets smaller, and the tensile force becomes stronger [10]. Likewise in a study showed that at a fixed amount of glycerol, the tensile strength of edible films increased with the increase in cassava starch [20].

3.3 Percent Elongation

Percent elongation is the change in maximum length at the time of stretching until the film breaks [21]. The greater the elongation value, the better the edible film because it is more elastic and not easily torn [22]. The results of the percent elongation showed that the higher the concentration of surimi added, the percentage of elongation of the edible film produced decreased. The results of testing the percent elongation of the edible film made from dark muscle surimi of mackerel tuna can be seen in Table 3.

Table 3. Edible Film Percent Elongation

Surimi Concentration	Average Percent

(%)	Elongation (%)
8	211,67 ± 20,21[a]
10	148,33 ± 30,55[b]
12	123,33 ± 15,28[c]

The edible film made from surimi has a higher percentage of elongation along with the addition of surimi concentration. This happens because the resulting polymer matrix is getting stronger and results in stronger intermolecular tensile strength so that the stretchability of the film also increases [23].The more protein there is, the greater the opportunity for intermolecular interactions, which causes the flexibility of the edible film to be large and the percent elongation value to be higher. However, if the addition of glycerol continues, the increase in the concentration of surimi also causes a decrease in the ratio of glycerol as a plasticizer to protein, resulting in a decrease in the percent elongation of the film when exposed to force, which then causes the film to break easily [24].

The percent elongation value is usually inversely proportional to the tensile strength value [25]. The greater the value of the percent elongation will cause the value of the tensile strength to be smaller. When the material is more elastic (the value of the percentage of elongation is large), the ability of the material to withstand the load is getting weaker (the value of the tensile strength is small) [23].

3.4 Transparency

Transparency is the ability of a material to transmit light [26]. The value of film transparency is an important part of the application of edible films to food products. Transparency describes the level of clarity of the resulting film [27]. High transparency values or clear colored films will not change the original color of the coated food product [28], so the coated product can be seen clearly. The average value of transparency is presented in Table 4.

Table 4. Edible FilmTransparency

Surimi Concentration (%)	Average Transparency
8	5,72 ± 0,52[a]
10	6,27 ± 0,26[a]
12	6,92 ± 0,99[a]

The thickness of the edible film affects the value of transparency. The thicker the film, the higher the transparency value because more light is absorbed on the film recorded by a spectrophotometer with a certain wavelength [28]. This is because the higher the protein concentration in the manufacture of the film will increase the viscosity of the suspension so that the dissolved solids in the film will increase and cause the film-forming polymer to increase which increases film thickness which is finally able to diffuse light, as a result, the edible film will appear dull and opaque [29].

The clarity results showed that the higher the concentration of surimi added, the lower the clarity of the edible film produced (Table 5). The thinner the edible film, the more transparent it will be [30].

Table 5. Edible Film Clarity

Surimi Concentration (%)	Average Clarity (%)
8	94,28 ± 0,52[a]
10	93,73 ± 0,26[a]
12	93,08 ± 0,99[a]

Edible film from mackerel tuna dark muscle surimi will produce a darker color than dark muscle surimi. This is because in the dark muscle of mackerel tuna there are blood pigments, such as myoglobin and hemoglobin [2]. Both of these substances can cause the resulting surimi to be dark (not bright). So that the resulting edible film is brownish yellow to dark brown.

4. CONCLUSION

Edible film with the best characteristics was found in the addition of 8% concentration of surimi dark muscle mackerel tuna with a thickness value of 0.096 mm, tensile strength 486.78 kgf/cm2, percent elongation 211.67%, transparency 5.72 and clarity 94.28%. . Based on the research results, the overall treatment has met the Japanese Industrial Standard (JIS) so that the dark muscle surimi of mackerel tuna is suitable to be used as packaging material for a product.

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