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Physicochemical Characteristics of Edible Film Sodium Caseinate with Sappan Wood Extract Addition

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ABSTRACT

Packaging will protect food from physical and chemical deterioration and maintains the economic value during storage. Generally, food packaging was made by plastic material which is cheap and easy to use. Plastic waste makes it difficult to degrade, so it is necessary to develop technology that aims to reduce the impact of plastic waste pollution by biodegradable packaging included edible film. Casein is one of the hydrocolloid ingredients which is utilized to made of edible film. Casein has flexibility, transparency, and tasteless film properties also it has a carrier antioxidant capacity. The addition of sappan wood extracts to the edible film that is interesting to observed as a carrier of antioxidant compounds. This research was conducted to obtain the concentration of sappan wood extract, which produces the best physicochemical characteristics of sodium caseinate edible film. The method used in this study was a one-factor Randomized Block Design (RBD) consisting of 5 levels of sappan wood extracts (0%, 2.5%, 5%, 7.5%, and 10% w/v_{total}) with 5 replications. Based on this research to obtained the best physicochemical characteristics of edible film sodium caseinate with the addition 10% sappan wood extracts, which has a thickness value of 0.20 mm, solubility 24.421%, color L* (79.0) a* (8.3) b* (32.8), water holding capacity of 6.863 (g/g), and antioxidant activity of 24.170%.

Keywords: antioxidant, edible film, sodium caseinate, sappan wood

INTRODUCTION

Packaging protects food from physical and chemical damage and maintains the economic value of stored food products. One of the packaging that are still being developed is edible packaging. Edible packaging is used to wrap (coating or wrapping) various foods to extend the shelf life of products that can be eaten together with food (Pavlath and Orts, 2009).

The edible film is a thin layer made of edible material and placed on top of food components which functions as a barrier to mass transfer such as moisture, oxygen, fat, and solutes (Julianti and Nurminah, 2006) and serves as a carrier for food components including vitamins, minerals, antioxidants, antimicrobials, preservatives, and ingredients to improve the taste and color of packaged products (Yulianti and Ginting, 2012). Edible films can be made from hydrocolloid, lipid, and mixed groups of these two materials (Prasetyaningrum et al., 2010). Hydrocolloids that can be used in the manufacture of edible films are proteins. Edible films made of protein are better at inhibiting water vapor, gas, or solutes and are also more biodegradable to reduce environmental problems (Yoshida and Antunes, 2004). Casein is one of the proteins used to manufacture edible films (Sabil et al., 2021).

Casein is the leading milk protein that primarily contains the amino acid glutamine, which gives it a particular property that is difficult to decompose at high temperatures. Casein comprises 80% of the total milk protein and has polar functional groups, such as amino and hydroxyl groups (Ningsih et al., 2019). Based on these properties, casein is generally used as the main ingredient for forming edible film structures that can produce specific characteristics (Sabil et al., 2021). Casein has flexible, transparent, and tasteless film properties and has good nutritional value. Casein can also be a carrier for additives such as antimicrobial and antioxidant substances (Rai and Poonia, 2019).

Muin et al. (2017) stated that in addition to essential components, edible films also require additional constituent materials, such as plasticizers, antioxidants, antimicrobials, dyes, and flavors. One of the natural ingredients that can be added to manufacture of edible films is sappan wood. Sappan wood contains a lot of phenolic and flavonoid compounds that have antioxidant properties. These compounds are brazilin, 3'-O-methylbrazilin, saponins, chalcone, and sappancalchone, which can be used as primary and secondary antioxidants (Rina, 2013). Based on the potential, further research is needed to determine the best physicochemical properties of adding sappan wood extract to the sodium caseinate edible film. So that the edible film produced can protect food products from physical and chemical damage, increase the functional value of the product, and is eco-friendly, which can help reduce the problem of plastic waste that is difficult to decompose.

MATERIALS AND METHODS

Tools and Materials

The materials used for making edible film were sodium caseinate “Excellion DMV” obtained from Subur Kimia Jaya shop, and sappan wood obtained from Traditional market at Pontianak. Glycerol and aquadest were obtained from the Kalimantan Research store. The material for analysis is DPPH (1,1-diphenyl-2-picrylhydrazyl) (HIMedia). The research equipments were blender (Miyako), 80 mesh sieve, coarse filter paper, glass plate measuring 13 cm x 18 cm x 1.5 cm, analytical balance (Mettler Toledo), thermometer, hot plate (Cimarec Thermolyne), magnetic stirrer, cabinet dryer (Control egp (IL-80EN)), vortex mixer (VM-300), UV-VIS Spectrophotometer (Shimadzu UV mini-1240), digital colorimeter AMT506, oven (Phillip Harris Ltd), desiccator (Duran), Erlenmeyer (IWAKICTE33), measuring cup (IWAKICTE33), Beaker glass (IWAKICTE33), test tube, digital caliper and centrifuge (Hettich EBA III).

Methods

The research was carried out in three stages: sappan wood powder production, sappan wood extract production, and edible film production. The physicochemical tests included film thickness, solubility, color, water holding capacity, and antioxidant activity.

Sappan Wood Powder Production

The production of sappan wood powder is carried out by Dewi (2021) with modifications. The sappan wood is cleaned thoroughly, then cut into small pieces with a size of ± 3-5 cm to be dried for 5 hours at 60ºC using a cabinet dryer. The dried wood was then blended until smooth and sieved using an 80 mesh to obtain sappan wood powder.

Sappan Wood Extract Production

Sappan wood extract was made using the method of Karyantina et al. (2021) modified. 10 g sappan wood powder was added 100 ml of aquadest, and the solution was heated at 60℃ for 60 minutes using a hot plate. The resulting sappan wood suspension was filtered using filter paper to collect the filtrate. The filtrate obtained will be used for edible film productions.

Edible Film Production

The production of edible films refers to the research of Kadam et al. (2015), which has been modified. 5 g of sodium caseinate was dissolved in 100 ml of aquadest using a hot plate at 65℃ for 10 minutes. 1.5 ml of glycerol was added to the solution under the same conditions for 15 minutes of stirring. Sappan wood extract as much as 0%, 2.5%, 5%, 7.5%, and 10% (w/v_{total}) was added to the film-forming solution then stirred using a stirrer for 15 minutes to make it homogeneous.

The film-forming solution was cooled to 40℃ and filtered using filter paper. The filtering results are poured into a glass plate with a size of 13 cm x 18 x 1.5 cm^3, dried for 48 hours at a temperature of 35℃ using a cabinet dryer, then cooled at room temperature for 15 minutes.

Thickness

Thickness testing was carried out by Huri and Nisa (2014). Samples were measured using a digital caliper at five different places, different than the average measurement results due to film thickness. Thickness is expressed in mm, while the micrometer used has an accuracy of 0.01 mm.

Solubility

The solubility testing was carried out by Indrarti and Indriyati (2016). Solubility was measured by taking a 2 cm x 2 cm film sample and weighing it as the initial weight. Film samples were soaked in 50 ml of distilled water and stirred for 30 minutes with a stirrer. The soaked sample was filtered using filter paper, dried in an oven at 105°C for 2 hours, stored in a desiccator for 15 minutes, and then weighed.

Color

The color testing was carried out by Huri and Nisa (2014). Color measurement using a digital colorimeter with target readings of L, a*, b* determined at five different points.

Water Holding Capacity

The water holding capacity testing was carried out by Deden et al. (2014). Test tube in the oven for 1 hour and put in a desiccator then weighed. 0.25 g of sample was put into a test tube and added with 10 ml aquadest. Homogenize using a vortex mixer. Let stand for 1 hour, then centrifuged for 20 minutes.

Antioxidant Activity

The antioxidant activity was determined by Miranda et al. (2018). Each sample weighed 500 mg and dissolved in 5 ml methanol. The solution was allowed to stand for two hours and filtered through filter paper. 0.1 ml of solution filtrate was added to 3.9 ml of DPPH solution, then incubated at room temperature for 30 minutes.

Data Analysis

The results of testing the physicochemical properties of edible films were statistically analyzed using Analysis of Variance (ANOVA) to determine the effect of the treatment and further tested with Tukey's Honestly Significance Difference (HSD) at a 5% level. The best treatment is determined by index effectivity value (De Garmo et al., 1984).

RESULTS AND DISCUSSION

Thickness

Film thickness is included in the physical characteristics of edible films. According to the Japanese Industrial Standard (JIS), thickness is an essential characteristic in determining the suitability of films as packaging for food products. The thicker the edible film indicates that the retaining ability is also more significant, or it is more difficult for water vapor to pass so that the product's shelf life will be longer (Afriyah et al., 2015). The results of the thickness of the edible film sodium caseinate at various concentrations of adding sappan wood extract are shown at Table 1.

Table 1 shows that the thickness of the edible film ranges from 0.14 to 0.20 mm. The results of this study indicate that although it has no significant effect on the Analysis of Variance, an increase in the concentration of sappan wood extract tends to increase the thickness of the edible film. Kusumawati and Putri (2013), several factors affect the thickness of the edible film, including the area of the mold plate and the volume of the suspension, as well as the components that make up the edible film. The components of the edible film that are thought to affect the thickness of the sodium caseinate edible film are sappan wood.

Previous research from Emam-Djomeh et al. (2015) investigated adding pomegranate peel extract to edible film sodium caseinate. The addition of pomegranate peel extract causes the formation of a sponge-like structure in the film, which can increase the thickness of the edible film. Water molecules trapped in this structure's pores will increase the film's moisture content and swelling, which ultimately causes an increase in thickness. Mulyadi et al. (2016) said that the material's total solids affect the film's thickness. Hosseini et al. (2009) reported that adding cinnamon, clove, and thyme extracts to chitosan-based films caused an increase in film thickness. Li et al. (2014) found that polyphenolic compounds affected gelatin film thickness. Film thickness was higher when natural antioxidants were added. The increase in the thickness of the edible film is related to the nature of colloid compounds as thickeners and suspenders and the interaction between the components that make up the edible film (Galus and Lenart, 2013). Glycerol can absorb edible film moisture to a certain extent which causes an increase in the thickness of the edible film due to the swelling process (Ahmadi et al., 2012). Cahyo et al. (2017) stated that the more compositions of materials used in the manufacture of edible films, the thicker they will be due to the various constituent components. The higher the concentration of the constituent polymers at a specific limit can increase the thickness and stability of the edible film (Warkoyo et al., 2014).

Solubility

Solubility is one of the physical properties of edible films. Related to their solubility in water and the ability of edible films to retain water (Bourbon et al., 2011). Films with a high solubility value showed film hydrophilicity and lower water resistance (Fardhyanti and Julianur, 2015). The results of the solubility of the edible film sodium caseinate with the addition of sappan wood extract are shown at Table 2. The solubility of edible film sodium caseinate between 20.219 – 24.421%, with the highest value addition of 10% sappan wood extract.

According to Fardhyanti and Riski (2015), sappan wood contains brazilin compounds which contain many hydroxyl groups (OH^-). The hydroxyl group can bind to water molecules (H_2O), so the more hydroxyl groups are included in the edible film matrix, the higher the solubility or percent solubility (Santoso et al., 2016). Glycerol used in the ingredients for the edible film is also thought to affect the solubility of the edible film. Glycerol is known to have hydrophilic properties, so it is easily soluble in water. Adding glycerol as a plasticizer can attract water from the environment to increase the solubility of edible films in water (Negara and Simpen, 2014). Edible films with higher solubility indicate that films are easier to consume (Krisna, 2011). The edible film, with the addition of sappan wood extract which has higher solubility, can be applied to products that can be eaten directly.

Color

The CIELAB color space is a color model similar to the perception of human vision by implementing three components: L*, a*, and b* (Harnis et al., 2019). The notation L* states showed that the brightness level with a value of 0-100 (black-white), and a* states the type of color with a negative value for green (0 - (-80)) and positive for red (0 - 80), and b* states the color type with negative values for blue (0 – (-70)) and positive for yellow (0 – 70) (Sinaga, 2019). The color results of edible film sodium caseinate with the addition of sappan wood extract shown at Table 3.

Table 3 shows that adding the concentration of sappan wood extract significantly affects the edible film sodium caseinate at the level of $\alpha = 5\%$. The value of L* decreases with adding the concentration of sappan wood extract. The highest L* value was found in the addition of 0% sappan wood extract which was 87.2, and the lowest value was in the addition of 10% sappan wood extract, which was 79.0. This happens because the more significant the concentration of sappan wood extract in the manufacture of edible films, the brightness of the edible film will decrease. According to Romruen et al. (2022), sappan wood has a red pigment compound called brazilin which can affect the brightness of the edible film itself. Colors of the edible film sodium caseinate at various concentrations of adding sappan wood extract are shown in Figure 1.

Huri and Nisa (2014) stated that the thickness of the edible film could also affect the brightness level. The higher the thickness value of the edible film, the lighter will diffuse so that the object of the edible film will appear cloudy, and the brightness will be lower. The uneven thickness also affects the color of the edible film, which causes the color of the edible film to be inhomogeneous. The same thing was reported by Emam-Djomeh et al. (2015), who investigated adding pomegranate peel extract to edible film sodium caseinate. Adding pomegranate peel extract increased the a*, b*, and ΔE indexes and decreased the L* and WI (Whiteness Index) values. Wang et al. (2012) stated that adding extracts affected the color, which was thought to come from the polyphenol component. According to Karlina et al. (2016), sappan wood contains phenolics, flavonoids, tannins, polyphenols, cardenolin, anthraquinone, sappan chalcone, caesalpin, resin, resorcin, brazilin, d-alpha phellandrene, ocimene, and essential oils. Increasing the concentration of sappan wood extract will increase the edible film's redness, yellowness, and darkness. Based on the color produced, this edible film is suitable for protecting products from protein sources, such as milk candy. Milk candy is generally only white, so applying colored edible film to milk candy can produce more attractive colors.

Water Holding Capacity

Water Holding Capacity (WHC) is defined as the ability to bind water in the material or added during the processing process and the ability of the material to hold water. WHC can also be related to the magnitude of the attraction of water (Deden et al., 2020). According to Ulfah et al. (2018), the value of WHC is closely related to the value of solubility. The higher the solubility of edible films, the lower their ability to hold water. The WHC value of sodium caseinate edible film with the addition of sappan wood extract between 6.863 – 8.091 (g/g). The results of WHC edible film sodium caseinate with the addition of sappan wood extract shown at Table 4.

Several factors can cause the solubility of the film in water. According to Schmidt et al. (2013), the interaction between the components that make up the film matrix, such as hydrophilic and hydrophobic components, and the resulting film structure. This is presumably because sappan wood extract has a hydroxyl group that makes it hydrophilic (Fardhyanti and Riski, 2015). Lindriati et al. (2014) also stated that the main ingredients for making edible films affect the WHC value, in which protein gels have a lower water binding ability than starch gels. Protein gels have fewer hydroxyl groups than starch gels, so the ability to bind water is also lower. Edible films with low water binding capacity can be applied to food products that do not contain much water or are dry, such as candy.

Antioxidant Activity

The antioxidant activity of edible film sodium caseinate with the addition of sappan wood extract shown in Table 5. The antioxidant activity of sodium caseinate edible film range from 1.678 – 24.170%, with the highest value addition of 10% sappan wood extract. This indicates that the higher the concentration of sappan wood extract added, the higher the antioxidant activity.

Another study conducted by Oka et al. (2016) regarding the addition of cinnamon leaf extract to edible films can increase the phenol content by 4.24 (mg/100 g GAE) with the addition of 20% cinnamon leaves. These phenolic compounds are the main compounds that act as antioxidants in the product. So, with the increasing concentration of cinnamon leaf extract, the antioxidant activity produced also increases. The increase in antioxidant activity at various extract concentrations was thought to be due to increased phenolic and flavonoid compounds in the extract (Cepeda et al., 2018). Kadam et al. (2015) studied edible film made from sodium caseinate, which was incorporated with brown seaweed extract, producing antioxidant activity of 78.107% and total phenolic 5.381 mgPGU/100gdb. According to Kusumawati and Putri (2013), the antioxidant activity of edible films is influenced by the antioxidant compounds contained in the ingredients and the ability of these compounds to reduce free radicals.

Phenol compounds have a significant effect on the antioxidant activity of edible films. The higher the total phenol, the higher the antioxidant activity (Huri and Nisa, 2014; Nuansa et al., 2017). Antioxidant activity with the addition of 0% sappan wood extract showed a value of 1.678%, which means that the manufacture of sodium caseinate edible film without the addition of sappanwood extract already has antioxidant activity. This is possible due to edible films uses sodium caseinate and glycerol which antioxidant activity (Elias et al., 2008) and glycerol can be protected phenolic compounds (Nuansa et al., 2017).

Adding antioxidant compounds to the packaging aims to protect the product from oxidation. Edible films with high antioxidants can be applied to food products such as sausages and jelly candies. Both of these products are products that can undergo oxidation. According to research by Manuhara et al. (2009), sausage wrapped in edible film with added ginger extract had a lower free fatty acid value. This shows that adding natural antioxidants can reduce the breakdown of fat in the product. This antioxidant edible film can also be applied to jelly candies because, apart from being edible, antioxidant edible films can help prevent a decrease in the quality of the candy from going rancid (Nuansa et al., 2017).

Effectivity Index

The value of the effectivity index of edible film sodium caseinate with supplementation by sappan wood was shown in Table 6. Determination of the best treatment value with this method begins with assigning a weighted value with the largest value to the observation variable that is the author's goal. Then followed by the weighting of other variables. After the analysis, the largest value indicates the best treatment value. The 1st level of variable value is the antioxidant activity assessed based on this study's urgency and its functional properties when applying edible film to a product, which aims to protect the product from quality degradation. Second, the thickness parameter refers to the characteristics of the edible film in the Japan Industrial Standard (JIS). Solubility, water holding capacity, and color are based on ease of consumption and food products that can be applied using edible films with specific characteristics.

The highest value of effectivity index was the edible film sodium caseinate with supplementation by 10% sappan wood extract (5.767). The physicochemical characteristics of the edible film was thickness (0.20 mm), solubility (24.421%), color L* (79.0) a* (8.3) b* (32.8), water holding capacity (6.863 g/g), and antioxidant activity (24.170%).

CONCLUSION

The best physicochemical characteristics of edible film sodium caseinate with the supplementation of sappan wood extract at a concentration of 10% with characteristics of 0.20 mm thickness, 24.421% solubility, color L* (79.0) a* (8.3) b* (32.8), Water Holding Capacity of 6.863 (g/g), and antioxidant activity of 24.170%.

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Table 1. Edible Film Sodium Caseinate Thickness

Sappan Wood Extract (%)	Thickness (mm)
0	0.14 ± 0.057
2.5	0.15 ± 0.032
5	0.17 ± 0.032
7.5	0.18 ± 0.051
10	0.20 ± 0.025

Table 2. Edible Film Sodium Caseinate Solubility

Sappan Wood Extract (%)	Solubility (%)
0	20.219 ± 0.880[a]
2.5	21.793 ± 2.447[ab]
5	23.037 ± 1.443[ab]
7.5	23.096 ± 2.273[ab]
10	24.421 ± 1.571[b]
HSD 5% = 3.552	

Note: Numbers followed by different letters show a significant difference in the 5% HSD test

Table 3. The Color of Edible Film Sodium Caseinate

Sappan Wood Extract (%)	L*	a*	b*
0	87.2 ± 2.781[a]	1.1 ± 0.273[a]	9.0 ± 0.432[a]
2.5	86.4 ± 1.806[a]	1.6 ± 0.257[b]	10.7 ± 1.547[a]
5	84.9 ± 2.161[a]	2.9 ± 0.751[c]	18.8 ± 1.025[b]
7.5	80.5 ± 2.180[b]	7.0 ± 0.359[d]	31.2 ± 2.409[c]
10	79.0 ± 2.650[b]	8.3 ± 0.091[d]	32.8 ± 4.840[c]
HSD 5% =	4.333	0.758	4.458

Note: Numbers followed by different letters show a significant difference in the 5% HSD test

Table 4. Edible Film Sodium Caseinate Water Holding Capacity

Sappan Wood Extract (%)	WHC (g/g)
0	8.091 ± 0.923
2.5	7.773 ± 0.484
5	7.488 ± 0.407
7.5	7.370 ± 0.423
10	6.863 ± 0.758

Table 5. Antioxidant Activity of Edible Film Sodium Caseinate

Sappan Wood Extract (%)	Antioxidant Activity (%)
0	1.678 ± 0.180[a]
2.5	7.938 ± 0.288[b]
5	18.566 ± 1.384[c]
7.5	22.020 ± 0.516[d]
10	24.170 ± 0.644[e]
HSD 5% = 1.484	

Note: Numbers followed by different letters show a significant difference in the 5% HSD test

Table 6. Effectivity Index of Edible Film Sodium Caseinate

Sappan Wood Extract (%)	NP
0	1.167
2.5	1.923
5	3.463
7.5	5.131
10	5.767

Figure 1. Edible film with different Sappan wood concentrations