The Evaluation of Pectin Concentration and Heat Treatment on Physical Properties of Banana Peel Pectin Edible Coating

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Abstract. Edible coating from banana peel pectin is one of the alternative packagings that utilizes organic compounds to preserve food quality. The research was conducted to study the characteristics of banana peel pectin coating with different concentrations of pectin (0.5%, 1%, 1.5%, 2%, and 2.5%) and heat treatment added during the processing. The research showed a significant difference from the different concentrations of pectin on the parameters which correlate with the amount of total solid dissolved in the coating. The difference concentration showed an increase in thickness value from 0.033 ± 0.0005 to 0.106 ± 0.001 mm and a decrease in transmittance value from 73.75% to 53.6%. Meanwhile, heat treatment showed insignificant differences (except the light transmittance) in several physical properties where the heat treatment only contributes to the dispersion interval of the pectin. The research concluded that banana peel pectin was one of the potential alternatives for fabricating edible film.

1 Introduction

Food packaging is one of the essential aspects in the food industry due to its usability for preserving the quality and shelf life of food from environmental causes. Until now, much research around alternative packaging, which gives more benefit to food quality, has been developed, and one of them is edible coating. Edible coating, especially the natural one, utilizes organic compounds such as polysaccharides, lipids, and protein which are biodegradable as the primary matrix for maintaining the structural compound of the edible coating. Besides that, each natural compound has its chemical structure, which gives distinctive properties such as reducing water transfer, enhancing material strength, or controlling the flow of gases when produced into coatings [1,2].

Polysaccharide, especially pectin, as one of the compatible natural base ingredients, has been researched and developed in the edible coating. Pectin is a soluble biopolymer derived

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from fruits and vegetables and is primarily available in abundance on fruit peel. Pectin is utilized in the food industry as a stabilizer, thickener, and gel-making due to its structure of β-1,4-linked α-galacturonic acid. Due to its structure, the edible coating made by pectin is found to enhance the mechanical structure of the coating and is excellent in controlling the flow of gasses, especially oxygen [3,4].

Although most pectin is extracted through fruits and vegetables, different extraction materials also produce different characteristics of the edible coating. One of the factors that influence the characteristic of the coating is the degree of methyl-esterification (DM) which is indicated by the amount of moles of methanol in the galacturonic acid structure. DM of pectin can be classified into two types of low DM (<50%) and high DM (>50%) which different materials could have different DM values [4]. Earlier studies found that pectin with a higher DM value has more favorable and excellent mechanical, water barrier, and thermal stability properties than low DM value pectin [5]. Other than DM, heat treatment on pectin also could contribute to the structure of the edible coating due to the degradation of the pectin chain structure [6,7].

Banana peel is the most common waste material in the food industry utilizing bananas as the main ingredient. However, studies show that banana peel contains a high amount of pectin, which shows potential as the main matrix of the edible coating [8]. Research found that pectin in banana peel is categorized as pectin with high DM values, around 63,15% and 72,03% which are higher than conventional pectin from fruit. Because of that, it's possible that the coating made from banana peel pectin may have excellent properties, which are expected in the edible coating. Other than that, the development and usage of banana peel for edible coating are also expected to reduce the banana peel waste often found in the food industry [9].

The research aims to study the characteristics of banana peel pectin as the main ingredient of edible coating. The study was conducted by analyzing the edible film on five levels of concentration (0.5%, 1%, 1.5%, 2%, and 2.5%) and the effect of heat treatment on the properties of the edible film. The study aims to provide scientific information and a better understanding of the characteristics of banana peel pectin when applied to the edible coating.

2 Methods

The research is mainly conducted in the Laboratory of Chemistry at Bina Nusantara University. The materials used in the edible coating making are banana peel pectin which was purchased in the local marketplace and glycerol as a plasticizer with a concentration of 30% of pectin weight (w/w). The variable in this research was divided and arranged from two factors with two replications. The first factor was the concentration of the banana peel pectin, which was divided into three levels (0.5%, 1%, 1.5%, 2%, and 2.5%) (w/w). The second factor was the heat treatment during the process, which was divided into two levels (no heat treatment and heat treatment at 80℃).

The making of edible coating started with adding the materials (pectin, glycerol, and aqua dest) into the glass beaker. The mix was stirred until homogenized with no heat involved in the no heat treatment meanwhile for coating with the heat treatment was heated at 80℃. The homogenized coating was indicated with a clear solution without spotting left from the pectin. Then, 25 mL of the mixed solution was molded into a silicone mold (8 cm x 8 cm x 2 cm) and dried using a Food Dehydrator at 35℃ for 24 hours. The edible film's final product was removed from the mold and analyzed further from several parameters.

The method analysis of the edible coating was mainly referred to as the research method [10]. The physical properties of the edible coating were analyzed from several parameters such as thickness, color properties, and light transmittance. The thickness of the film was measured using a Digital Micrometer (Mitutoyo Micrometer, Japan) from five different spots of the sample. The color properties of the film were measured by Portable Colorimeter (Colorimeter CS-10) with the film prepared on a standard white plate. The color measurement is conducted from five different spots per sample using CIE L*, a*, b*, and ΔE color methods. The value of ΔE can be obtained using the following formula below:

$$\Delta E = \sqrt{(L_0 - L^*)^2 - (a_0 - a^*)^2 + (b_0 - b^*)^2} \quad (1)$$

In this case, the value of L0, a0, dan b0 refers to the reading of the white standard, while the value of L*, a*, dan b* refers to the reading of the sample.

For the light transmittance analysis, the film is attached to the cuvette and measured using a UV-Vis spectrophotometer (Genesys 10 Spectrophotometer) within the wavelength range of 200-800 nm. Data from each parameter were analyzed using Analysis of Variant (ANOVA) followed by post hoc testing using the Fischer LSD method with a significance level of 5% (a= 0.05%) using Minitab 19 Software.

3 Result and Discussion

3.1 Thickness

The thickness parameter in edible coating is one of edible film's most important physical properties of edible film. Thickness as a base parameter affects other parameters, such as the rate of water vapor, the exchange rate of gas, and the tensile strength [11]. Studies showed that the ideal thickness of the edible coating is generally a thin layer of coating with a value lower than 0.25 mm [12]. The thickness value of each factor is presented in Fig. 1. The graph shows that the lowest concentration of 0.5% produces the lowest thickness value of 0.033 ± 0.0005 mm; meanwhile, the highest concentration of 2.5% produces the highest thickness value of 0.106 ± 0.001 mm. From the result, the data were analyzed using ANOVA and showed that the interaction between heat treatment and concentration is not significant on the thickness of the edible coating. However, the different concentrations of pectin showed a significant difference in the thickness of the edible coating besides the thickness between 1% and 1.5% concentration. The results above show that a higher concentration of pectin (as the matrix) results in an increased thickness value of the edible coating, which is in line with other studies [8,12,13].

Different concentrations of pectin affect the thickness of edible film due to the different viscosity each concentration produces. Polysaccharide as the base material, especially pectin, shows an increase of viscosity in the solution due to the increase of total dissolved solids in the same volume [14]. Because of the same principle above, pectin in general has been used as a thickener in the food industry. When the edible film is dried, the total dissolved solids as polymers in the solution will constitute the matrix of the film. They will result in increased interaction between polymers bonds with the concentration increased.

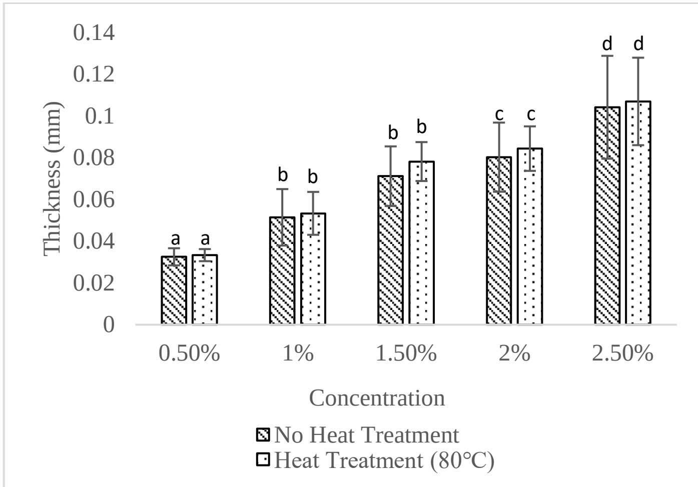


Fig 1. The thickness of the edible coating in different concentrations. Different letters indicate a significant difference at $P < \alpha$ ($\alpha = 0.05$).

3.2 Color

One of the parameters which greatly affected by the number of total solids inside the edible coating is color properties. In this research, the color changes in the edible film are observed and calculated using the color parameter of CIE LAB. Each parameter shows different aspects of color, which are translated into numbers. Parameters like L* (lightness), a* (green to red), and b* (blue to yellow) are measured with the value of each parameter processed to obtain the ΔE value. ΔE values are measured to show the composite color difference from the standard white plate. A much higher ΔE value will result in a much more distorted color difference and vice versa [15].

A previous study reported that banana peel pectin had the average color properties of L*= 81.684, a*= 3.06, and b*= 6.942, which results in a light yellowish color [9]. Banana peel pectin contains pigments such as beta-carotene and xanthophyll which primarily contributes to the yellow color banana peel usually gives [16]. Table 1 and 2 show that the value of L*, a*, and b* from pectin concentration treatment which mostly significant ($P < 0.05$) on the difference between the lowest and the highest concentration with some significance on several concentrations between them. The data showed that the increase in pectin concentration results in the increased value of b* and decreased value of L* and a*, resulting in a much darker and more intense yellow color.

Meanwhile, the ΔE value is usually differentiated and compared with the other value of ΔE on different parameters. Research showed that the difference value of $\Delta E < 1$ shows that observers do not notice the difference, the difference value for $1 < \Delta E < 2$ shows that some experienced observers can notice the difference, and $\Delta E > 2$ shows most observers can mostly distinguish the difference between sample [17]. From Table 1 and 2, most of the data show a main difference of $\Delta E > 1$ which shows that some observers can mainly perceive the difference in color on different concentrations of pectin added. The increase of pectin concentration added into the solution results in a higher number of total solids present, especially pigments which contribute to changing and enhancing the color into the color resembling the base matrix (pectin) based on the pigments [18]. Meanwhile, the effect of heat treatment on the color properties mostly is not significant enough ($P > 0.05$), which means that the color does not get affected due to heat treatment mainly only affecting the dispersion of the pectin but not the color properties of the edible film [19].

Table 1. The Color Properties of Edible Coating with No Heat Involved Treatment.

	Concentration	L*	a*	b*	ΔE
No Heat Treatment	0.005	91.74^{a}	1.385^{a}	5.384^{a}	2.037^{a}
	0.01	91.334^{ab}	1.052^{b}	8.009^{b}	4.701^{b}
	0.015	90.691^{b}	0.854^{bc}	9.533^{c}	6.347^{c}
	0.02	90.417^{b}	0.595^{cd}	11.282^{d}	8.128^{d}
	0.025	90.402^{b}	0.454^{d}	13.101^{e}	9.91^{e}

Table 2. The Color Properties of Edible Coating with Heat Involved Treatment.

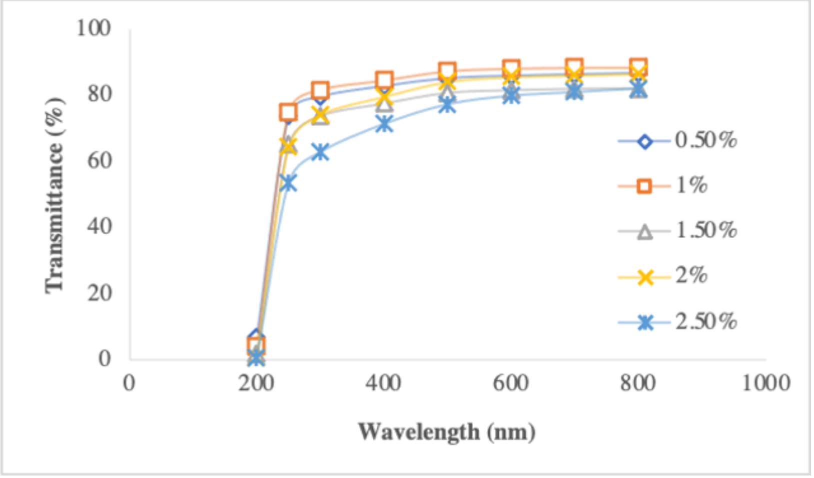
	Concentration	L*	a*	b*	ΔE
With Heat Treatment	0.005	91.268^{ab}	1.18^{a}	6.875^{a}	3.614^{a}
	0.01	91.382^{a}	1.18^{a}	6.502^{a}	3.228^{a}
	0.015	90.635^{bc}	0.792^{b}	9.105^{b}	5.963^{b}
	0.02	90.217^{c}	0.733^{b}	10.403^{b}	7.322^{b}
	0.025	89.243^{d}	0.654^{b}	12.677^{c}	9.777^{c}

3.3 Light transmission

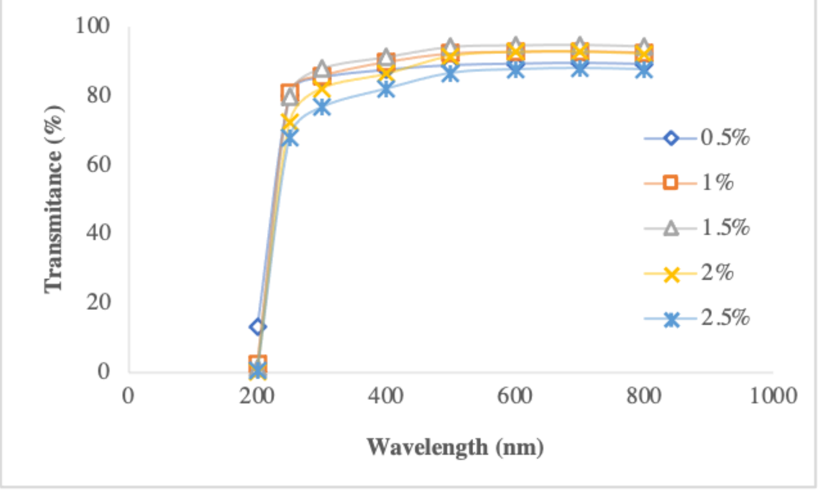
Light transmittance is a parameter that determines the film's ability to reflect UV light (100-380 nm) and Visible light (380-800 nm). The transmittance is defined by the amount of light that passes through the film in a particular wavelength [20]. A lower transmittance value indicates that a low amount of light passes through the film, which helps prevent light damage to the food substance. It is due to certain organic substances in food that can undergo an oxidation process from specific wave lengths of light which correlates with the decline of food quality [21]. Previous reports stated that AFM is a highly effective technique for evaluating film surface roughness at the nano-scale level, both qualitatively and quantitatively [7]. These surface properties are directly influenced by irregularities, which are often caused by the incorporation of other materials.

The light transmittance values of each factor and treatment are shown in Fig. 2. From each concentration, the data shows that a higher concentration of pectin results in a lower transmittance value. Coating with the concentration of 2.5% of banana peel pectin shows the lowest transmittance value between 53.6% and 82.1% (in wavelength order), which correlates with coatings that can block more light than other coating does in different concentrations. Meanwhile, the lower concentration of 0.5% of banana peel shows the highest transmittance value between 73.75% and 86.6% (in wavelength order). Meanwhile, for wavelength, banana peel pectin generally shows the lowest transmittance value at 200 nm (UVC) but an increase of transmittance value in the increase of wavelength, especially in the visible light range. The highest transmittance value on both treatments is seen in the wavelength of 700-800 nm.

The decrease of transmittance value in higher pectin concentrations occurs due to the high total dissolved solid present in much higher concentrations. An earlier study shows that higher pectin concentration results in a much higher total dissolved solid resulting in a much thicker film [21,22]. The total dissolved solid in the film most likely absorbs a high amount of light, especially in much lower wavelengths [23]. Other than that, the other factor that could affect the transmittance value is the heat treatment of the pectin. Heat treatment on pectin usually results in the degradation of the pectin chain, which affects the structure of the matrix resulting in a much porous and scattered structure [19]. Because of that, the effect of the structure then decreases the light transmittance on the edible coating with heat treatment.



(a)



(b)

Fig. 2. Light transmittance of the edible coating on different concentrations and different heat treatments at 25°C (a) and 80°C (b)

4 Conclusion

Banana peel pectin has the potential as the base matrix of the coating on several parameters. Each factor in the making of banana peel pectin coating shows significant differences in parameters, such as thickness, color properties, and light transmission. On the concentration of banana peel pectin treatment, the different concentration shows a significant difference and affect each parameter due to higher concentration correlating with higher total solid content inside the solution. Meanwhile, for heat treatment, the heat involved during the process making of the coating is mostly not significant enough (except for the light transmission) on several parameters because of mostly heat only involves quick dispersion of the pectin but does not change most of the pectin properties. The data from this study concludes that edible coating with banana peel pectin has the potential as the main matrix of edible coating.

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