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Environmental friendly packaging based on rice liquid as edible film: a feasibility study

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Abstract: Rice liquid is the water obtained from the process of washing rice. This waste is easy to get because Indonesian people tend to eat rice as their main staple food which results in a lot of rice liquid. The rice liquid waste can be used as the main ingredient of an edible film. This study aims to determine the effect of the addition of sorbitol concentration on the characteristics of the edible film from rice liquid waste which includes thickness, tensile strength, elongation and water vapor transmission rate. The method used in this study is one-way ANOVA completely randomized design (CRD) with 3 variations of sorbitol concentrations, they are: 2%, 4%, and 6% and was carried out three times. The data obtained from the research were then analyzed at a significant level of $P \leq 0.05$. The parameters tested include thickness, tensile strength, elongation and water vapor transmission rate. The research data shows that the thickness values obtained are between 0.01367 mm - 0.2453 mm, tensile strength values range from 180.61 $kgf.cm^{-2}$ -159.28 $kgf.cm^{-2}$, elongation between 190.613% - 186.920%, and water vapor transmission rates between 1.3004 $g.m^{-2}.h^{-1}$- 4.6444 $g.m^{-2}.h^{-1}$. The addition of sorbitol variation does not have significant effect ($P>0.05$) on the tensile strength, elongation and water vapor transmission rate, but had a significant effect ($P \leq 0.05$) on the thickness of the edible film. A good variation of sorbitol by producing a good edible film made from rice liquid waste is a variation of sorbitol with a sorbitol concentration of 2%.

1. Introduction

Waste is residue in the form of materials or liquids that are no longer used and disposed of by the producer. The waste disposal as it is now will cause problem for the society who does not want it due to its negative impact on the surrounding environment. The increasing amount of waste is the impact of human activities, for example: the results of disposal from household activities, industrial activities, and transportation activities. Therefore, the waste must be managed to minimize the negative impact it causes.

Indonesia is a country where the majority of the population consumes rice as a staple food; rice contains high levels of carbohydrates and is useful for the energy needs. In the process of cooking rice, people tend to wash the rice first, thus producing rice washing water. The majority of the population usually will immediately throw away the water from washing the rice without knowing there are other benefits to the rice washing water waste. Whereas in the rice washing water contains a lot of organic compounds, such as vitamins and carbohydrates which can still be utilized [1]. The starch type carbohydrates contained in rice washing water are as much as 85-90% in rice with cracked skin [2].

Edible films are renewable because they are formed from environmentally friendly materials that can be used as food packaging which can make the quality of a product last and minimize environmental pollution. In making edible films, stabilizers such as sorbitol must be added. Sorbitol and glycerol which functions as an emulsifier, CMC (Carboxymethyl Cellulose) is added because it can make the appearance much better than the packaging produced [3]. This study aims to determine the effect of sorbitol concentration on the characteristics of edible film from rice washing water waste or rice liquid.

2. Materials and methods

2.1. Materials

This research was conducted at the Laboratory of Food and Agricultural Product Analysis, Department of Agricultural Product Technology, Faculty of Agriculture, Syiah Kuala University, Material Physics Laboratory, Department of Physics, Faculty of Mathematics, Natural Sciences, Syiah Kuala University and the Institute for Industrial Research and Standardization, Banda Aceh. The equipments used in this study are: scissors, measuring pipette, petri dishes, spatula, hotplate, magnetic stirrer, oven, thermometer, Teflon, analytical scales, desiccator, filter cloth, cutter, ruler, screw micrometer, Teflon, measuring cup, beaker glass, stainless steel, stopwatch, and tensile strength test equipment (Autograph Type-HT 8503 Hung Ta brand). The materials used in this study include rice liquid, distilled water, sorbitol, silica gel, acetic acid, Carboxy Methyl Cellulose, wipes, and gloves.

2.2. Methods

2.2.1. The Preparation of Rice Liquid. Before the rice liquid is used as a mixture for making edible film, first the rice liquid to be used is filtered to produce a clean solution, and place it in a container.

2.2.2. The process of making carboxy methyl cellulose (CMC) solution. The process of making Carboxy Methyl Cellulose (CMC) solution begins with, powdered Carboxy Methyl Cellulose (CMC) poured it into a petri dish, then weighed as much as 2 g using an analytical balance. Furthermore, 40 ml of distilled water is poured gradually and stirred it gradually by using stainless to dissolve Carboxy Methyl Cellulose (CMC) so that the CMC powder dissolves and becomes lumps then put it into the beaker glass.

2.2.3. The process of making edible film solutions. In the process of making edible film solution, there are several ingredients that must be mixed into one, namely a solution of Carboxymethil Cellulose (CMC) which is still clotted, add 140 ml of distilled water, then add 20 ml of rice liquid. The next step is that the edible film solution is heated on a hot plate until it reaches a temperature of 700 C. After the heat of the edible film solution is cooled for 1 hour, then the sorbitol solution is added according to the concentration (2%, 4%, 6%), each addition of sorbitol is stirred for ± 5 minutes until a thick, clear solution is obtained.

2.2.4. Edible film printing process. The edible film solution poured into a mold, and then the edible film solution was dried in an oven at 65 oC for 15 hours, and then placed it into a desiccator for 15 minutes to cool it down. The next stage is an analysis which includes a thickness test [4], a water vapor transmission test [5], a tensile strength test [6], an elongation test [6].

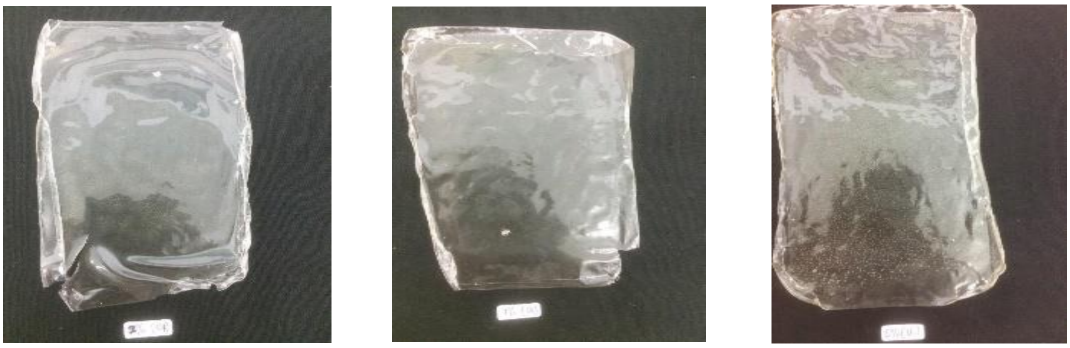
2.3. Data analysis

This study used a non-factorial completely randomized design (CRD) method. The sorbitol concentration factor consisted of 3 levels, namely S1 = 2%, S2 = 4% and S3 = 6% of the total volume of the film-making solution. With 3 treatments and 3 repetitions in order to obtain 9 experimental units, then the research data obtained was analyzed using One-way ANOVA and Least Significance Different (LSD) test at a significant level of $P \leq 0.05$. All data were analyzed using SPSS (Package for Social Sciences) software ver.24.

3. Results and discussion

3.1. Edible film characteristics

The carbohydrate content was first analyzed before the rice liquid is processed into edible films. This analysis was carried out in order to see whether the rice liquid contains the basic components for making edible films. The results of the analysis showed that the rice liquid contains carbohydrates of 0.33%. Thus, the rice liquid is suitable for making edible films. The characteristics of edible film packaging can be seen in the following figure.



a b c

Figure 1. Packaging of edible film produced based on differences in sorbitol concentrations; (a) sorbitol 2%; (b) sorbitol 4%; (c) 6% sorbitol.

3.2. Thickness of edible film

The mean value of edible film thickness at various concentrations of sorbitol resulted in different thickness values: 0.1367 mm, 0.17867 mm, and 0.2453 mm, as shown in Figure 2.

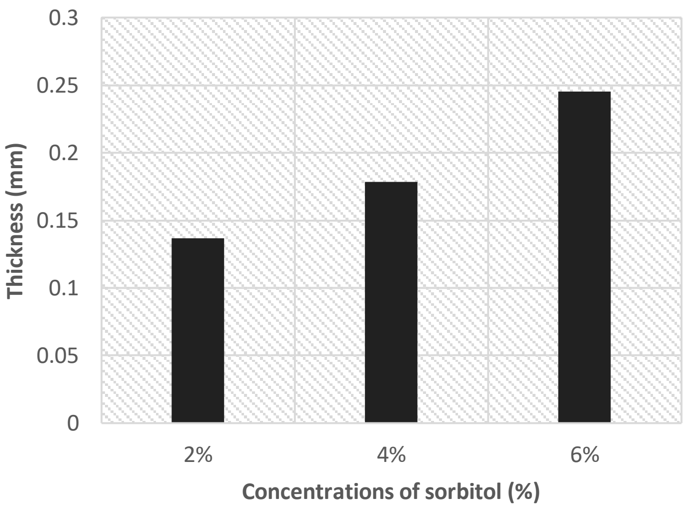


Figure 2. The concentration of sorbitol towards the mean thickness of edible film.

The picture above shows that the greater the sorbitol concentration the thicker the edible film produced. [7] stated that if the plasticizer concentration is added, it can make the polymer in the preparation of the film matrix experience a total of solids which increases in the dissolved film solution, so that the edible film increases its thickness. The edible film thickness produced is good because it is below the maximum level. The thickness of the edible film according to the Japanese

Industrial Standard is a maximum of 0.25 mm. The difference in the thickness value of edible film with previous research conducted by [8], on the use of chitosan sago starch as the basic ingredient by having a volume of solution and mold with the same area with a thickness value between 0.40-0.50 mm, but the thickness value in this study is 0.1367-0.2453 mm which is classified as much lower but has met the predetermined standards. The results of the one-way ANOVA variance analysis and the results of the Least Significance Different (LSD) advanced test are as in Table 1.

Table 1. Results of one-way Anova dan LSD post hoc tests with significant level 5% for thickness of edible film.

Treatments		Significant	
		One-way ANOVA	LSD
Sorbitol 2%	Sorbitol 4%	0.000	0.004
	Sorbitol 6%		0.000
Sorbitol 4%	Sorbitol 2%		0.004
	Sorbitol 6%		0.000
Sorbitol 6%	Sorbitol 2%		0.000
	Sorbitol 4%		0.000

The table above shows that the results of the one-way Anova analysis have a significant effect on the thickness of the edible film. The results of LSD further test showed that the 2% sorbitol concentration was significantly different from the 4% sorbitol and 6% sorbitol concentrations. Likewise, the 4% sorbitol and 6% sorbitol concentrations were significantly different from the other sorbitol concentrations.

3.3. Water vapor transmission rate (WVTR) of edible film

The average value of edible film water vapor transmission based on different sorbitol concentration variations ranged from 1.3004 $g.m^{-2}.h^{-1}$- 4.6444 $g.m^{-2}.h^{-1}$, can be seen in Figure 3.

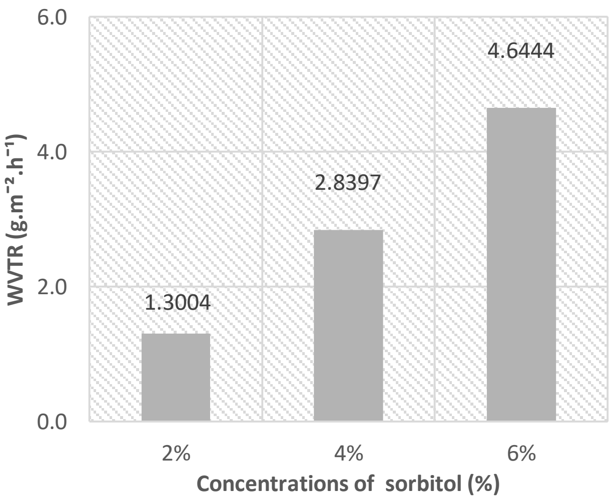


Figure 3. Concentration of sorbitol to average WVTR value of edible film.

Figure 3 shows the water vapor transmission rates obtained are: 1.3037 $g.m^{-2}.h^{-1}$, 2.8397 $g.m^{-2}.h^{-1}$, and 4.6444 $g.m^{-2}.h^{-1}$. The results obtained from this study are not good because the standard has not been met based on the Japanese Industrial Standard [9] which is the maximum value of the water vapor transmission rate is 10 $g.m^{-2}.h^{-1}$. This is because the type of plasticizer used is sorbitol. Sorbitol is a polyhydric alcohol monosaccharide compound that is hydrophilic, the increase in hydrophilic components contained in the film will cause the film to be easily penetrated by water vapor and cause the water vapor transmission rate to increase. This is in accordance with Farida [10] that sorbitol is hydrophilic or able to increase water and soften the surface of the film. The results of the one-way ANOVA variance analysis and the results of the Least Significance Different (LSD) further test are as in Table 2.

Table 2. Results of one-way Anova dan LSD post hoc tests with significant level 5% for WVTR of edible film.

Treatments		Significant	
		One-way ANOVA	LSD
Sorbitol 2%	Sorbitol 4%	0.396	0.552
	Sorbitol 6%		0.193
Sorbitol 4%	Sorbitol 2%		0.552
	Sorbitol 6%		0.435
Sorbitol 6%	Sorbitol 2%		0.193
	Sorbitol 4%		0.435

The table above shows that the results of the Anova one-way analysis have no significant effect on WVTR edible film. The results of LSD further test showed that the 2% sorbitol concentration was not significantly different from the 4% sorbitol and 6% sorbitol concentrations. Likewise, the 4% sorbitol and 6% sorbitol concentrations were not significantly different from the other sorbitol concentrations. That is, all treatments give the same response to WVTR of edible film.

3.4. Tensile strength of edible film
Tensile Strength is a maximum tension that can be held by the film until the film is torn or broken, which aims to find out how strong the film can hold the material to be packaged. The average tensile strength of the edible film based on different sorbitol concentration variations is shown in Figure 4.

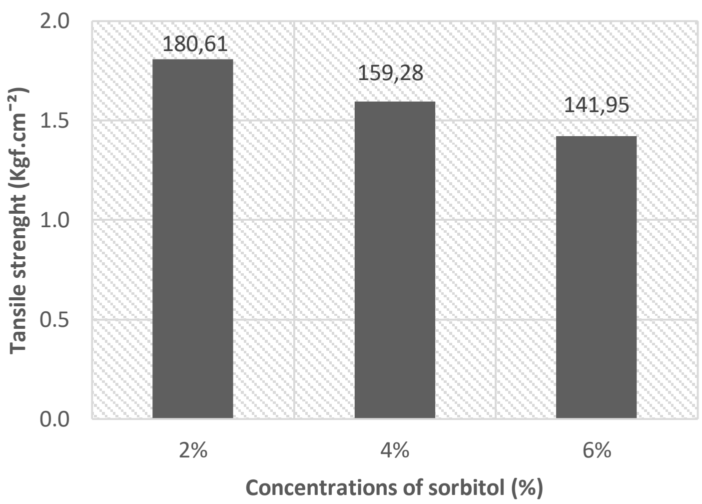


Figure 4. The concentration of sorbitol towards the average value of tensile strengths of edible film.

In Figure 2, it can be seen that the tensile strength values obtained are 180.61 kgf.cm^{-2}, 159.28 kgf.cm^{-2} and 141.95 kgf.cm^{-2}. The results in this study have met the standard of tensile strength values based on the Japanese Industrial Standard [9], which is a minimum value of 3.92 Mpa (40 kgf.cm^{-2}). [11] stated that the plasticizer molecules will be evenly dispersed at a saturation point and interact between the structures between the polymers and will make it difficult to move a polymer chain. However, if the sorbitol concentration is added again it will cause the tensile strength value to decrease because the excess plasticizer molecules are in a separate phase because the saturation point is exceeded in an edible film solution, so it will reduce the intermolecular force between the chains and make the chain more free and the film is getting more elastic. The results of the one-way ANOVA variance analysis and the results of the Least Significance Different (LSD) further test are as in Table 3.

Table 3. Results of one-way Anova dan LSD post hoc tests with significant level 5% for tensile strenght of edible film.

Treatments		Significant	
		One-way ANOVA	LSD
Sorbitol 2%	Sorbitol 4%	0,329	0,401
	Sorbitol 6%		0,153
Sorbitol 4%	Sorbitol 2%		0,401
	Sorbitol 6%		0,490
Sorbitol 6%	Sorbitol 2%		0,153
	Sorbitol 4%		0,490

The table above shows that the results of the Anova one-way analysis have no significant effect on the tensile strength of edible film. The results of LSD further test showed that the 2% sorbitol concentration was not significantly different from the 4% sorbitol and 6% sorbitol concentrations. Likewise, the 4% sorbitol and 6% sorbitol concentrations were not significantly different from the other sorbitol concentrations. That is, all treatments give the same response to tensile strength edible film.

3.5. Elongation of edible film

Elongation is the percentage of film elongation that is calculated when the film will be cut off when it is pulled. The average elongation value of edible film can be seen in Figure 5.

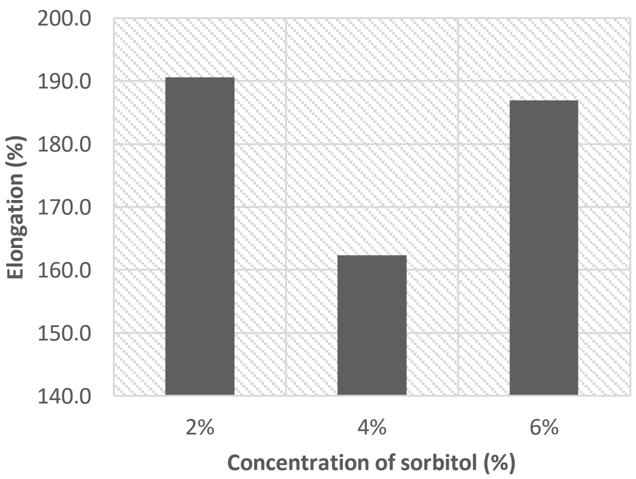


Figure 5. Concentration of sorbitol to the average value of the elongation value of edible film.

The picture above shows that the edible film elongation value produced by the addition of 2%, 4% and 6% sorbitol are: 190,613%, 162,373%, and 186,920%. These results have met the standard for the elongation value of edible film according to (JIS), which is a minimum elongation value of 70%. Lukasik and Ludesher [12], Plasticizer can reduce the activation energy for the movement of molecules in the matrix. The less moving molecules will increase the elasticity of the edible film, so that sorbitol with an increased concentration up to a certain point can make the elongation increase. In addition, the addition of a plasticizer is very important so that the resulting film is not easily brittle. The results of the one-way ANOVA variance analysis and the results of the Least Significance Different (LSD) further test are as in Table 4.

Table 4. Results of one-way Anova dan LSD post hoc tests with significant level 5% for elongation of edible film.

Treatments		Significant	
		One-way ANOVA	LSD
Sorbitol 2%	Sorbitol 4%	0.576	0.351
	Sorbitol 6%		0.899
Sorbitol 4%	Sorbitol 2%		0.351
	Sorbitol 6%		0.413
Sorbitol 6%	Sorbitol 2%		0.899
	Sorbitol 4%		0.413

The table above shows that the results of the one-way Anova analysis have no significant effect on the elongation of edible film. The results of LSD further test showed that the 2% sorbitol concentration was not significantly different from the 4% sorbitol and 6% sorbitol concentrations. Likewise, the 4% sorbitol and 6% sorbitol concentrations were not significantly different from the other sorbitol concentrations. This means that all treatments give the same response to the elongation of edible films. The MLP method was utilized to predict quality of nutmeg. This method employed six inputs as above-mentioned, and chooses two hidden layers as the best layers. The first hidden layer has five nodes, and the second hidden layer has four nodes. Table 4 displays the percentage of classification of nutmeg quality, in average, which able to classify 99.2% of accuracy for data training and 100% for data testing, respectively. These results are similar to that found in Dinar et al. [5] who stated the accuracy of nutmeg classification was 100%. In contrast to earlier findings, however, greater input nodes and hidden layers were utilized in this study. Whereas, more input nodes and hidden layers tend to be more steady result.

4. Conclusions

Rice washing water waste or rice liquid can be used in making edible films, apart from being easy to obtain, it is also friendly to the environment. The variations in the 2%, 4%, and 6% sorbitol concentrations have no significant effect on the tensile strength, elongation and water vapour transmission rates to the thickness of the edible film. The best characteristic of edible film is edible film that has a sorbitol concentration of 2% compared to edible with a sorbitol concentration of 4%, and 6%, with a thickness value of 0.1367 mm, a tensile strength value of 180.61 $kgf.cm^{-2}$, an elongation value of 190.613%, and a water vapour transmission value. 1.3037 $g.m^{-2}.h^{-1}$.

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