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Characteristics of Edible Film from Rice Bran Starch as Affected by the Concentration of Sorbitol Plasticizer

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ABSTRACT

Edible films made from starch have disadvantages, namely they are brittle so they are easily broken and hydrophilic. The manufacture of starch-based edible films basically uses the principle of gelatinization. The purpose of this study was to make edible film from rice bran, and to examine the effect of concentration of plasticizer (sorbitol) and gelatinization time on the characteristics of the edible film. The process chosen in this study is Steam Boiler with the advantage that it can optimize the gelatinization of rice bran starch and takes 22 minutes at a temperature of 65°C - 70ºC. The percentage of solubility of edible films ranges from 48 – 75%. The results of the analysis of the variance of the treatment effect on the solubility level of the edible film at 6 hours of immersion showed that the treatment concentrations of 3%, 4% and 5% had no significant effect on the percentage of the solubility of the edible films. Meanwhile, the 6% and 7% sorbitol concentrations had a greater effect than the 3%, 4% and 5% concentrations. The results of the biodegradability test showed that the biodegradable film from rice bran starch treated with the concentration of sorbitol that was stockpiled in the soil could be degraded after stockpiling in the soil for 18 days, which was marked by damage to the biodegradable film sheet. Edible film with 3% sorbitol concentration has the lowest water vapor transmission rate compared to other edible films, which is -0.27 %. The highest water vapor transmission rate was found in edible film with 6% sorbitol concentration.

Keywords: edible film, plasticizer, rice bran, sorbitol, starch

1. Introduction

Rice bran is the husk of rice and in the milling process the husk will be released [1] [2]In each rice milling process, 8-10% rice bran is produced, 30% husks and 70% rice. Rice bran contains carbohydrates which are quite high, namely 53.29% [2][3]. Due to the high carbohydrate content, rice bran is used as a raw material in the manufacture of edible films. Thus, the use of bran for the manufacture of edible films can be used as an alternative to increase the economic value of the bran.Edible films can be made from various materials including polysaccharides, proteins, lipids or also by combining all three [4]Starch is one type of polysaccharide with physical characteristics similar to plastic but such as colorless, odorless, and tasteless. Starch is often used in the food industry as a biodegradable film to replace plastic polymers because it is economical, renewable, and provides good physical characteristics. The manufacture of starch-based edible films basically uses the principle of gelatinization. With the addition of a certain amount of water and heated at a high temperature, gelatinization will occur. Gelatinization causes amylose bonds to tend to be close to each other because of hydrogen bonds. The drying process will cause shrinkage as a result of the release of water, so the gel will form a stable film [3]The manufacture of edible films from starch has been done by many researchers, including using palm starch, corn, sweet potatoes, taro, breadfruit and many others [5] Rice bran in the by-product of rice milling has the main carbohydrate content with the percentage of hemicellulose (8.7-11.4 %), cellulose (9-12.8%), starch (5-15%), and -glucan (1%) [2]. Edible films made from starch have disadvantages, namely they are brittle so they break easily and are hydrophilic (very sensitive to water) so that edible films are less flexible .Therefore, to improve the weakness of edible films made from starch, it is necessary to add glycerol or sorbitol as a plasticizer to make it more elastic [6]. Plasticizers are low molecular weight organic materials added with the intention of weakening the rigidity of the polymer, while increasing its flexibility and extensibility. Several types of plasticizers that can be used in the manufacture of edible films are glycerol, beeswax, polyvinyl alcohol, sorbitol and others [3]The purpose of this study was to make edible film from rice bran, and to examine the effect of concentration of plasticizer (sorbitol) and gelatinization time on the characteristics of the edible film.

Starch is a starch from carbohydrates with a glucose polymer compound consisting of two main components, namely amylose and amylopectin. Starch is one of the basic ingredients in the manufacture of edible films which are classified as polysaccharides. Polysaccharides have very hydrophilic properties so that when used as ingredients in the manufacture of edible films, they produce poor water vapor and gas inhibition properties, but polysaccharides can inhibit the loss of moisture from food products. In addition, polysaccharides can be used to provide thickness and viscosity to edible film solutions [7]. According to [5] rice bran has the following composition:

Table 1. Composition of rice bran starch product

Component	%weight[a]
Starch	84.24
Fiber	5.76
Protein	0.66
Ash	9.23

[a] Dry Basis [8]

In addition, rice bran is known to have the main carbohydrate content, namely hemicellulose (8.7-11.4%), cellulose (9-12.8%), starch (5-15%), and -glucan (1%). With a high starch content, rice bran has the potential to be used as a raw material for making edible films[9]. Edible films made from starch have disadvantages, namely they are brittle so they break easily and are hydrophilic (very sensitive to water) so that edible films are less flexible [6] Therefore, to improve the weakness of edible films made from starch, it is necessary to add glycerol [3] or sorbitol as a plasticizer to make it more elastic [10]

In the process of making edible films, additional materials are needed, namely stabilizers which function to stabilize, concentrate and thicken as well as plasticizers which are emulsifiers which can avoid cracking during the handling and storage process. The stabilizer commonly used is chitosan while the plasticizer commonly used is sorbitol.

The addition of sorbitol as a plasticizer in the manufacture of edible films so that the permeability of the film to oxygen is reduced, it is also able to reduce the brittleness of the film so that the breaking strength of the film increases [11], [12] The addition of sorbitol is directly proportional to the percentage of strain or elongation, meaning that the greater the addition of sorbitol, the greater the percentage of strain or elongation[13]. The concentration of sorbitol used for the manufacture of edible films if it is too high can increase the thickness and decrease the tensile strength of the edible film.

The factors that affect the manufacture of edible films are:

1. Temperature
   The right temperature will produce edible film with good quality so that when the

edible film is dried it will avoid cracking. In the gelatinization process, the temperature must be considered. According to [12] the effective gelatinization temperature ranges between 65^{o}C-70^{o}C within 22 minutes.

2. Starch concentration

The physical properties of the plastic and the nature of the resulting paste will be greatly influenced by the starch concentration. The thickness of the plastic produced is also influenced by the concentration of starch, where the higher the starch concentration, the greater the number of polymers that make up the plastic matrix so that thick plastic will be produced.

2. Type and concentration of plasticizer

Plasticizers are added to overcome the brittle nature of plastics caused by extensive intermolecular forces. According to [6], [10], [12]the most commonly used polyol plasticizers are glycerol and sorbitol.

Characterization of edible films, among others:

1. Solubility in Water

Solubility analysis in water was carried out to determine the solubility of the edible film by dipping some edible film samples into water for 24 hours.

2. Biodegradabilitas

The biodegradation of edible films can be determined by conducting a soil burial test which aims to determine the rate of sample degradation with various variations, so that it will be seen how long the sample will be decomposed by microorganisms in the soil. how to bury a sample into the soil with a certain soil depth for some time [10]

3. Water Vapor Permeability

Water vapor permeability is the amount of water vapor lost per unit time divided by the area of the film. Therefore, one of the functions of edible films is to resist the migration of water vapor, so its permeability to water vapor must be as low as possible. [12]

2. Material and Methods

2.1. Material

The method used in this study basically uses the gelatinization method in the manufacture of starch-based edible films. With the addition of a certain amount of water and heated at a high temperature, gelatinization will occur. Gelatinization causes amylose bonds to tend to be close to each other because of hydrogen bonds. The drying process will cause shrinkage as a result of the release of water, so the gel will form a stable film [11]

The procedure carried out in the study was as follows: The study was carried out by entering all ingredients according to their composition into a beaker glass with variations in the weight ratio of rice bran starch and water 1:2 and with variations in the concentration of sorbitol plasticizer (1%, 2%, 3%, 4 % and 5%). Then during heating the water temperature is continuously controlled from 65oC - 70oC while stirring. Pour the mixture over a metal mold that has been cleaned with 70% alcohol. Printing is placed in the sun for 2 hours. The edible film is slowly removed from the printer. Further tests were carried out in the form of water solubility test, biodegradability test, and water permeability test.

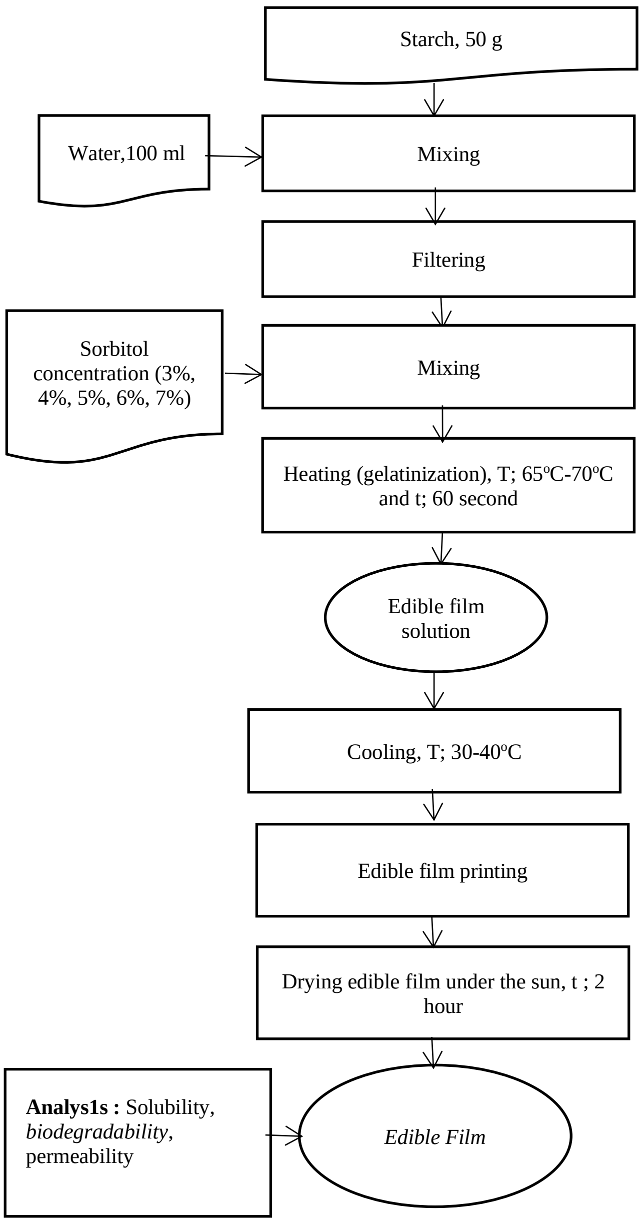

Figure 1. Flow Chart

3. Results and Discussions

3.1.Solubility in Water

Table 2. Solubility in Water

Sample	Sorbitol Concentration (% w/w)	Initial Weight (%w)	Final weight (g)	Time (t)	Solubility in water (%)
1	3%	0,31	0,17	6	48%
2	4%	0,38	0,18	6	53%
3	5%	0,32	0,08	6	56%
4	6%	0,21	0,07	6	67%
5	7%	0,41	0,18	6	75%

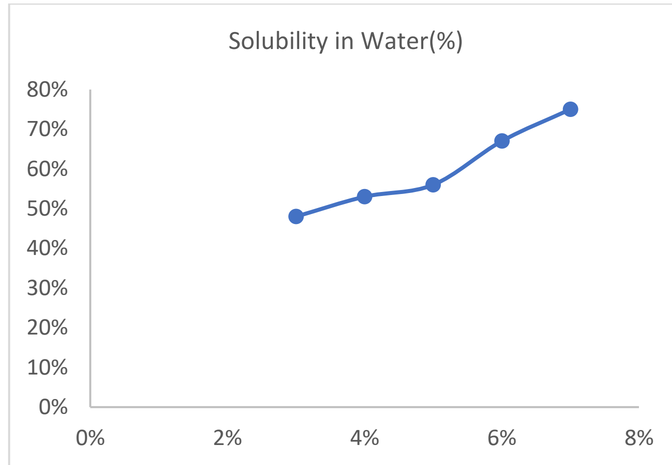

Figure 2. Solubility in Water

Samples data as presented in table 2. show that the concentration of sorbitol significantly affected the solubility of the edible film. The weight lost of edible film is indicated as the total weight of the film dissolved in the water during immersion. The percentage of solubility of edible films ranges from 48 – 75%. The results of the analysis of the variance of the treatment effect on the solubility level of the edible film at 6 hours of immersion show that the sorbitol concentrations of 3%, 4% and 5% had no significant effect on the percentage of the solubility of the edible film. Meanwhile, the 6% and 7% sorbitol concentrations had a greater effect than the 3%, 4% and 5% concentrations. The highest water solubility results were obtained at a 7% sorbitol concentration, which was 75%. Sorbitol is a compound that can dissolve completely in water, so the higher the concentration of sorbitol, the higher the solubility value. (Sobral, Menegalli, Hubinger, & Roques, 2001) reported that increasing the concentration of plasticizers increased the moisture content of the films due to the high hygroscopicity between adjacent macromolecules. The addition of plasticizer to the film solution in addition to increasing the flexibility of the film can also increase the permeability of the film (Parris, 1995), so that water is easier to diffuse in the film. The addition of sorbitol to the film increases the solubility in water. This is because sorbitol has hydrophilic properties. According to Bourtoom (1998), the type and concentration of the plasticizer used will affect the solubility of the starch-based film. The more the use of plasticizers, the more solubility will increase.

According to [7] it was explained that the higher the starch concentration used, the greater the ability of the film to dissolve in water.

3.2. Biodegradability

Table 2. Biodegradability Test Result for 18 days

Samples	Days	Biodegradabilty	Average
1	3	43%	69%
	6	59%	
	11	66%	
	15	77%	
	18	100%	
2	3	25%	54%
	6	40%	
	11	45%	
	15	60%	
	18	100%	
3	3	21%	55%
	6	36%	
	11	50%	
	15	68%	
	18	100%	
4	3	22%	54%
	6	41%	
	11	49%	
	15	66%	
	18	93%	
5	3	28%	63%
	6	51%	
	11	64%	
	15	77%	
	18	95%	

Plastic film biodegradation analysis was carried out through visual observation of the film. Figure 5 shows the visual appearance of the biodegradable film at week 0 which looks 100% intact and has not been visually damaged but has experienced texture damage, namely becoming softer and starting to grow fungus in the first and second weeks. Meanwhile, in the third week after excavation, the observations showed that the biodegradable film had been completely degraded, indicated by the absence of biodegradable film samples in the soil and it was suspected that it had become humus.

The biodegradable film is easy to decompose, because the raw materials used easily interact with water and microorganisms and are sensitive to physico-chemical influences. The rate of biodegradation depends on temperature (50-60^{o}C) humidity, also number and type of microbes. Biodegradation runs fast if all three requirements are met.[14]

The results of variance showed that the addition of different concentrations of sorbitol significantly affected the value of the water vapor transmission rate. The average value of the edible film's water vapor transmission rate is presented in Table 2.

Based on Table 2, it can be seen that edible film with 3% sorbitol concentration has the lowest water vapor transmission rate value compared to other edible films, which is -0.27%. The highest water vapor transmission rate was found in edible film with 6% sorbitol concentration. The rate of water vapor transmission increases with the increase in the concentration of sorbitol. Sorbitol is a monosaccharide polyhydric alcohol compound that is hydrophilic. The increase in hydrophilic components contained in the film causes water vapor to easily penetrate the film thereby increasing the value of the water vapor transmission rate hydrophilic (capable of binding water) and softens the surface of the film so that the addition of sorbitol concentration can increase the value of the water vapor transmission rate.

4. Conclusion

1. In this study, it was shown that the concentration of sorbitol significantly affected the solubility of edible films. The weight of the lost film is indicated as the total weight of the film dissolved in the water during immersion. The percentage of solubility of edible films ranges from 48 – 75%. The results of the analysis of the variance of the treatment effect on the solubility level of the edible film at 6 hours of immersion showed that the treatment concentrations of 3%, 4% and 5% had no significant effect on the percentage of the solubility of the edible film. Meanwhile, the 6% and 7% sorbitol concentrations had a greater effect than the 3%, 4% and 5% concentrations.
2. The results of the biodegradability test showed that the biodegradable film from rice bran starch treated with the concentration of sorbitol that was stockpiled in the soil could be degraded after stockpiling in the soil for 18 days, which was marked by damage to the biodegradable film sheet.
3. Edible film with 3% sorbitol concentration has the lowest water vapor transmission rate compared to other edible films, which is -0.27%. The highest water vapor transmission rate was found in edible film with 6% sorbitol concentration. The rate of water vapor transmission increases with the increase in the concentration of sorbitol. This is because the type of plasticizer used is sorbitol.

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