International Journal of Design & Nature and Ecodynamics
Vol. 18, No. 2, April, 2023, pp. 443-448
Journal homepage: http://iieta.org/journals/ijdne

Jackfruit (Artocarpus Heterophyllus) Seed Starch with Sorbitol as a Plasticizer and Rosella Flower Antioxidant in the Making Edible Film (Hibiscus Sabdariffa)

Sitti Rahmawati*, Kasmudin Mustapa, Suherman, Anang Wahid M. Diah, Supriadi, Minarni Rama Jura, Meyke Ratna Wulan

Department of Mathematic's and Natural Sciences Education, Faculty of Teacher Training and Education, Tadulako University, Jl. Soekarno Hatta Km 9, Palu 94118, Central Sulawesi, Indonesia

Corresponding Author Email: sittirahmawati@untad.ac.id

https://doi.org/10.18280/ijdne.180223

Received: 5 November 2022
Accepted: 20 March 2023

Keywords:
edible film, rosella flower extract, sorbitol, jackfruit seed starch

ABSTRACT

A thin, biodegradable sheet of starch known as the edible film can be used to wrap food and is also suitable for consumption. In this work, sorbitol will be used as a plasticizer, and an antioxidant will be utilized to examine the physical and chemical characteristics of the jackfruit seed starch-based edible film. The results showed that the most successful therapy in this investigation was the edible jackfruit seed starch film with 3% (v/v) rosella flower extract. Its physical characteristics included 0.13 mm thickness, 147.62% water absorption, 30% solubility, and a speed of vapor transport of water of 0.6775 gram/hour m^{-2}. The shelf life of the edible film is six days at room temperature and seven days at cold temperatures. The edible film in this study can decompose, according to the biodegradability test, and the chemical characteristics obtained for pH 6.236 and according to the results of the FTIR tests, this study's method of producing edible film is a physical mixing procedure without the introduction of any additional groups. Having an IC50 of 165,496 ppm, it has antioxidant action within seven days. Other advantages of edible films that serve as food wrappers from the oxidation (antioxidant) process can be obtained by adding rosella flower extract.

1. INTRODUCTION

Plastic packaging materials are widely used in the food industry due to their durability, flexibility, and low cost. However, the low rate of plastic recycling and the accumulation of plastic waste in the environment have become major environmental concerns worldwide. In Indonesia, the packaging industry is expected to grow by 6% to 8% this year, generating significant revenue for the country. However, it is crucial to ensure that this growth is sustainable and does not harm the environment. Less than 5% of plastic waste is recycled in Indonesia, which is significantly lower than the global average. This means that a vast amount of plastic waste ends up in landfills or pollutes the environment, causing severe harm to wildlife and humans. Plastic waste can take hundreds of years to degrade, and during this time, it can release harmful chemicals into the environment and harm ecosystems [1].

By creating ecologically friendly food packaging comprised of organic materials, efforts are being made to replace the usage of plastic packaging. The edible film is one form of packaging that is favorable to the environment. The term "edible film" refers to a thin layer of organic material that is applied to food and can be eaten [2].

The level of release of the bioactive substances they contain can be managed with edible films [3]. Packaging that may be consumed, such as grain, protein, or fat, is known as edible film [4]. It has been demonstrated that using a variety of materials to create edible films with a high starch content is efficient and results in high-quality edible films. Jackfruit seeds are one of the alternate raw sources for starch-rich edible film.

The choice of jackfruit seeds was made because of their high starch content, which ranges from 36.7% per 100gram [5]. Additionally, jackfruit seeds are widely available, but the general population is still unaware of how best to use them. Making edible films from jackfruit seeds is also a relatively simple process. Rahmawati et al. [6] used glycerol and sorbitol as plasticizers to create edible films utilizing the starch from jackfruit seeds. According to the findings, jackfruit seed starch has a shelf life of 4 to 6 days and can be used to make edible films. Edible films can serve as carriers of antioxidant chemicals in addition to serving as food packaging [7]. Rosella flowers are an example of an antioxidant source that can be exploited. Saponins and tannins, which are members of the flavonoid family, are found in rosella flowers [8, 9].

Based on the aforementioned literature search and research, it is evident that no studies have been done on the properties of edible film made from jackfruit seed starch with the addition of sorbitol as a plasticizer and rosella flower extract as an antioxidant. Sorbitol is being used as a plasticizer and rosella flower extract is being used as an antioxidant to describe jackfruit seed starch edible films.

2. METHODS

In this study, a quantitative descriptive research design was adopted. The study focuses on quantitative data from laboratory experiments done for the production of edible films made from jackfruit seed starch with antioxidants added from rosella flowers.

2.1 Jackfruit seed starches production

Extraction of starch from jackfruit seeds begins with small pieces of Jackfruit seeds weighing up to 2 kg, then mashed by adding a solution of 2 liters of purified water and 0.0230% sodium bisulfite (2.3 grams of sodium bisulfite). The sample was filtered, then the water was allowed to stand for 24 hours until a clean precipitate was obtained and then dried for 12 hours at a temperature of 50℃. The dried residue was crushed and sieved to produce jackfruit seed starch [10].

2.2 Making roselle flower extract

Making rosella flower extract is the same as what was done by Ningsih, et al. [9] and Paristiowati et al. [11].

2.3 Making edible film

The first step in making edible films is to weigh 3 grams of jackfruit seed starch, then include variations of 1.5%, 2.0%, 2.5%, and 3% in rosella extract, along with sorbitol at 2% (w/v). Following that, 80 mL of distilled water was added, and the mixture was heated with a magnetic stirrer for 15 minutes at 80℃. Then, after heating for 7 minutes, 20 mL of distilled water and 1 gram of CMC were added. Once the mixture has been poured into the mold, it is placed in an oven set to 80℃ for 18 hours to dry. The sample was removed from the range and cooled for 10 minutes, and a thin layer/edible film was obtained by Combining rosella flower extract with jackfruit seed starch [12].

The physical and chemical characteristics in this study include thickness, the use of FTIR (Fourier Transform Infrared Spectroscopy) for functional group analysis, pH testing, biodegradability testing, water absorption testing, edible film testing, water vapor transmission rate gravimetric method testing, shelf life testing, and investigation of the DPPH method's antioxidant activity.

A micrometer was used to measure the edible film sample's thickness with an accuracy of 0.01 mm at five separate locations. Measurements are averaged due to film thickness, as has been done by Kurt and Kahyaoglu [13] and Ningsih et al. [9].

In order to use functional group analysis with FTIR, samples from each step of the production of the edible film are examined. This study seeks to identify the actual physical or chemical mixing process that takes place. After setting the sample into the set holder, the right spectrum is then looked up. The outcome will be a diffractogram that displays the relationship between wave number and intensity. A spectrophotometer was used to record the FTIR spectra at room temperature [14].

In order to determine the pH, in a petri plate, 1 gram of edible film was diluted in 10 mL of distilled water. A palatable film solution is placed in a cup, and the electrode is dipped into it. Next, the pH meter's reading is examined. Apply it to each sample [15].

The edible film sample was submerged in EM4 during the biodegradation test, which evaluated the bioplastics' ability to break down (Effective Microorganism 4). The edible film was cut to a size of 2 x 2 cm, then soaked EM4 bacteria in a petri dish and observed for changes until the edible film was destroyed entirely for several days [16].

A sample weighing 2 grams was used as the beginning weight (D) and submerged for 10 seconds in a container of distilled water for the edible film's water absorption test. The water remained still stuck to the edible film's surface after the sample was removed from the container. Weighed to determine the ultimate weight of the piece after being extracted with a tissue (C). The sample was reinserted for ten seconds into the distilled water container, after which it was taken out and weighed once more. Once the final sample weight was constant, the immersion and weighing process was repeated [17].

$$\%\text{Water Absorption} = \frac{C-D}{D} \text{x } 100\%$$

where:
C = Final weight
D = initial weight

Weighing 2 grams of the edible film sample and placing it in a cup-lined oven at 100℃ for 30 minutes was how the solubility test was conducted. Additionally, the film was weighed at its initial weight (B), the edible film was soaked for 24 hours, the insoluble film was taken out, and the remaining film was dried in the oven for 2 hours at 100℃. The film was removed and dried for ten minutes. After soaking, to determine the weight of the dry edible film, it was weighed once more (D) [18].

$$\%\text{ Film Solubility} = \frac{B-D}{B} \text{x } 100\%$$

where:
B = Weight prior to soaking
D = Weight following soaking

Using a porcelain cup, calculated was the rate of water vapor transmission to the edible film. The room in the desiccator was adjusted to have a relative humidity (RH) of 75% before the measurement by introducing a 40% NaCl salt solution. Put 3 grams of edible film and activated silica gel weighing 5 grams in a porcelain dish and seal the borders of the word in order to prevent gaps. Additionally, the porcelain bowl was precisely weighed to the nearest 0.0001 grams before being set within a desiccator that had been preconditioned and then securely closed. The porcelain cup's water vapor transfer rate is calculated every hour for five hours [19].

$$\text{WvTR} = \frac{\text{Mv}}{tA}$$

where:
Mv = equal to the mass of water vapor added or taken away (grams)
t = Weighing period (hours)
A = The portion of the edible test film (cm^2)

The shelf life test is determined using the acceleration method. This test was conducted after learning the ideal composition for creating edible films. After being prepared according to the treatment, apples or potatoes are wrapped in edible film plastic and stored in an open area at 30 degrees. There are three different types of packaging: K1 (no packaging), K2 (edible film wrapped), and K3 (covered in parchment paper). Storage in a freezing chamber serves as the second treatment (16 C). Packaging comes in two different forms: K0 (no packaging) and K1 (edible film-wrapped) [20].

Utilizing a spectrophotometric method and the DPPH reagent, the antioxidant activity of the sample's concentrated extract was evaluated. A 10 mL volumetric flask containing

the sample extract was filled after it had been weighed to a maximum of 10 mg, and the ethanol solution concentration was then adjusted to a maximum of 1000 ppm. Then, a number of dilutions were carried out to create solutions with concentrations of 20, 40, 60, 80, and 100 ppm. The prepared solution is pipetted up to 1 Ml, and 3 Ml of a 50 M DPPH solution is then added. After homogenizing the mixture, it was placed in a dark area for 30 minutes. Then, the absorption was determined at a 517 nm wavelength. The DPPH solution was also put to the test.

$$\% \ Inhibition = \frac{Abs\ blank - Abs\ sample}{Abs\ blank} \times 100\%$$

where:
Abs. Blank = DPPH Absorbance 50 μM;
Abs. Sample = Absorbance Test Sample.

On the basis of the resulting regression equation, additional tests, an inhibition percentage curve, and an IC50 determination were made [21].

3. RESULTS AND DISCUSSIONS

3.1 Using rosella flower extract in the production of edible film

In the form of jackfruit seed flour, the starch from jackfruit seeds resembles that of powdered starch., is yellowish white, and has a faint jackfruit seed flavor. Figure 1 shows how rosella flower extract was added to jackfruit seed starch to create edible films in four different concentrations, namely 1.5% (S1), 2% (S1), 2.5% (S3), and 3% (S4) (v/v) as an antioxidant utilizing ethanol and aquades as a solvent in a 50:50 (v/v) ratio.

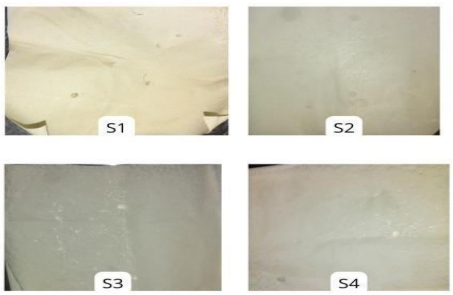

Figure 1. Jackfruit seed-based food film with roselle flower extract added

3.2 Edible films' physical and chemical properties

3.2.1 Thickness test

With an accuracy of 0.01 mm, the thickness of the edible film formed from jackfruit seed starch was measured using a screw micrometer in 5 separate places, specifically the corner and the center. The findings are then averaged, resulting in Table 1's value for edible film thickness.

According to the findings, Edible films with different thicknesses were produced by adding rosella flower extract at 1.5%, 2%, 2.5%, and 3% (v/v). The type of raw material, the quantity of solids, the size of the mold, the volume of the solution, and the unevenness of the edible film's print are all factors that affect thickness [22]. The product's ability to withstand gas migration and protect itself from physical damage grows as the edible film's thickness and structural tightness do [23]. The thickness of the edible film is shown in Table 1.

Table 1. Edible films' physical and chemical properties

Parameter	Treatment			
	S1	S2	S3	S4
Thickness(mm)	0.15	0.10	0.11	0.13
pH	6.11	6.52	6.12	6.24
Water Absorption	214.80	160.00	283.33	147.62
Solubility (%)	33.33	33.33	25	30
WvTR (gram.hour^{-1}m^{-2})	1.11	0.97	0.65	0.68

3.2.2 FTIR functional group analysis

Functional group analysis using FTIR aims to detect the functional groups present in the created edible film in order to ascertain whether a new group has developed or not [17]. The results of the FTIR analysis of the edible jackfruit seed starch film with rosella flower extract are shown in Figure 2. The spectrum interpretation, which is shown in Table 2, is based on Figure 2.

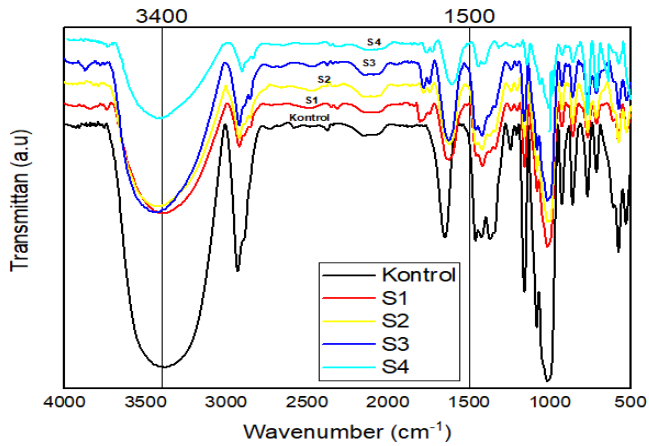

Figure 2. FTIR spectrum of edible film

3.2.3 pH test

The edible film's pH test results are shown in Table 1, which shows that the inclusion of rosella flower extract produced an acidic edible film (pH 7). The pH of the mixture is lower than that of edible jackfruit starch without quote, which has a pH of 6.499, because of the chemical interaction between the active components and rosella flowers [6]. The concentration of hydrogen ions in edible films rises as a result of antioxidant compounds' high reactivity as hydrogen donors [24].

3.2.4 Biodegradability test

The biodegradability test was carried out with the help of EM4 bacteria by producing enzymes capable of breaking polymer chains. The test findings in Figure 3 demonstrate that the edible film made from jackfruit seed starch and rosella flower extract entirely degrades or disintegrates after seven days. The addition of sections to edible films causes the formation of stronger intramolecular bonds, thereby increasing the degradation time of edible films, and it is proven that edible films are able to provide an environmentally friendly impact than synthetic plastics that have been degraded for years.

Table 2. Interpretation of FTIR edible film results science

Functional groups	Frequency Area (cm-1) [25]	Wave Number (cm-1)				
		Starch	S1	S2	S3	S4
CH Alkanes	2850-2970	2929.87	2920.23	2922.16	2920.23	2922.16
	1340-1470	1421.54	1454.33	1456.26	1456.26	1458.18
CH Alkene	675-995	927.76	925.83	925.83	925.83	925.83
OH H. Bonded Alcohol	3200-3600	3414.00	3381.21	3412.08	3446.79	3446.79
C=C Alkenes	1610-1680	1647.21	1624.06	1616.35	1620.21	1620.21
CO Ester, Alcohol, Ether, Acid Carboxylate	1000-1300	1016.49	1240.23	1242.16	1240.23	1240.23

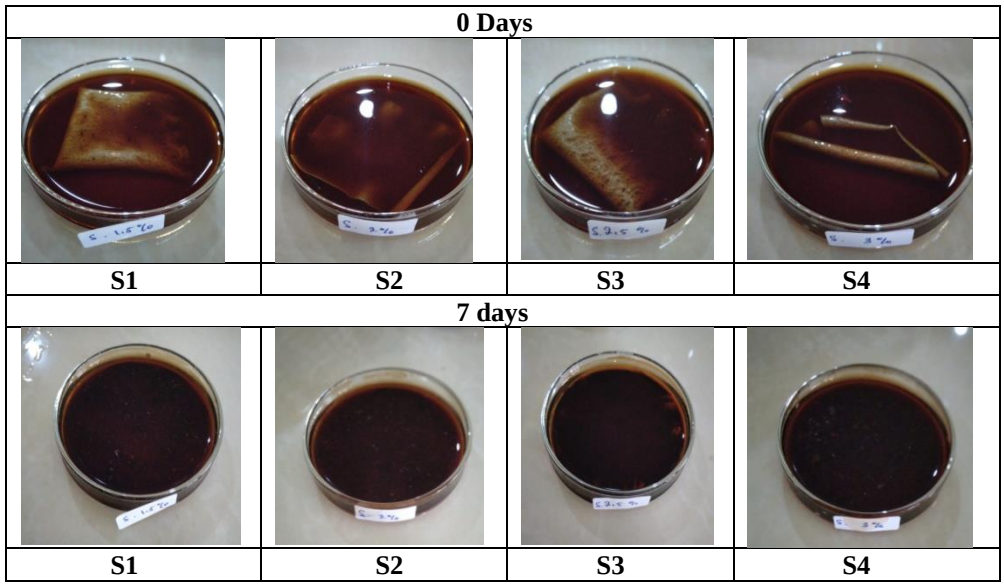

Figure 3. Degradation of edible film using EM4 bacteria

3.2.5 Water absorption test

Table 1 displays the results of the water absorption test, which reveals that edible films containing different concentrations of rosella flower extract (1.5%, 2%, 2.5, and 3% (v/v) have various water absorption capabilities, namely 214.8%, 160%, 283.33%, and 147.62%. The addition of 3% (v/v) extract showed the lowest water absorption value, which suggested the best water resistance. This test's objective is to figure out how much of the edible film absorbs water. Rosella flower extract can reduce the absorption of edible films because it increases intramolecular hydrogen bonding in the polymer film, tightening the structure and improving water resistance [24]. dissolved after immersion in water for 24 hours [26]. Edible films have properties that are like water (hydrophilic) and are more soluble in water.

3.2.6 Solubility test

According to Table 1's findings from the edible film solubility test, different results were achieved when rosella flower extract was added at concentrations of 1.5%, 2%, 2.5, and 3% (v/v), yielding results that were, respectively, 41.67%, 33.3%, 25%, and 30%. The highest solubility values were obtained when extract was added at 1.5% (v/v), whereas the lowest values were obtained when extract was added at 2.5% (v/v). The high solubility value in edible films will be easier to digest and consume [13].

3.2.7 Gravimetric method of water vapor transmission rate

The study's findings are shown in Table 1, where the water vapor transmission rate of the edible film with different concentrations of rosella flower extract is displayed. These concentrations are 1.1065 gram/hour.m^2, 0.9692 gram/hour.m^2, 0.6493 gram/hour.m^2, and 0.6775 gram/hour.m^2. A 2.5% (v/v) extract variation produced the most outstanding results. Due to an increase in intramolecular hydrogen bonds in the polymer film, which results in a denser structure and greater water resistance, the addition of flower extracts can lessen the absorption of edible films [11]. The amount of water that an edible film can absorb is directly correlated with its thickness; the thicker the product, the more water it can absorb [26].

3.2.8 Shelf life test

Table 3 displays the results of this experiment, which required covering slices of sticky rice with edible film.

3.2.9 Antixidant activity using the DPPH method

The sample concentration (ppm) is the x-axis, and the percent inhibition value is the y-axis in a linear regression equation that is used to calculate the IC50 value from the relationship between the sample concentration and the percentage of inhibition. The amount of extract needed to inhibit a radical's activity by 50% is known as the IC50 value. Figure 4 depicts the linear regression equation for each edible film.

Table 3. Longevity test of the edible film

No	Request regarding potatoes	Ambient Temperature (℃)	Shelf life (power)	Physical state
1	With *edible film* inside	16	7	Excellent, somewhat wrinkly, unblackened, and unmold
2	No Packer	16	3	somewhat wrinkly and darkened
3	With *edible film* inside	30	6	Not rotten, slightly wrinkly, and darkened somewhat
4	Encased in oil paper	30	3	Wrinkled, slightly browned, and moldy
5	No Packer	30	2	Wrinkled, slightly browned, and moldy

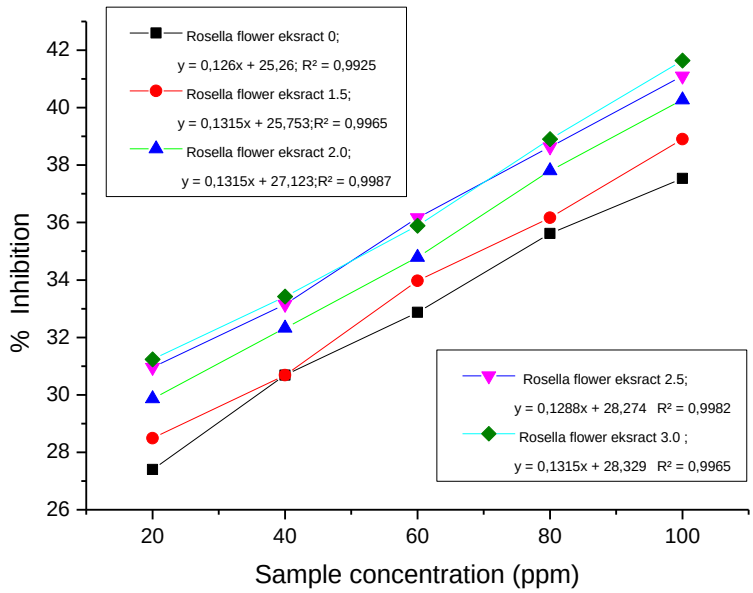

Figure 4. Edible film inhibition percent curve

Table 4. Value of edible film's IC_{50}

Sample	IC value$_{50}$
Control	196.349
S1	185.115
S2	174.656
S3	169.766
S4	165.496

Based on the linear regression equation in the previous figure, Table 4 contains the IC value of 50. The outcomes demonstrated that the concentration of rosella flower extract improved the edible film's antioxidant activity. With a 3% extract addition, the edible film exhibited the maximum antioxidant activity, with an IC_{50} value of 165.496 ppm. The potential for antioxidant activity increases with decreasing IC_{50} values [27]. Strong antioxidants have IC_{50} values between 150 and 200 ppm, weak antioxidants between 150 and 50 ppm, while fragile antioxidants have IC_{50} values of less than 50 ppm. Potent antioxidants have IC_{50} values between 50 and 100 ppm. IC_{50} > 200 ppm. According to the study's findings, the edible film has poor antioxidants due to its low IC_{50} of 150–200 ppm. The addition of rosella flower extract increased the edible film of jackfruit seed starch's antioxidant content.

4. CONCLUSION

An edible film produced from jackfruit seed starch and rosella flower extract was the study's most effective treatment, which had the following physical characteristics: thickness of 0.13 mm, water absorption of 147.62%, solubility of 30%, transmission speed of 0.6675 gram/hour/m2, shelf life of 5 days at room temperature and 7 days at cold temperatures. The results of the chemical tests reveal that the edible film has an antioxidant activity with an IC50 value of 165.496 ppm, a pH of 6.236, was made through physical mixing without the addition of different functional groups, can degrade after 7 days, and can be consumed.

ACKNOWLEDGEMENT

The author would like to thank the Laboratory of Advanced Chemistry FKIP Tadulako University, Laboratory of Advanced Physics FKIP Tadulako University, Chemistry Laboratory of FMIPA Tadulako University and Chemical Engineering Department of Chemistry, Faculty of Mathematics and Natural Sciences, Hasanuddin University and all parties who helped the author complete this research.

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