PHYSICAL PROPERTIES OF DURIAN (*Durio zibethinus Murr*) SEED STARCH AND ITS ASSOCIATED EDIBLE FILM

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Article Info	ABSTRACT
Article history : Received July 4th, 2025 Revised September 12th, 2025 Accepted October 18th, 2025 ***Corresponding email :*** philipus.patty@lecturer.unpatti.ac.id	Starch has become a popular material as a substitute for conventional crude oil in plastic production. An edible film, a transparent thin film made from biobased materials, is one product that mostly uses starch. In this study, the starch of durian (Durio zibethinus Murr) fruit seed was used to make an edible film, and the physical properties of the starch and its associated edible film were characterized. A light microscope was used to observe the shapes and size distribution of the granules, a basic component of the starch consisting of linear amylose and branched amylopectin chains, and XRD spectroscopy was used to characterize the crystalline properties of the starch. Most of the granules were in spherical shapes with some irregularities, and the diameter ranged from 1.11 to 6.67 µm. Based on the XRD data, durian seed starch can be classified as a B-type starch with a crystallinity index of 22.2%. An edible film made from durian seed looks transparent brownish with dark brown spots. Its water vapor transmission rate was 2.49±0.01 g/m^{2}hour, water absorption 145.1±34.9%, and water solubility 13.36±0.86%. ***Keywords:*** *Starch, durian seed, granules, edible film, water vapor transmission rate*

Introduction

Edible film is a transparent thin film made from bio-based materials, one of which is a starch that is used by plants as an energy store. Starch is a polymer, where glucose units are the monomers, and it is composed of semi-crystalline granules, the basic components of which consist of linear amylose chains and branched amylopectin chains (Li *et al.,* 2021). Various starches have been used as raw materials in making edible films, including sago (Lintang *et al.,* 2021), cassava (Esfahani *et al.,* 2022), corn (Chatariya *et al.,* 2022), potatoes (Hirpara *et al.,* 2021), and avocado seeds (Muryeti *et al.,* 2021). The properties of edible films made from the above starch materials have been studied and developed to achieve standards that are equal to or better than conventional plastic films.

Besides the properties of an edible film, the properties of starch itself have been the focus of many studies, one of which is its crystallinity. Studies have shown that granules of starch consist of rings of alternate crystalline and amorphous parts, where crystalline parts consist of double helices formed by branches of amylopectin, and in amorphous parts there is an interaction between junctions of amylopectin and long amylose molecules (Bertoft, 2027). Based on the arrangement of double helices and measured by XRD, starches can be classified as type A, B, or C. Type A starch is indicated by XRD peaks of 2θ at 15°, 17°, 18°, and 23°; type B starch at 5.6°, 17°, 22°, and 24°; and type C starch, a combination of type A and type B, at 5.6°, 15°, 17°, and 23° [8]. In an A-type starch, the structure of double helix packing is monoclinic with eight water molecules per unit cell, while in a B-type starch, it is hexagonal with 36 water molecules per unit cell (Xie *et al.,* 2017).

Durian (*Durio zibethinus* Murr) seed is one of the materials that can be potentially utilized to make an edible film. It has high starch content (Ho *et al.,* 2015), varying from 41.7% to 59.2% depending on the origin of the fruits (Fadjria *et al.,* 2047; Purnama *et al.,* 2022). The seeds are a waste of food. They cannot be directly consumed due to their cyclopropane fatty acids, which are harmful (Djaeni and Prasetyaningrum, 2010). They can be consumed after some treatments such as cooking, steaming, or burning. Regardless of their high content of starch, durian seeds have not received much attention from the experts in their use as basic ingredients for making edible films. Utilization of durian seed starch to make an edible film doubles the profit : turning waste into something useful. The objectives of this study are to characterize the physical properties of durian seed starch and to make an edible film from the starch, as well as to characterize the physical properties of the edible film.

Methods

Preparation of Durian Seed Starch

Durian seed starch was prepared from durian seeds taken from a local garden in Ambon Island, Indonesia. The seeds were washed using tap water and left to dry. After removing their outer layer using a knife, the seeds were ground using a blender. After grinding, the paste was mixed with distilled water with a ratio of 1:3, and the slurry was filtrated through a cloth bag. The filtered slurry was then allowed to rest for two hours for the process of sedimentation. The liquid at the top was decanted and discarded. The process of filtration was repeated three times, and the sediment was dried in the oven at 45°C for 48 hours and stored in a container for further analysis.

Preparation of Edible Film

The preparation of edible film followed the protocol from Ningsih et al. (Ningsih *et al.,* 2019). 5 g of durian seed starch was mixed with CMC at a ratio of 12% and dissolved in 100 ml of distilled water. Furthermore, this solution was mixed with 1% chitosan in 20 ml of acetic acid. This mixture was then heated on a hot plate stirrer at a temperature of 85°C for 10 minutes or until a gel was formed. Next, 1 ml of glycerol was added and then stirred with a stirrer for 1 hour at a temperature of 55°C at a rate of 200 rpm. The solution was poured into the available mold, then dried in an oven at a temperature of 60°C for 5 hours to obtain the film. The edible film was cooled and then released from the mold and was ready to be used for measurement.

XRD Measurements and Analysis

The crystalline property of starch was conducted using an XRD spectrophotometer, XRD Rigaku MiniFlex 2. The monochromator used was Cu-Kα radiation with λ=1.5405 Å at a power of 30 kV, 15 mA under an angle of 2θ ranging from 3 to 145° with an interval of 0.02°. The data of 2θ was truncated between 14° and 26° and was smoothed by applying a Savitzky-Golay filter with the polynomial degree of 3 and 40 points for clarity. The index of crystallinity, I_C, of the starch was determined following the protocol of the previous study (Patty and Wattimena, 2023). It was calculated using equation 1.

$$I_C = \frac{A_C}{A_C + A_A} \quad (1)$$

where A_C and A_A are the areas of crystalline and amorphous parts, respectively. The A_C and $A_C + A_A$ were determined by integrating the area under the peaks and the whole area of the XRD data, respectively.

Size and Shape Measurements

The size and shape of the durian seed granules were characterized using a light microscope, Olympus Polarized Microscope.

Water Vapor Rate Transmission Measurement

To determine the water vapor transmission rate (WVTR) of the edible film, the sample was cut into a circle with a diameter of 10 cm and was used to cover the petri dish surface with a diameter of 10 cm that already contained silica gel. Before covering the petri dish with the film, the petri dish and silica gel were weighed as an original weight. The petri dish with silica gel and edible film was put inside a desiccator containing water. The weight of the petri dish and silica gel was measured every hour to observe the change of the silica gel mass. The WVTR is determined using the equation 2.

$$R_T = \frac{m}{A} \quad (2)$$

where m is the change of mass per hour determined from the slope of the graph of mass vs. time data, and A is the area of the edible film.

Water Absorption Measurement

To determine water absorption, the edible film was cut to a size of 2.50 x 5.00 cm. The sample was weighed as initial weight W_0. Then, the sample was immersed in water for 1 minute and was dried using tissue to remove the remaining water adhering to the film. After drying, the sample was weighed as final weight W_1. Water absorption A_W was calculated using equation 3.

$$A_w = \frac{W_1 - W_0}{W_0} \times 100\% \quad (3)$$

Water Solubility Measurement

To determine the water solubility, the edible film sample was cut into 2.00 cm x 2.00 cm and weighed as an initial weight, W_i. The sample then was immersed in water for 24 hours, the undissolved film was dried in an oven at 80°C, and was weighed as W_f. Water solubility S_w was calculated using equation 4.

$$S_w = \frac{W_i - W_f}{W_i} \times 100\% \quad (4)$$

Results and Discussion

Figure 1 shows an example of the results of light microscope measurements of durian seed starch. The figure shows granules of the starch, where most granules are spherical in shape with some irregularities. The diameter from 171 granules randomly chosen from light microscope measurements was analyzed to see the size distribution of the granules. Figure 2 shows the size (diameter) distribution of the granules. The diameter of the granules ranges from 1.11 µm to 6.67 µm, with a mean diameter of 2.64 ± 1.40 µm. The size of durian seed starch granules is in the same order of magnitude as the size of other starch granules, such as rice and buckwheat, whose size distributions are less than 10 µm (Guo *et al.,* 2023). This size is relatively small compared to other starch granules, such as potato, which is larger than 30 µm (Wang *et al.,* 2016); avocado seed, 5–30 µm (Du *et al.,* 2020); and sago, 10–50 µm (dos Santos *et al.,* 2016).

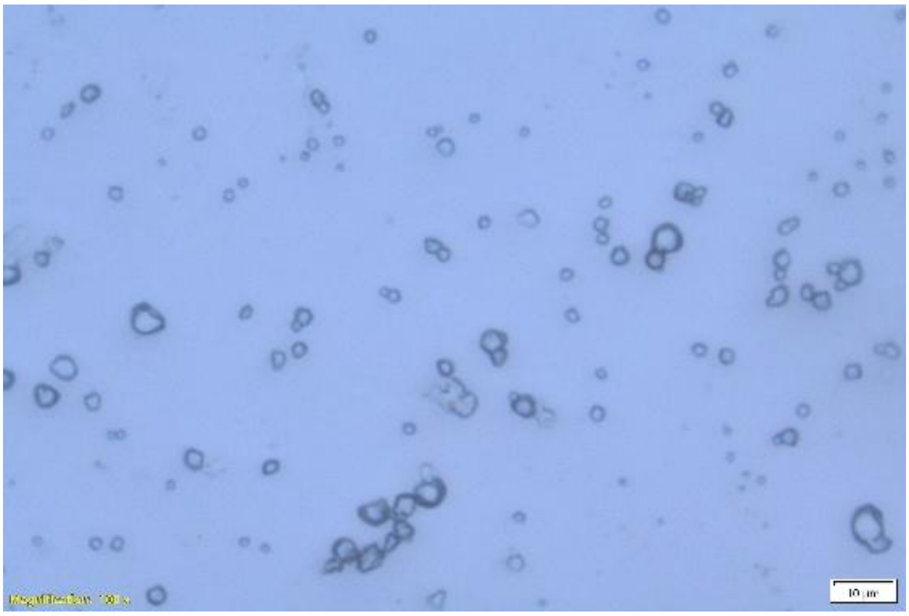

Figure 1. Light microscope measurement of durian seed starch

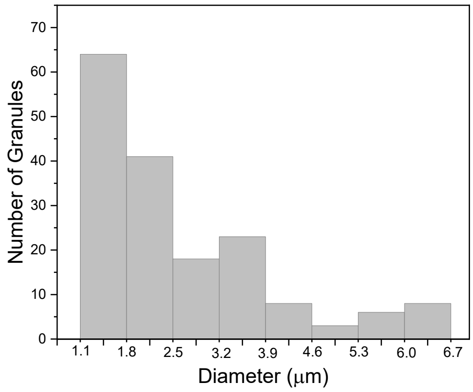

Figure 2. Size distribution of durian seed starch granules

Figure 3 shows the results of XRD spectroscopy of durian seed starch: both the raw and the smoothed data. There are four main peaks of 2θ: 15.3°, 17.2°, 22.3°, and 24.1°. Based on these peaks, durian seed starch can be categorized as a B-type starch. Thus, in durian seed starch, the pack of double helices is hexagonal with 36 water molecules per unit cell (Bertoft, 2017). The index of crystallinity was determined using Equation 1 and was found to be 22.2%. The index is in the same order of magnitude as other granules, such as sago (28.13%) (Du *et al.*, 2020) and potato (20–22%) (dos Santos *et al.*, 2016). Other granules have a higher index of crystallinity, such as cassava at 41% (Patty and Wattimena, 2023) and corn at 36% (Dome *et al.*, 2020).

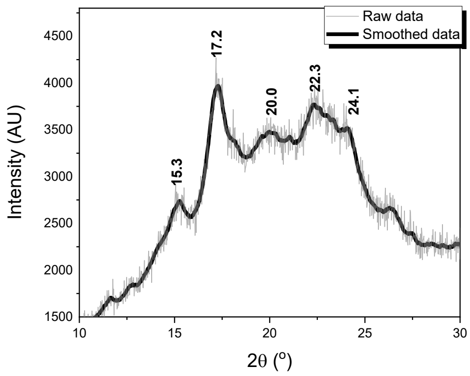

Figure 3. Size distribution of durian seed starch granules

Figure 4 shows an example of edible film made from durian seed starch. It looks transparent brownish with dark brown spots.

Figure 4. An example of edible film made from durian seed starch

The WVTR of the edible film was determined using Equation 1 and was found to be 2.49±0.01 g/m^2hour or 58.86±0.24 g/m^2day, as summarized in Table 1. For comparison, the WVTR of edible film made from arrowroot starch varied from 85 to 100 g/m^2day (Giyatmi *et al.,* 2017), from modified purple yam starch 576 g/m^2day (Parera *et al.,* 2021), from cassava starch 240 g/m^2day (Nasution *et al.,* 2025), and from taro starch 25.37 g/m^2day (Siskawardani *et al.,* 2020). The WVTR indicates the ability of the film to resist water: the lower the WVTR, the better the resistance, and the better the film is in terms of its function as a food package to protect the food. Although the WVTR of durian seed edible film is still high, it is lower than the WVTR of all other edible films mentioned.

The water absorption of the edible film was determined using Equation 2 and was found to be 145.1±34.9%, as summarized in Table 1. For comparison, water absorption of potato starch containing chitosan varied from 100 to 175% (Atker *et al.,* 2012), other edible starch films from 30 to 75% (Teaca *et al.,* 2012), and ginger starch 42.85% (Sariningsih *et al.,* 2018). Water absorption of the edible film indicates the ability of the film to take up moisture from its surrounding environment. In relation to its function in food packaging, the water absorption of the film needs to be low. The water absorption of durian seed edible film is still high and needs to be lowered with some treatments, such as modifying the starch or adding hydrophobic materials like chitosan.

The water solubility of the edible film was determined using Equation 4 and was found to be 13.36±0.86%, as summarized in Table 1. For comparison, the water solubility of edible film made from arrowroot starch varies from 60 to 80% (Giyatmi *et al.,* 2017), from modified purple yam starch 32.080±4.671% (Parera *et al.,* 2021), from taro starch 23.4% (Siskawardani *et al.,* 2020), and from cassava 19–25% (Desire *et al.,* 2021). The water solubility of the edible film indicates how readily the film dissolves in an aqueous environment. Durian seed starch edible film has low solubility, i.e., it is more resistant to water.

Table 1. Summary of the results of physical measurements of durian seed starch edible film

Measured Quantity	Value (Unit)
Water vapour	2.49±0.01 (g/m^2hour)
transmissin rate	58.86±0.11(g/m^2day)
Water Absorption	145.1±34.9 (%)
Water solubility	13.36±0.86 (%)

Conclusion

This study shows that durian seed starch is a B-type starch, where the pack of double helices in the granule is hexagonal and the index of crystallinity is 22.2%. The granules of durian seed starch are in spherical shape with some irregularities, varying from 1.11 to 6.67 μm in diameter. Edible film made from durian seed starch has a WVTR of 2.49±0.01 g/m^2hour or 58.86±0.24 g/m^2day, a water absorption of 145.1±34.9%, and a water solubility of 13.36±0.86%. These properties of durian seed starch edible film are still to be improved; that can be done by modifying the starch or adding the hydrophobic materials.

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