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Physical Characterization of Cassava Starch Edible Films with Different Sorbitol Concentrations

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A B S T R A C T

The extensive use of synthetic plastic packaging in food products has raised serious environmental concerns due to its low biodegradability. At the same time, cassava is widely cultivated in Indonesia and is readily available at low cost, making it a practical raw material for the development of biodegradable and edible packaging. This study aimed to evaluate the effect of sorbitol concentration as a plasticizer on the physical properties of cassava starch edible films. Edible films were prepared using 3% (w/v) cassava starch with different concentrations of sorbitol through gelatinization and casting method. The films were characterized based on thickness, elongation at break, and disintegration time in water. The results showed that increasing sorbitol concentration improved film flexibility, as indicated by higher elongation values, and increased film thickness. In contrast, higher sorbitol content accelerated disintegration time due to increased water absorption related to the hydrophilic nature of sorbitol. Overall, this study demonstrates that cassava starch based edible films plasticized with sorbitol have strong potential as environmentally friendly, edible, and biodegradable sachet packaging, while also supporting the utilization of abundant local resources in Indonesia.

A R T I C L E I N F O

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1. INTRODUCTION

Plastic packaging is still the most common choice in the food industry because it is inexpensive, strong, and easy to use. However, most plastic materials are very difficult to degrade and can persist in the environment for a long time, leading to serious environmental pollution and waste accumulation (Geyer et al., 2017). The continuous increase in plastic waste, particularly from food packaging, has become a major environmental issue and has encouraged researchers in food technology to develop more environmentally friendly and sustainable packaging materials.

One alternative that has received increasing attention is edible film. Edible film is a biodegradable packaging material made from natural polymers that can be consumed together with food or safely decompose after disposal (Gontard et al., 1993). Starch is widely used in edible film production because it is affordable, biodegradable, and capable of forming thin films (Azwar et al., 2022). Cassava starch is considered particularly promising since cassava is abundantly cultivated in Indonesia and is easy to obtain. In addition, cassava starch is renewable, non-toxic, and suitable for food applications, making it a potential local resource for sustainable food packaging development.

However, edible films made from starch generally have weak mechanical properties. They tend to be stiff and brittle, which limits their practical application as packaging materials. This weakness is mainly caused by strong intermolecular interactions, especially hydrogen bonding, between starch molecules that form a rigid film structure (Gontard et al., 1993; Rusli et al., 2017). To overcome this limitation, plasticizers are usually added to starc based edible films to improve flexibility and mechanical performance.

Sorbitol is one of the plasticizers commonly used in edible film formulations. Sorbitol can reduce strong bonding between starch molecules by forming hydrogen bonds with starch chains, allowing the film to become more flexible and easier to stretch (Rusli et al., 2017; Syahputra et al., 2022). Previous studies have shown that variations in sorbitol concentration influence film thickness, flexibility, and disintegration behavior in water (Patil and Shrivastava, 2014; Bestari et al., 2024). Therefore, this study aimed to evaluate the effect of different sorbitol concentrations on the thickness, elongation at break, and disintegration time of cassava starch based edible films, as well as to assess their potential application as biodegradable sachet packaging for instant powdered food products.

2. METHODS

2.1 Material

The materials used in this study were cassava starch, sorbitol, distilled water, and acetic acid. Cassava starch was used as the main film forming polymer at a fixed concentration of 3% (w/v). Sorbitol was used as a plasticizer with concentration variations of 1.25%, 1.5%, 1.75%, and 2.0% (v/v). All materials used were food-grade and suitable for edible film preparation.

2.2 Film Preparation

Edible films were prepared using the gelatinization and casting method with slight modifications from previous studies. Cassava starch (3 g) was dispersed in 100 mL of distilled water in a beaker and heated to approximately 70 °C while continuously stirred until gelatinization occurred and a homogeneous solution was obtained. Acetic acid (4 mL) was then added to the solution. Sorbitol was incorporated according to the specified concentrations (1.25%, 1.5%, 1.75%, and 2.0% v/v) and the mixture was stirred for approximately 8 minutes until a viscous gel was formed.

The film forming solution was poured onto a flat tray. The volume of solution was adjusted to obtain a target film thickness of 0.04 cm, calculated based on the tray area. The films were dried at room temperature for 24 hours. After drying, the edible films were carefully peeled off and stored in a desiccator prior to testing.

2.3 Film Characterizations

2.3.1 Thickness Measurement

Film thickness was measured using a digital caliper following the method adapted from Turhan and Şahbaz (2004). Film samples were cut into 1 × 1 cm pieces, and ten layers of film were stacked to reduce measurement error. Thickness was recorded in millimeters (mm), and measurements were conducted at three different points for each sample.

2.3.2 Elongation at Break Test

Elongation at break was determined using a tensile testing method adapted from Rusli et al. (2017). Film samples were cut into rectangular strips with a width of 35 mm and a length of 50 mm. Each sample was mounted between two grips, with one grip fixed and the other movable. The film was stretched slowly until it broke. Elongation at break was calculated based on the initial length and the length at break.

2.3.3 Disintegration Time Test

Disintegration time was evaluated using the petri dish method adapted from Patil and Shrivastava (2014). Two milliliters of distilled water were placed in a petri dish, and one piece of edible film was placed on the water surface. The time required for the film to completely dissolve was recorded in seconds.

2.4 Application Test on Powdered Products

The edible films were applied to instant powdered products by wrapping or coating the powder. The disintegration behavior of the films was observed when the packaged product was dissolved in hot water to evaluate the suitability of the films as biodegradable sachet packaging.

3. RESULTS AND DISCUSSION

3.1 Effect of Sorbitol Concentration on Physical Properties of Cassava Starch Edible Film

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The physical properties of cassava starch based edible films prepared with different sorbitol concentrations are summarized in Table 1. The results show that sorbitol concentration plays an important role in determining film thickness, elongation at break, and disintegration time.

Table 1. Effect of sorbitol concentration on physical properties of cassava starch edible film

Sorbitol Concentration (%)	Thickness	Elongation at Break	Disintegration Time
1.25%	Low	Very Low	Long
1.50%	Low	Moderate	Moderate
1.75%	Low	High	Short
2%	Low	Very High	Very Short

Table 1 shows that increasing sorbitol concentration generally improves film flexibility, as indicated by higher elongation at break values, while reducing disintegration time in water. Film thickness also shows a slight increasing trend with higher sorbitol content.

3.2 Influence of Sorbitol on Film Elasticity and Hydrogen Bonding

The increase in elongation at break with higher sorbitol concentration indicates improved film elasticity. This behavior is closely related to the role of sorbitol as a plasticizer in starch-based edible films. Sorbitol contains multiple hydroxyl (-OH) groups that can form hydrogen bonds with starch molecules. These interactions partially replace the strong hydrogen bonds between starch polymer chains, particularly amylose-amylose interactions.

At low sorbitol concentration or in the absence of plasticizer, hydrogen bonding between starch chains dominates, resulting in a rigid and brittle film structure. As sorbitol concentration increases from 1.5% to 2.0%, the disruption of intermolecular hydrogen bonding becomes more pronounced. This allows greater molecular mobility within the polymer matrix, producing a more flexible and elastic film. Similar effects have been reported in previous studies, where sorbitol reduced tensile strength but increased elongation due to enhanced chain mobility (Gontard et al., 1993; Syahputra et al., 2022; Darni et al., 2025).

3.3 Effect of Sorbitol Polarity on Film Disintegration Behavior

Sorbitol is a highly polar and hydrophilic compound, which strongly affects the interaction between the edible film and water. Increasing sorbitol concentration significantly accelerates film disintegration when exposed to water. This occurs because sorbitol attracts water molecules and facilitates water penetration into the film matrix. The absorbed water weakens hydrogen bonding between starch chains, leading to swelling and rapid disintegration of the film.

This behavior is advantageous for biodegradable sachet applications, especially for instant powdered products. The edible film remains stable under dry storage conditions but dissolves quickly when in contact with hot water, ensuring that the packaging does not interfere with product preparation. Similar disintegration behavior related to sorbitol polarity has been reported in starch based edible films (Bestari et al., 2024; Foods, 2024).

3.4 Effect of Sorbitol Concentration on Film Thickness

Film thickness increased with increasing sorbitol concentration. This effect can be attributed to the presence of sorbitol within the starch polymer matrix, which increases the spacing between polymer chains and reduces matrix compactness. Higher sorbitol levels add to the solid content and create a less dense film structure, resulting in thicker films after drying, a pattern also reported in similar edible film formulations (MDPI Processes, 2021). Thicker films may arise because plasticizers like sorbitol enhance chain mobility during casting, which can increase the volume occupied by the polymer network once dried (MDPI Processes, 2021). These results highlight the importance of optimizing sorbitol content to achieve a balance between flexibility, thickness, and overall functional performance. Insufficient sorbitol leads to brittle films, while excessive sorbitol may produce films that are too soft or rapidly absorb moisture, which can compromise mechanical integrity.

4. CONCLUSIONS

Variation in sorbitol concentration was found to significantly influence the physical properties of cassava starch based edible films. An increase in sorbitol concentration improved film flexibility and elongation at break, which is associated with the ability of sorbitol to reduce strong intermolecular hydrogen bonding between starch chains and increase polymer chain mobility. At the same time, higher sorbitol content accelerated film disintegration due to the polar and hydrophilic nature of sorbitol, which promotes water absorption and weakens the film structure when exposed to water. Sorbitol concentration also affected film thickness by modifying the arrangement and spacing of the starch polymer matrix. Films containing intermediate sorbitol concentrations showed more balanced characteristics, combining adequate flexibility with acceptable disintegration behavior.

Overall, cassava starch based edible films plasticized with sorbitol demonstrate good potential as biodegradable sachet packaging for herbal instant powder products, supporting the development of environmentally friendly and sustainable food packaging systems.

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