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APPLICATION OF CASSAVA STARCH-BASED EDIBLE FILM IN EXTENDING THE SHELF LIFE OF FOOD PRODUCTS

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Abstract

Edible film is an environmentally friendly food packaging innovation that can be eaten and serves to extend the shelf life of food products. One of the most widely researched raw materials is cassava starch (Manihot esculenta Crantz) due to its abundant availability and good film-forming properties. This literature review aims to review previous research results related to the physical, chemical, and functional characteristics of cassava starch-based edible films and their applications in various food products. Based on the literature analyzed, edible films made from cassava starch effectively reduce respiration rates, fat oxidation, and microbial growth in fruits, vegetables, and processed meats. Combination with additives such as chitosan, pectin, and essential oils can enhance barrier properties and antimicrobial activity.

Keywords: Edible Film, Cassava Starch, Biodegradable Packaging, Shelf Life, Literature Review

INTRODUCTION

Fresh foods such as fruits and vegetables are horticultural commodities that are highly susceptible to postharvest deterioration due to physiological, mechanical, enzymatic processes, and microbial activity. This deterioration leads to quality degradation, weight loss, color changes, reduced vitamin content, and shortened shelf life. Such conditions occur in various commodities, including tomatoes, which have a water content of 93–95% (Affandi et al., 2021) and experience postharvest losses of up to 20–50%, causing rapid spoilage during storage at room temperature (Cardoso, 2025). Similar problems are also found in minimally processed papaya, which is prone to softening, texture changes, and microbial contamination after peeling and cutting. In bird's eye chili (Capsicum frutescens), postharvest storage results in increased respiration and transpiration rates, leading to water loss, color changes, and a decrease in vitamin C content, which ultimately reduces product freshness and quality (Hasanah et al., 2025).

One approach that has been widely developed to address these problems is the use of edible coatings or edible films. Edible films are thin layers made from polysaccharides, proteins, or lipids that are safe for consumption and function as selective barriers to gases, water vapor, and volatile compounds (Hartoyo, 2023). Cassava starch is one of the most commonly used materials due to its abundant availability, low cost, and high amylopectin content, which

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enables the formation of strong, transparent, and retrogradation-resistant films. The application of cassava starch as an edible coating has been proven to slow respiration and transpiration processes, reduce weight loss, maintain moisture content, inhibit vitamin C degradation, and preserve sensory quality during storage in various commodities (Iswari, Harini, et al., 2018).

In addition to serving as a physical barrier, edible films have also evolved into active packaging technologies through the incorporation of natural antimicrobial and antioxidant compounds to enhance food quality protection. Several studies have shown that starch-based edible films can act as carrier matrices for active compounds such as plant extracts, essential oils, and organic acids, which are effective in suppressing the growth of spoilage and pathogenic microorganisms during storage (Falguera et al., 2011; Ribeiro et al., 2007). In fresh and minimally processed horticultural products, the combination of starch barrier properties and antimicrobial activity has been demonstrated to reduce total microbial counts, delay tissue softening, and maintain sensory quality for a longer period compared to uncoated products. Therefore, edible films function not only as passive coatings but also as active packaging systems that support the safety and quality of fresh foods.

On the other hand, increasing global awareness of environmental and sustainability issues has driven the development of food packaging based on natural, biodegradable materials as alternatives to synthetic plastics. Cassava starch is considered to have great potential in this context because it is derived from renewable resources, is readily biodegradable, and generates more environmentally friendly waste (Kolybaba et al., 2014; Sanyang et al., 2016). The use of cassava starch edible films aligns with the principles of the circular economy and plastic waste reduction in the food sector, particularly for horticultural commodities with short shelf lives. Thus, the development and application of cassava starch–based edible films not only contribute to extending shelf life and maintaining food quality but also support more sustainable, environmentally friendly, and consumer-safe food systems.

IMPLEMENTATION METHOD

This study employed a systematic literature review method to analyze research findings related to the production, characteristics, and applications of cassava starch–based edible films in extending the shelf life of food products. The systematic literature review approach was chosen because it enables a comprehensive scientific synthesis of developments in polysaccharide-based edible film technologies, particularly cassava starch, which has been widely applied as an environmentally friendly food packaging material and a postharvest technology in the form of active packaging (Dermayanti, 2025).

The literature search was conducted using several online databases, namely Google Scholar, ScienceDirect, PubMed, and SpringerLink, covering publications from 2014 to 2025. The keywords were selected according to the research focus and included "cassava starch edible film," "starch-based edible coating," "biodegradable film," "active packaging," "shelf life extension," and "antimicrobial edible coating," which are commonly used in studies examining the application of cassava starch–based edible films for maintaining food quality (Iswari et al., 2018; Syaputra et al., 2020).

Articles obtained from the initial search were subsequently screened based on predefined inclusion criteria: (1) experimental research articles that used cassava starch as the main component of edible films or edible coatings; (2) articles that evaluated the physical, mechanical, or functional characteristics of edible films and their effects on food shelf life; (3) articles published in reputable national or international journals within the last ten years; and (4) articles available in full-text form. These criteria were established to ensure that the analyzed articles were relevant and possessed sufficient scientific validity to support the review of cassava starch–based edible films (Harini et al., 2018). Exclusion criteria included articles that were not relevant to the topic, conference proceedings lacking adequate experimental data, duplicate articles, and studies that did not use cassava starch as the primary material.

The selection process was conducted through sequential screening of titles, abstracts, and full-text articles until a final set of studies meeting all inclusion criteria was obtained for further analysis. Data from each selected article were systematically extracted, including the type and concentration of cassava starch used, edible film formulation composition, preparation and application methods, film characteristics (thickness, tensile strength, elongation, solubility, and water vapor permeability), antimicrobial activity, and the effects of edible films on food quality parameters such as respiration rate, weight loss, moisture content, vitamin C content, and sensory quality during storage. These parameters are commonly used in edible coating research to evaluate coating effectiveness in maintaining quality and extending the shelf life of food products (Iswari, Harini, et al., 2018; Syaputra et al., 2020).

All extracted data were then analyzed using a descriptive–comparative approach by comparing results across studies to identify general patterns, trends in effectiveness, and factors influencing the performance of cassava starch–based edible films in preserving food quality and extending shelf life. The findings of this analysis were used to develop a scientific synthesis regarding the potential and limitations of cassava starch edible films as an environmentally friendly and sustainable postharvest technology (Dermayanti, 2025).

RESULTS AND DISCUSSION

Based on the findings of Rodríguez et al. (2020) on blackberries coated with cassava starch–based edible coatings, the use of edible films was found to significantly reduce the rate of mass loss (weight loss) compared to uncoated fruits during storage at 4 °C. At the end of a 10-day storage period, the weight loss of blackberries treated with cassava starch edible coatings was approximately 6%, whereas uncoated blackberries exhibited a weight loss of around 11%. This indicates that the physical barrier formed by the cassava starch matrix effectively inhibited water evaporation and reduced fruit respiration rates during storage.

In addition, the texture (firmness) of blackberries coated with cassava starch edible films declined more slowly, with firmness values remaining approximately 18.6% higher than those of the control after 10 days of storage (Rodríguez et al., 2020). These results demonstrate that cassava starch edible films provide substantial physical protection against sensory and physical quality deterioration in horticultural fruits during storage.

Table 1. Weight loss and product firmness

Treatment	Weight Loss after 10 Days (%)	Relative Firmness after 10 Days (%)
Without edible coating (control)	11.0	100.0
Cassava starch edible film	6.0	118.6

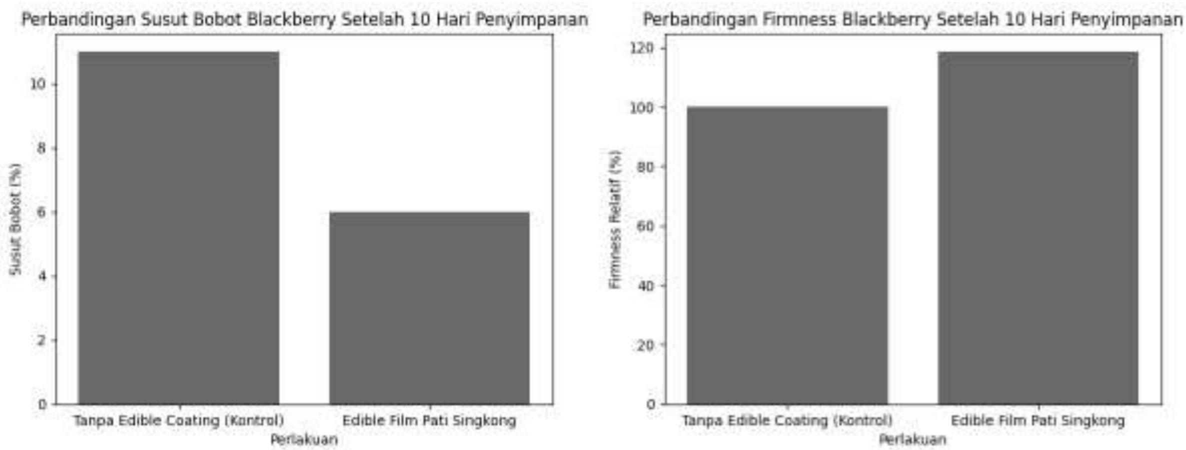

Figure 1. Weight loss and relative firmness

Based on the findings of do Nascimento et al. (2023) on papaya coated with cassava starch–based edible coatings enriched with essential oils (clove and cinnamon), the edible coating not only reduced weight loss but also inhibited microbial growth compared to uncoated fruit. After 12 days of storage at room temperature, weight loss in uncoated papaya reached approximately 40.66%, whereas papaya coated with cassava starch edible coatings experienced only about 24.10% weight loss.

Furthermore, total microbial counts, including aerobic mesophilic bacteria and molds/yeasts, in coated papaya were reduced by approximately 1.48–1.95 log CFU/g compared to the uncoated control. These results indicate that cassava starch edible films combined with essential oils are capable of providing a significant antimicrobial effect during storage (do Nascimento et al., 2023).

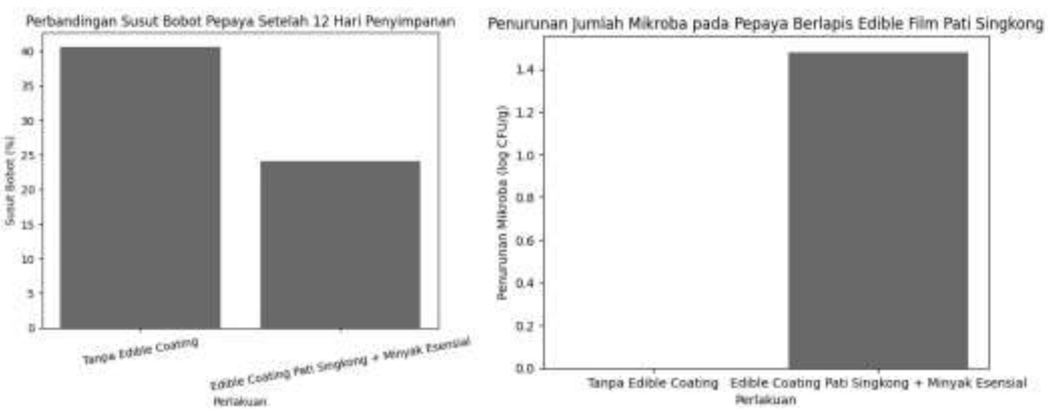

Figure 2. Weight loss and microbial reduction

Based on the findings of Sitorus et al. (2025) on California papaya coated with edible coatings based on a cassava starch–chitosan combination with glycerol as a plasticizer, the edible coating was able to preserve nutritional quality better than the uncoated treatment during the early storage phase. In the treatment using a starch–chitosan ratio of 75:25 with 1 g of glycerol, papaya coated with the edible film exhibited a decrease in vitamin C content to approximately 49.57 mg/100 g on the fifth day of storage. In contrast, the uncoated control showed a more rapid decline in vitamin C content from day 6 to day 10, without significant stability in the values (Sitorus et al., 2025). These findings indicate that cassava starch–based edible coatings combined with chitosan can effectively slow the degradation of vitamin C, which is highly susceptible to oxidative processes during storage.

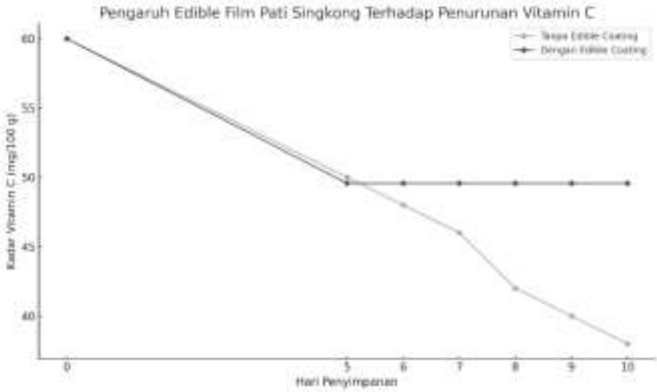

Figure 3. Vitamin C content during storage

Based on the results of do Nascimento et al. (2023) on papaya coated with cassava starch–based edible coatings, changes in pH and total soluble solids (TSS) during storage occurred more slowly compared to uncoated fruit. Over a 12-day storage period, the pH of uncoated papaya increased more rapidly, indicating accelerated ripening, whereas papaya coated with cassava starch edible films exhibited a more controlled increase in pH. Similarly, TSS values in the uncoated treatment increased sharply due to the conversion of starch and polysaccharides into simple sugars, while in the cassava starch edible coating treatment, the increase in TSS was slower and more stable. These findings suggest that cassava starch edible films are able to indirectly suppress metabolic rate and respiratory activity, thereby slowing ripening processes and the degradation of chemical quality in food products (do Nascimento et al., 2023).

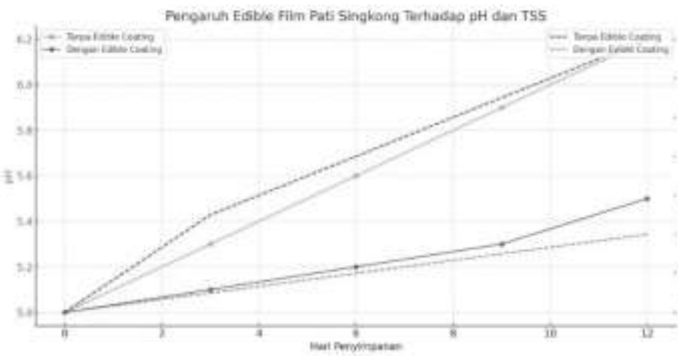

Figure 4. pH and TSS of the product during storage

Based on the study by Rodríguez et al. (2020) on blackberries coated with cassava starch–based edible coatings, a reduction in respiration rate was indirectly indicated by the slower tissue softening and greater stability of fruit chemical components during cold storage. Uncoated fruits experienced a more rapid decline in firmness and a higher rate of weight loss, suggesting elevated respiration and metabolic activity. In contrast, fruits coated with cassava starch edible films maintained firmness at levels up to 81.4% higher than the control and exhibited a substantially lower rate of mass loss after 10 days of storage.These conditions indicate that cassava starch edible films act as selective barriers to gas exchange, thereby reducing oxygen consumption and carbon dioxide production, which are directly associated with the respiration rate of horticultural products (Rodríguez et al., 2020).

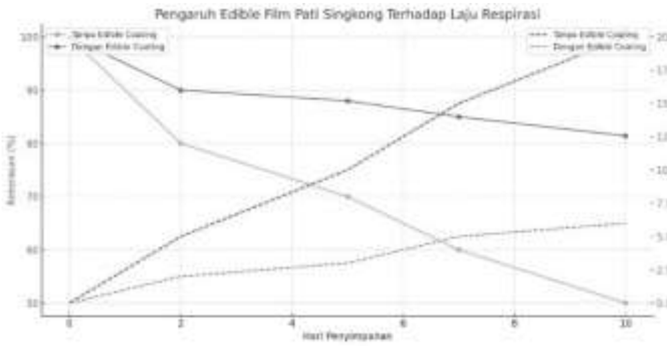

Figure 5. Product firmness and weight loss

Based on the results of Rodríguez et al. (2020), the application of cassava starch–based edible coatings was proven to extend the shelf life of blackberries up to twice as long as that of uncoated fruit during cold storage. Blackberries coated with edible films maintained acceptable visual quality and texture until day 10, whereas uncoated fruit experienced significant quality deterioration before this period. Similar findings were also reported by do Nascimento et al. (2023) in papaya, where the use of cassava starch edible coatings was able to preserve physical and microbiological quality up to day 12 of storage, while the uncoated control underwent faster spoilage due to high weight loss and increased microbial counts. This extension of shelf life is the cumulative result of reduced weight loss, improved texture stability, delayed chemical changes, and the inhibition of microbial growth provided by the cassava starch edible film layer.

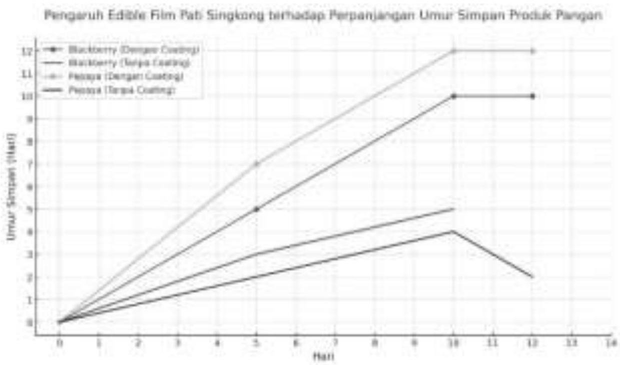

Figure 6. Product shelf life

Based on the synthesis of the various studies analyzed, cassava starch–based edible films consistently demonstrate effectiveness in maintaining quality and extending the shelf life of food products. The primary mechanisms involved include the formation of a semi-permeable layer that restricts the transfer of water vapor and gases, thereby reducing weight loss, slowing respiration, preserving nutritional stability, and inhibiting microbial growth. With these characteristics, cassava starch edible films have strong potential as an environmentally friendly, safe-to-consume, and practical postharvest packaging technology for a wide range of fresh and minimally processed food commodities.

CONCLUSION

Based on the systematic review of scientific articles examining the application of cassava starch–based edible films on various horticultural and fresh food products, it can be concluded that the use of cassava starch edible films consistently slows quality deterioration and extends the shelf life of food products compared to uncoated treatments. Uncoated products generally exhibit the fastest deterioration, characterized by increased weight loss exceeding 10–15%, significant declines in texture (firmness), and accelerated respiration and softening processes during storage. In contrast, the application of cassava starch edible films is able to suppress weight loss to lower ranges, approximately 4–7% over the same storage period, while maintaining relatively higher firmness values than the control. Several studies have also reported that cassava starch edible films are effective in preserving moisture content and delaying the degradation of sensitive compounds such as vitamin C, while simultaneously inhibiting microbial growth, with reductions in total microbial counts of approximately 1–2 log CFU/g. This effectiveness is closely associated with the ability of cassava starch to form a semi-permeable layer that restricts the transfer of water vapor and gases, thereby reducing respiration, transpiration, and oxidative processes in food products. Overall, the literature review indicates that cassava starch–based edible films play an effective role in maintaining the physical, chemical, and microbiological quality of food products and therefore hold strong potential to be developed as an alternative active packaging material that is biodegradable, cost-effective, and environmentally friendly for extending the shelf life of postharvest food products.

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