FACULTY OF CIVIL ENGINEERING & TECHNOLOGY FKTA Universiti Malaysia Perlis (UniMAP)
FKTA Postgraduate Colloquium 2024
UNIVERSITI MALAYSIA PERLIS

Future-Oriented Preservation Strategies of Mango

Teo L. T.[*], Madzuki I. N., Abidin N. S. A., Mohd Fikri S. N. F.

Faculty of Chemical Engineering & Technology, Universiti Malaysia Perlis (UniMAP), Perlis, Malaysia.

KEYWORDS

Mango Preservation
Drying Techniques
Nutrient
Bioactive Compound
Coatings

ABSTRACT

Mango, being a climacteric fruit, is readily perishable after harvesting due to the ripening, climatic conditions, and improper postharvest management, resulting in severe quality and financial losses. Traditional preservation techniques even effective to some extent, often fall short in maintaining nutritional value and sensory attributes. This review highlights emerging and future-focused preservation strategies for mangoes, such as gas barrier coating, biodegradable film, innovative drying techniques like freeze-drying and UV-A dehydration and smart drying, cold plasma treatment and hexanal-based treatments. These approaches emphasize sustainability, energy efficiency, and enhanced shelf life while preserving nutritional and physicochemical properties. Future research should focus on integrating these methods into scalable and eco-friendly systems to meet global demands effectively.

1. INTRODUCTION

Mangoes (Mangifera indica L., Family Anacardiaceae) are highly important agricultural products in many countries. In 2020, 54.83 million tons of mangoes, mangosteens, and guavas were produced worldwide, with Asia accounting for 72.5% of total output. India is the largest producer globally (24.7 million tons) [1]. In 2023, the exports are predicted to become 2.3 million tons worldwide, up 1% from the year before [2].

These horticulture crops are experiencing ongoing physiological and biochemical changes that result in significant losses from physical injury, microbial impacts, and postharvest senescence [3]. Innovative preservation technologies, such as gas-barrier coatings, have emerged as promising solutions to mitigate postharvest losses like cellulose nanocrystals (CNCs) that reduce moisture loss and delay the deterioration of mangoes by controlling microbial activity and enzymatic reactions [4]. Natural bio-based coatings, which include essential oils from plants, have antimicrobial and antioxidant properties extend the shelf life of mangoes by controlling microbial growth and maintaining their freshness during storage [4].

Drying technologies play a role in preserving mangoes by reducing decay and nutrient degradation. UV-A light dehydration, freeze-drying, and intermittent hot-air drying can maintain the fruit's physical and chemical properties [5]. These technologies still require fine-tuning to improve energy efficiency and scalability for cost-effective large-scale production, to assist small-scale farmers that have no access to expensive equipment. Hence, the objective of this review paper is to explore various innovative preservation strategies for mangoes to reduce postharvest losses and preserve their nutritional and sensory qualities.

2. INNOVATIVE APPROACHES TO MANGO PRESERVATION

The preservation of mangoes faces continuous challenges due to their high perishability and susceptibility to postharvest losses. To address these issues, modern technologies have been explored to maintain their nutritional and sensory qualities while reducing waste. Emerging strategies emphasize sustainability and adaptability to meet global preservation needs. These approaches leverage advancements in biochemistry, engineering, and environmental science to provide solutions that are efficient, scalable, and eco-friendly. By focusing on innovative techniques, researchers aim to create preservation systems capable of meeting the growing demands of the mango industry.

2.1 Gas-Barrier (GAB) Coating

The coating method control the interchange of materials over the mango peels and prolong the preservation time by dipping or spraying the solution or dispersion of barrier materials on the mango [8]. Coating enhances the gas-barrier ability, slows down matter exchange over the peel, and consequently reduces the metabolism rate. One innovative approach to enhance mango preservation is the use of gas-barrier coatings. Research presented the use of cellulose nanocrystals (CNCs) as coatings for mangoes, aiming to control the gas exchange, slow down respiration, and reduce moisture loss. This methodology involved creating coatings using CNC membranes integrated with clove essential oil to improve preservation properties [4].

2.2 Biodegradable Film

A significant area of research focuses on developing coatings and films to preserve mangoes and other fruits. One such method includes the use of polysaccharide

*Corresponding author: teoliyana@studentmail.unimap.edu.my

coatings enriched with plant extracts. Research showed that applying polysaccharide-based films to mangoes extended their shelf life to 21 days, improving their appearance and slowing down the spoilage process compared to untreated fruit, which became rotten [10]. Similarly, Zhang et al. (2024) examined biodegradable bioplastics made from citrus peels, which demonstrated antimicrobial properties and gas barrier capabilities. These bioplastics extended the shelf life of mangoes while reducing environmental harm.

Another novel technique explored by Zhang et al. (2023) involved the use of Pickering emulsion-based sodium alginate (SA) films for mango preservation, which showed improved mechanical properties and sustained the quality of mangoes during storage. These studies reflect the growing interest in developing sustainable and effective coatings for the preservation of tropical fruits.

2.3 UV-A Light Dehydration

Several methodologies focus on improving drying technologies to preserve mangoes and other crops. The use of UV-A light dehydration was explored, where mango slices were exposed to UV-A radiation with low relative humidity air [5]. The combination of UV-A light exposure and dehydration techniques retains the integrity of the mangoes, preserving their color and texture better than traditional methods. The application of UV-A light resulted in approximately 85% moisture removal, while maintaining the fruit's physical characteristics.

2.4 Freeze-Drying

Freeze-drying, compared to other traditional methods, helped retain the mango's natural properties and shelf life, enhance preservation while minimizing nutrient loss. This method is most popular as it produces a superior dried product with a longer shelf life. Mango powder produced by freeze drying is employed in a variety of food recipes because it retains greater rehydration and has a color comparable to mango pulp [11]. Freeze-drying is an effective process for preserving material structure and product quality. Further study is needed to assess the porosity of the material structure and evaluate the shelf-life of the product [7].

2.5 Smart Drying System for Energy-Efficient

Smart drying technologies are essential for efficient drying and high-quality preservation of mangoes. Intelligent drying system that employs LoRaWAN technology was developed for remote monitoring and control [10]. This long-range, low-power communication system enables users to manage drying operations effectively from a distance, optimizing energy use and ensuring consistent drying conditions.

The system integrates a temperature sensor and a Proportional-Integral-Derivative (PID) controller to maintain steady drying temperatures. The temperature sensor provides real-time data, and the PID controller adjusts the heating elements based on this feedback, preventing over-drying or under-drying [10]. Embedded programming on a microcontroller supports real-time data analysis, allowing quick adjustments to maintain optimal conditions for mango drying.

2.6 Cold Plasma Treatment

The use of cold plasma, a novel approach in the food industry, presents an alternative to traditional preservation methods by treating fruits without the need for heat, which helps to maintain their natural flavor and texture. The application of dielectric barrier discharge cold plasma (DBD-CP) on mangoes effectively reduced browning and microbial growth, while enhancing enzyme activity and improving phenylpropanoid metabolism. This method demonstrated its potential in improving the shelf life and quality of fresh-cut mangoes by reducing the spoilage rates [6].

2.7 Combination of Hot Water and Hexanal Treatments

Hot water treatments, when combined with hexanal formulations, represent another promising methodology for extending the shelf life of mangoes. Hot water treatment coupled with hexanal-based formulations (EFF) was applied to mangoes to reduce postharvest deterioration. This method was found to extend the shelf life of mangoes to 35 days, preserving their firmness and antioxidant activity. The synergy between hot water treatment and hexanal has shown to be effective in delaying ripening, reducing weight loss, and maintaining the fruit’s overall quality. This treatment offers an environmentally friendly solution to mango preservation while maintaining the nutritional value of the fruit [9].

3. CONCLUSION

Future-oriented preservation strategies for mangoes emphasize the adoption of advanced and sustainable technologies to address postharvest challenges, including quality deterioration and microbial spoilage. Techniques such as biodegradable coatings, innovative drying methods, and cold plasma treatment demonstrate potential to prolong shelf life, maintain nutritional and sensory properties and reduce waste. Although significant advancements have been achieved, further research is essential to optimize these preservation techniques for large-scale applications, addressing challenges related to energy efficiency and cost, and ensuring affordability for broader application. Integrating multiple preservation methods may offer synergistic benefits, enhancing effectiveness and enabling wider applicability in the food industry. This comprehensive approach can help reduce postharvest losses, maintain quality, and support global food security through sustainable agricultural practices.

REFERENCE

[1] Food and Agricultural Organization of the United Nations (2023). FAOSTAT Database. Retrieved from http://www.fao.org/faostat.

[2] Food and Agricultural Organization of the United Nations (2023). FAOSTAT Database. Retrieved from http://www.fao.org/faostat.

[3] Imahori, Y., & Bai, J. (2024). Postharvest Management of Fruits and Vegetables—Series II. *Foods*, *13*(7), 1049. https://doi.org/10.3390/foods13071049.

[4] Zhang, S., Cheng, X., Yang, W., Fu, Q., Su, F., Wu, P., Li, Y., Wang, F., Li, H., & Ai, S. (2024). Converting fruit peels into biodegradable, recyclable and antimicrobial eco-friendly bioplastics for perishable fruit preservation. *Bioresource Technology*, *406*, 131074–131074. https://doi.org/10.1016/j.biortech.2024.131074.

[5] Roberts, M. S., & Bastarrachea, L. J. (2023). UV-A Light Dehydration of Mango and Apple. *Food and Bioprocess Technology*, *17*(4), 991–1003. https://doi.org/10.1007/s11947-023-03177-z.

[6] Liu, J., Huang, Y., Sun, Y., Zhou, L., Peng, S., Zeng, Z., & Liu, W. (2024). Improvement of Fresh-Cut Mangoes Preservation by Cold Plasma and Its Possible Mechanisms. *Food and Bioprocess Technology*. https://doi.org/10.1007/s11947-024-03588-6.

[7] Suherman, S., Hadiyanto, H., Trianita, A. P., Hargono, H., Sumantri, I., Jos, B., & Alhanif, M. (2023). Response surface optimization of time and pressure for freeze-drying mango slices. *Food Research*, *7*(1), 182–195. https://doi.org/10.26656/fr.2017.7(1).816.

[8] Zhao, P., Ndayambaje, J. P., Liu, X., & Xia, X. (2020). Microbial Spoilage of Fruits: A Review on Causes and Prevention Methods. *Food Reviews International*, *38*(sup1), 225–246. https://doi.org/10.1080/87559129.2020.1858859.

[9] Devi Darshan, Bir, K., Gill, P. S., Rajbir Singh Boora, Bajaj, K., Gill, M. S., & Singh, H. (2024). Combined application of hot water and hexanal-based formulations preserves the postharvest quality of mango fruits. *Journal of the Science of Food and Agriculture*. https://doi.org/10.1002/jsfa.13695.

[10] Nguyen, M., Le, K. H., Anh, V., Dao, V. M., Do, T. D., Nguyen-Tri, P., Chang, S. W., Nguyen, D. D., & La, D. D. (2024). Enhancing mango shelf life through natural preservation: Investigating the efficacy of polysaccharide edible coating and leaf extracts. *Journal of Food and Drug Analysis*, *32*(3), 325–337. https://doi.org/10.38212/2224-6614.3512.

[11] Yao, J., Chen, W., & Fan, K. (2023). Novel Efficient Physical Technologies for Enhancing Freeze Drying of Fruits and Vegetables: A Review. *Foods*, *12*(23), 4321–4321. https://doi.org/10.3390/foods12234321.