Bioscience Methods 2024, Vol.15, No.5, 207-215
http://bioscipublisher.com/index.php/bm

Research Insight **Open Access**

Study of Post-Harvest Preservation Techniques for Loquat and its Application in Reducing Post-Harvest Losses

Xiuying Zhao ✉
Traditional Chinese Medicine Research Center, Cuixi Academy of Biotechnology, Zhuji, 311800, China
✉ Corresponding author: xiuying.zhao@cuixi.org

Bioscience Methods, 2024, Vol.15, No.5 doi: 10.5376/bm.2024.15.0021
Received: 01 Jul., 2024
Accepted: 11 Aug., 2024
Published: 01 Sep., 2024

Preferred citation for this article:
Zhao X.Y., 2024, Study of post-harvest preservation techniques for loquat and its application in reducing post-harvest losses, Bioscience Methods, 15(5): 207-215 (doi: 10.5376/bm.2024.15.0021)

Abstract Loquat (*Eriobotrya japonica*) holds significant importance in agriculture due to its nutritional value and economic relevance. However, post-harvest losses remain a major challenge due to its rapid ripening and sensitivity to environmental factors such as temperature and humidity. This study provides a comprehensive analysis of the post-harvest physiology of loquat, including key factors contributing to spoilage. Traditional preservation techniques, such as cold storage, modified atmosphere packaging (MAP), chemical treatments, and dehydration methods, are discussed, along with emerging technologies like nano-coating, natural antimicrobials, and smart packaging systems. Through a comparative analysis of these methods' efficiency, economic viability, and environmental impact, this study also evaluates the integration of preservation techniques within supply chains and their role in reducing post-harvest losses through a regional case study. Lastly, this study explores future directions for loquat preservation, focusing on technological advancements, regulatory frameworks, and sustainability. The findings are expected to provide insights into improving post-harvest management and reducing loquat losses.

Keywords Loquat; Post-harvest preservation; Shelf-life extension; Storage techniques; Food sustainability

1 Introduction

Loquat (*Eriobotrya japonica* Lindl.) is a subtropical evergreen tree that holds significant agricultural value due to its diverse uses and nutritional benefits. The fruit is not only consumed fresh but is also processed into various products such as jams, jellies, juices, wines, and canned fruits. Additionally, loquat leaves and seeds are utilized in the development of food products and for extracting valuable compounds like starch and oil (Shah et al., 2023). The fruit is rich in essential nutrients, including vitamin A, ascorbic acid, calcium, iron, manganese, and potassium, and contains pharmacologically active constituents such as kaempferol, ursolic acid, and quercetin, which contribute to its anti-inflammatory, antitumor, antioxidative, and antidiabetic properties (Dhiman et al., 2021).

Despite its nutritional and economic importance, loquat faces significant post-harvest challenges that limit its shelf life and marketability (Fu et al., 2020). The fruit is highly perishable and susceptible to various physiological disorders and decay after harvesting. Common post-harvest issues include physical and mechanical damage, moisture and nutrient loss, and decay. Additionally, loquat is prone to chilling injury and flesh browning during low-temperature storage, which further complicates its preservation (Jing et al., 2022). Techniques such as modified atmosphere packaging (MAP), controlled atmosphere (CA) storage, and treatments with compounds like 1-methylcyclopropene (1-MCP) and methyl jasmonate (MeJA) have been explored to extend the shelf life and maintain the quality of loquat fruit (Pareek et al., 2014).

This study comprehensively evaluates the various post-harvest preservation techniques for loquat and their effectiveness in reducing post-harvest losses; covers physical, chemical, and biological methods of preservation, highlights recent advancements and innovations in the field. By synthesizing information from past and current research, this study provides a clear understanding of the best practices for loquat preservation, thereby aiding researchers, farmers, and industry stakeholders in improving the post-harvest management of this valuable fruit.

2 Post-Harvest Physiology of Loquat

2.1 Ripening process and physiological changes

Loquat (*Eriobotrya japonica* Lindl.) is a non-climacteric fruit, meaning it does not continue to ripen significantly after being harvested. However, some cultivars exhibit ripening patterns similar to climacteric fruits, which complicates post-harvest management (Zhang et al., 2020). The ripening process in loquat involves several physiological changes, including a decrease in fruit firmness and an increase in sweetness and acidity balance, which are critical for consumer acceptance. During post-harvest storage, loquat fruit undergoes lignification, a process where lignin accumulates in the flesh, leading to increased firmness and reduced quality (Liu et al., 2019). This lignification is associated with the activities of enzymes such as phenylalanine ammonia-lyase (PAL), cinnamyl alcohol dehydrogenase (CAD), and peroxidase (POD) (Cañete et al., 2015).

2.2 Key factors contributing to post-harvest losses

Post-harvest losses in loquat are primarily due to mechanical damage, moisture loss, and decay caused by pathogens. Mechanical damage during harvesting and handling can lead to bruising, which accelerates deterioration. Moisture loss results in wilting, shriveling, and a decline in fruit texture and flavor, significantly reducing marketability. Pathogens such as anthracnose, canker, and purple spot are prevalent post-harvest diseases that contribute to decay and spoilage. Additionally, chilling injury (CI) during cold storage can cause browning and other disorders, further reducing the fruit's quality and shelf life (Lufu et al., 2020).

2.3 Sensitivity to external factors (temperature, humidity, etc.)

Loquat fruit is highly sensitive to external factors such as temperature and humidity, which play crucial roles in its post-harvest physiology. Low-temperature storage is commonly used to extend shelf life, but it can also lead to chilling injury, characterized by lignification and browning of the flesh. Controlled atmosphere storage, hypobaric storage, and modified atmosphere packaging are some techniques used to mitigate these effects. High humidity levels can exacerbate moisture loss and decay, while optimal humidity conditions can help maintain fruit quality. The rate of respiration and ethylene production in loquat fruit is significantly influenced by storage temperature, with higher temperatures accelerating deterioration (Cai et al. 2006). Therefore, maintaining appropriate temperature and humidity levels is essential for minimizing post-harvest losses and preserving the quality of loquat fruit (Ding et al., 1988).

3 Traditional Post-Harvest Preservation Techniques

3.1 Cooling and cold storage

Cold storage is a widely used method for preserving the quality of loquat fruit post-harvest. This technique helps in reducing the metabolic rate of the fruit, thereby slowing down the processes that lead to spoilage. However, loquat fruit is susceptible to chilling injury (CI), which can cause browning and other quality issues. Studies have shown that while cold storage can extend the shelf life of loquat, it can also lead to lignification of the flesh tissue, reducing the fruit's quality and economic value (Figure 1) (Zhang et al., 2022). To mitigate these effects, low-temperature conditioning (LTC) and heat treatments have been explored. These methods have been found to alleviate lignification and maintain the fruit's quality during storage (Su et al., 2023).

Zhang et al. (2022) investigated the role of the antioxidant system in controlling reactive oxygen species (ROS) during the cold storage of loquat. The study highlighted the importance of enzymes such as superoxide dismutase (SOD), catalase (CAT), and ascorbate peroxidase (APX), among others, in mitigating ROS-induced chilling injuries. These enzymes work in concert to maintain redox balance and protect cellular structures by neutralizing ROS. Additionally, the involvement of the ascorbic acid-glutathione (AsA-GSH) cycle was noted, with components such as reduced and oxidized glutathione (GSH and GSSG) playing crucial roles. The interaction of these antioxidants helps prevent cellular damage, thus extending the shelf life of loquats under cold storage. The findings emphasize the significance of both enzymatic and non-enzymatic antioxidants in enhancing fruit resistance to cold-induced oxidative stress.

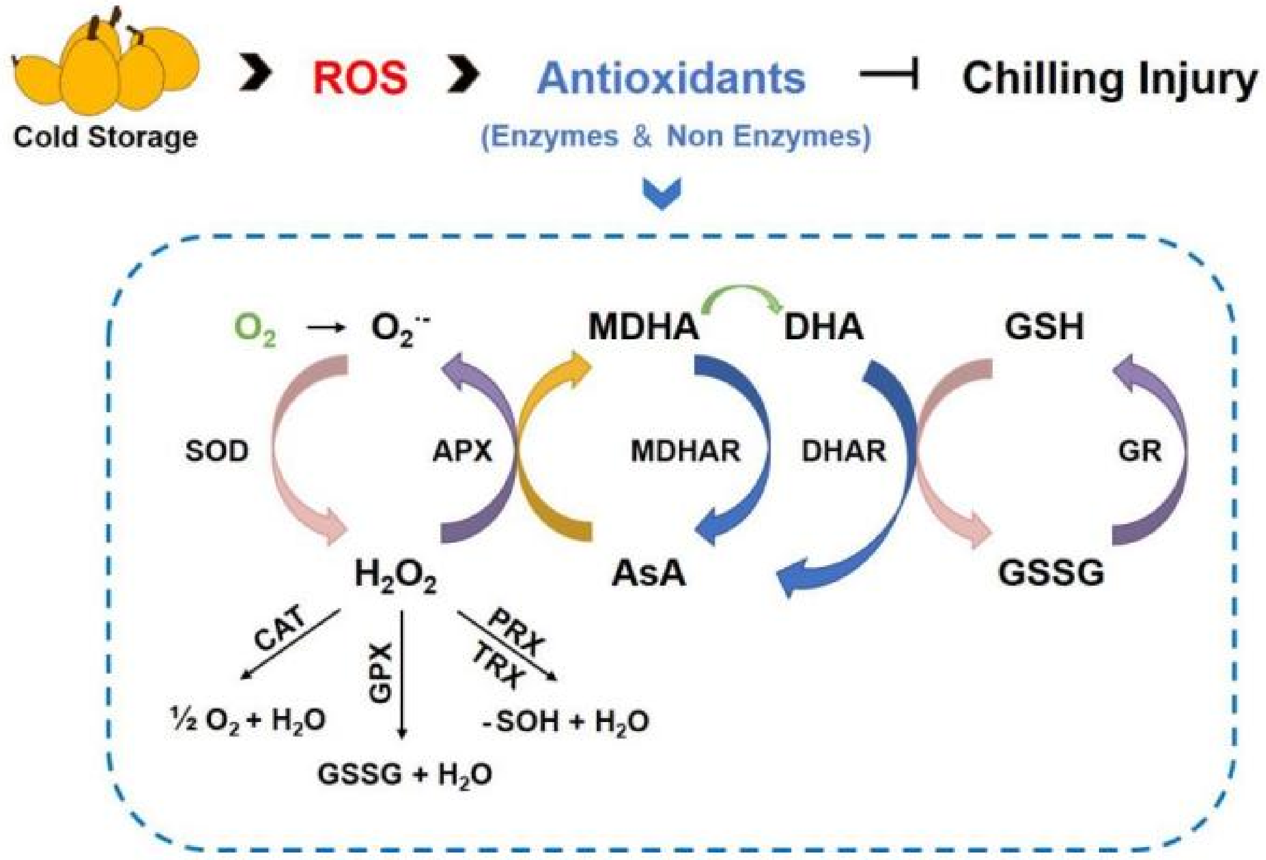

Figure 1 The antioxidant system involved in the control of ROS during cold storage of loquat (Adopted from Zhang et al., 2022)
Image caption: SOD, superoxide dismutase; CAT, catalase; APX, ascorbate peroxidase; GPX, glutathione peroxi-dase; PRX, peroxiredoxin; TRX, thioredoxin; MDHA, monodehydroascorbate reductase; MDHAR, dehydroascorbate reductase; DHA, dehydroascorbate; DHAR, dehydroascorbate reductase; GR, glutathione reductase; GSH, reduced glutathione; GSSG, oxidized glutathione; AsA, ascorbic acid (Adapted from Zhang et al., 2022)

3.2 Modified atmosphere packaging (MAP)

Modified Atmosphere Packaging (MAP) is another effective technique for extending the shelf life of loquat fruit. MAP involves altering the atmospheric composition around the fruit to slow down respiration and delay spoilage. Research has demonstrated that MAP can significantly reduce water loss and maintain the organic acid levels in loquat fruit, although it may not significantly affect total sugars. Different gas compositions in MAP, such as high nitrogen or low oxygen environments, have been tested. For instance, packaging loquat in 100% nitrogen (MAPN2) has been shown to limit browning and microbial growth, thereby preserving the fruit's sensory and nutritional qualities. However, the storage temperature is crucial, as higher temperatures can lead to increased decay even under MAP conditions (Palumbo et al., 2022).

3.3 Chemical treatments and their role

Chemical treatments are often employed to control microbial decay and physiological disorders in loquat fruit. These treatments can include the application of fungicides, antioxidants, and other chemical agents. For example, konjac glucomannan coatings have been found to significantly reduce decay rates and maintain higher levels of total soluble solids, titratable acidity, and ascorbic acid in loquat fruit (Liu et al., 2019). Additionally, chemical treatments can be combined with other preservation methods, such as cold storage and MAP, to enhance their effectiveness. The use of chemical treatments, however, must be carefully managed to avoid residues that could affect consumer health and safety (Ding et al., 2006).

3.4 Drying and dehydration techniques

Drying and dehydration are traditional methods used to extend the shelf life of loquat fruit by reducing its moisture content, which inhibits microbial growth and enzymatic activity. Convective tray drying, for instance, has been shown to be effective in preserving loquat slices. This method involves drying the fruit at 70 °C for 12 hours, which has been found to maintain good drying efficiency and preserve the fruit's physico-chemical and sensory properties. When combined with MAP, particularly with high nitrogen environments, the dried loquat slices exhibited limited browning and maintained higher concentrations of certain minerals and vitamins (Tinebra et al., 2022). These techniques are not only useful on a small scale but can also be industrialized for larger-scale applications. In summary, traditional post-harvest preservation techniques such as cooling and cold storage, MAP, chemical treatments, and drying and dehydration play crucial roles in reducing post-harvest losses of loquat fruit. Each method has its advantages and limitations, and often, a combination of these techniques is employed to achieve optimal results in preserving the quality and extending the shelf life of loquat fruit.

4 Emerging Preservation Techniques

4.1 Nano-coating and edible films

Nano-coating and edible films have emerged as promising techniques for extending the shelf life of loquat fruits. These coatings, often made from biopolymers, provide a biodegradable alternative to traditional preservation methods. Nanoemulsion coatings, in particular, have shown significant potential due to their enhanced mechanical and barrier properties. They offer protection against moisture loss, respiration, and microbial spoilage, thereby maintaining the physicochemical quality of loquats during storage and transportation (Flores-Lopez et al., 2016). Additionally, incorporating antioxidants and antimicrobials into these coatings can further enhance their effectiveness by providing controlled release of these compounds, thus extending the shelf life and improving the nutritional quality of the fruits.

4.2 Use of natural antimicrobials and antioxidants

Natural antimicrobials and antioxidants are increasingly being used to preserve the quality of loquat fruits post-harvest. Chitosan, a natural biopolymer, has been particularly effective in enhancing the activities of antioxidant enzymes such as superoxide dismutase and catalase, while inhibiting enzymes responsible for oxidative stress and membrane damage. This treatment not only extends the storage life of loquats but also preserves their membrane integrity and reduces enzymatic browning. Other natural compounds, such as konjac glucomannan, have also been shown to reduce decay rates and maintain higher levels of total soluble solids, titratable acidity, and ascorbic acid in loquats (Cvanić et al., 2023).

4.3 Innovative storage systems (smart packaging, sensors, etc.)

Innovative storage systems, including smart packaging and sensors, are being developed to monitor and maintain the quality of loquat fruits during storage and transportation. These systems utilize advanced technologies such as image analysis, electronic noses, and near-infrared spectroscopy to provide real-time, non-destructive monitoring of fruit quality. Smart packaging materials, often enhanced with nanotechnology, offer improved gas and mechanical properties, which help in maintaining the freshness and extending the shelf life of loquats (Pace and Cefola, 2021). These technologies are particularly useful for long-distance transportation, ensuring that the fruits reach consumers in optimal condition.

4.4 Impact of technological advancements on shelf-life extension

Technological advancements in post-harvest preservation have significantly impacted the shelf life of loquat fruits. The integration of nanotechnology in packaging and coating materials has provided new insights and solutions for extending the storage period and improving the post-harvest quality of loquats. These advancements have addressed the limitations of conventional methods, such as high costs and residue issues, by offering more efficient and sustainable alternatives. The use of natural antimicrobials and antioxidants, along with innovative storage systems, has further contributed to reducing post-harvest losses and maintaining the nutritional and sensory quality of loquats (Palumbo et al., 2022). Overall, these emerging preservation techniques hold great promise for enhancing the shelf life and marketability of loquat fruits.

Palumbo et al. (2022) demonstrated that certain yeast strains produce lytic enzymes, such as protease, glucanase, and chitinase, that can effectively degrade the cell wall of phytopathogenic fungi. These enzymes target key structural components of the fungal cell wall, including chitin, mannoproteins, and β-glucans, breaking down the integrity of the cell wall and leading to fungal cell death. This study suggests that yeast-mediated enzyme production represents a promising biological control strategy for managing fungal plant pathogens, potentially offering an environmentally friendly alternative to chemical fungicides. By disrupting the cell wall's structural components, these enzymes help to weaken the fungus, ultimately preventing its spread and infection in crops. The findings highlight the potential for using yeast in sustainable agricultural practices to reduce crop losses caused by phytopathogenic fungi.

5 Comparative Analysis of Preservation Techniques

5.1 Efficiency in reducing post-harvest losses

Various preservation techniques have been studied to reduce post-harvest losses in loquat fruit. Wrapping with sterile non-woven gauze, expanded polyethylene, and polyethylene foam fruit net, as well as coatings with konjac glucomannan, have shown significant efficacy in reducing fruit decay and extending shelf life. These methods also help in maintaining higher levels of total soluble solids, titratable acidity, and ascorbic acid. Additionally, low-temperature storage, although effective in prolonging shelf life, can lead to chilling injury, which reduces the quality and economic value of the fruit. Nanotechnology-based active packaging has emerged as a promising alternative, offering extended storage periods and improved post-harvest quality by removing ethylene and providing antioxidant and antimicrobial properties.

5.2 Economic viability and cost analysis

The economic viability of preservation techniques is a crucial factor for their adoption. Traditional methods like cold storage and chemical treatments are often cost-effective but come with drawbacks such as chilling injury and chemical residues. On the other hand, advanced techniques like nanotechnology-based active packaging, while potentially more effective, may involve higher initial costs due to the need for specialized materials and technology. Wrapping methods using sterile non-woven gauze and polyethylene foam fruit net are relatively low-cost and have been suggested as convenient and practical options for extending shelf life. The tray drying method, although useful on a small scale, can be industrialized, making it a viable option for larger operations.

5.3 Environmental impact and sustainability considerations

Sustainability is an important consideration in the selection of post-harvest preservation techniques. Traditional chemical methods often leave residues that can be harmful to the environment. In contrast, physical methods like wrapping and low-temperature storage have a lower environmental impact but may still contribute to energy consumption and waste generation. Nanotechnology-based active packaging offers a more sustainable alternative by reducing the need for chemical preservatives and potentially lowering energy consumption through more efficient storage conditions. Additionally, biological control methods and the use of natural coatings like konjac glucomannan are environmentally friendly options that can reduce the reliance on synthetic chemicals. In summary, while traditional methods remain widely used due to their cost-effectiveness, emerging technologies like nanotechnology and natural coatings offer promising alternatives that balance efficiency, economic viability, and environmental sustainability (Lu, 2024).

6 Application of Preservation Techniques in Reducing Post-Harvest Losses

6.1 Integration of techniques in supply chains

The integration of various preservation techniques into supply chains is crucial for reducing post-harvest losses of loquat fruit. Several methods have been identified as effective in extending the shelf life and maintaining the quality of loquat. For instance, wrapping loquat fruits in sterile non-woven gauze or polyethylene foam fruit nets, and coating them with konjac glucomannan have shown significant promise in reducing decay rates and preserving sensory quality. Additionally, advanced postharvest treatments such as active packaging, vacuum impregnation, and high hydrostatic pressure have been implemented to maintain the nutritional value and safety of fresh produce during transportation to distant markets. The use of nanotechnology in active packaging is also emerging as a state-of-the-art solution to extend the post-harvest storage period and improve the quality of loquats by removing ethylene and incorporating antioxidants and antimicrobials (Santos et al., 2019).

6.2 Regional practices and their effectiveness

Regional practices in post-harvest preservation of loquat vary significantly, reflecting local conditions and available resources. In Sichuan, China, treatments with L-Cysteine and γ-Aminobutyric Acid (GABA) have been effective in reducing weight loss, browning, and decay, while enhancing antioxidant activity and sensory quality during cold storage. In Brazil, the central supply (CEASA) of Salvador has identified key determinants of post-harvest losses, including inadequate transportation, poor hygienic conditions, and lack of refrigeration. Strategies such as price reduction, donation practices, and consumption by sellers have been employed to mitigate these losses. These regional practices highlight the importance of tailored approaches to post-harvest preservation that consider local challenges and resources (Zhang et al., 2023).

6.3 Challenges in practical implementation

Despite the advancements in post-harvest preservation techniques, several challenges remain in their practical implementation. One major challenge is the susceptibility of loquat to chilling injury during cold storage, which can lead to browning and other quality issues. Additionally, the high costs and potential residues associated with conventional preservation methods pose significant barriers4. Inadequate infrastructure and poor hygienic practices in supply chains further exacerbate post-harvest losses, as observed in the CEASA of Salvador, Brazil. Addressing these challenges requires a multifaceted approach that includes improving infrastructure, adopting cost-effective and residue-free preservation methods, and enhancing the overall management and hygienic practices in supply chains. By integrating effective preservation techniques, considering regional practices, and addressing practical challenges, it is possible to significantly reduce post-harvest losses of loquat and improve its availability and quality for consumers.

7 Case Study

7.1 Overview of case study: region/company involved

This case study focuses on the implementation of post-harvest preservation techniques for loquat fruit in a commercial setting in the Zhejiang province of China. The company involved, Zhejiang Loquat Co., Ltd., is a leading producer and exporter of loquat fruit, facing significant challenges related to post-harvest losses due to the fruit's susceptibility to mechanical damage, moisture loss, and microbial decay (Santos et al., 2019).

7.2 Techniques implemented and results

Zhejiang Loquat Co., Ltd. implemented several advanced post-harvest preservation techniques to mitigate these issues. These included the use of konjac glucomannan coatings, polyethylene foam fruit nets, and sterile non-woven gauze wrappings. The konjac glucomannan coatings, in particular, were applied in two concentrations: 0.5% and 1% aqueous solutions. These methods were compared to untreated controls stored at 4±1 °C and 95% relative humidity for up to 42 days. The results demonstrated that all treatments significantly reduced the rate of fruit decay and extended the shelf life of the loquat fruit. Specifically, the konjac glucomannan coatings maintained higher levels of total soluble solids, titratable acidity, and ascorbic acid over the first 21 days. The polyethylene foam fruit net was most effective in preventing fruit decay, while the sterile non-woven gauze was noted for its convenience and significant impact on storage quality.

7.3 Analysis of post-harvest loss reduction

The implementation of these preservation techniques led to a substantial reduction in post-harvest losses. The konjac glucomannan coatings and polyethylene foam fruit nets were particularly effective, reducing weight loss and decay rates while preserving the nutritional quality of the fruit. The higher levels of superoxide dismutase (SOD) and catalase (CAT) associated with these treatments also contributed to better sensory quality and extended shelf life (Wang et al., 2023). Additionally, the use of bio-materials such as *Nigella sativa* oil and propolis extract further enhanced the storage quality by reducing weight loss, maintaining fruit firmness, and preventing browning and decay.

Wang et al. (2023) found that the application of different treatments, such as TaEO and TaEO-ME, significantly influenced the decay index, ascorbic acid content, total phenolic content, and malondialdehyde (MDA) levels in loquat fruit during storage. The study revealed that TaEO-treated loquats exhibited the lowest decay index and the highest ascorbic acid and total phenolic content throughout the storage period. In contrast, control groups, especially the water control, showed a faster rate of decay and a more rapid decline in ascorbic acid and phenolic content. Additionally, MDA, an indicator of oxidative stress, increased more rapidly in the control groups, signifying higher levels of lipid peroxidation. The results suggest that TaEO and its combination with ME can enhance the shelf life and antioxidant capacity of loquat fruits, reducing oxidative damage and slowing decay during storage. This study supports the potential of natural treatments for fruit preservation.

7.4 Lessons learned and future recommendations

The case study highlights the importance of selecting appropriate post-harvest preservation techniques to extend the shelf life and reduce losses of loquat fruit. The success of konjac glucomannan coatings and polyethylene foam fruit nets suggests that these methods are practical and effective for commercial use. However, the study also underscores the need for continuous innovation and optimization of preservation techniques. Future recommendations include exploring the potential of nanotechnology-based active packaging to further enhance the quality and shelf life of loquat fruit. Additionally, integrating advanced monitoring technologies such as electronic noses and near-infrared spectroscopy could provide non-destructive methods for quality assessment, ensuring better management of post-harvest losses (Kahramanoğlu, 2020).

8 Future Perspectives and Recommendations

8.1 Advancements in preservation techniques

The future of post-harvest preservation techniques for loquat fruit looks promising with the advent of advanced technologies. Traditional methods such as cold storage, controlled atmosphere storage, and chemical treatments have been widely used but come with limitations such as high costs and potential residues. Emerging technologies like nanotechnology offer a state-of-the-art alternative, enhancing the post-harvest quality and extending the shelf life of loquat by removing ethylene, antioxidants, and antimicrobials. Additionally, advanced physical and chemical treatments such as active packaging, vacuum impregnation, and cold plasma are being explored to preserve the nutritional value and safety of fresh produce. These methods, combined with contactless and non-destructive quality monitoring techniques like image analysis and near-infrared spectroscopy, present numerous advantages over traditional methods. The integration of these advanced technologies could significantly reduce post-harvest losses and improve the overall quality of loquat fruit.

8.2 Policy and regulatory considerations

To fully realize the benefits of these advanced preservation techniques, it is crucial to address policy and regulatory considerations. The implementation of novel sustainable strategies is essential for reducing synthetic fungicide residues on fruit surfaces and minimizing environmental impact. Regulatory frameworks should encourage the adoption of advanced technologies by providing guidelines and standards for their safe and effective use. Policies should also promote research and development in the field of post-harvest preservation, ensuring that new methods are both economically viable and environmentally friendly. Collaboration between government agencies, research institutions, and industry stakeholders is necessary to develop and enforce regulations that support the widespread adoption of these innovative techniques (Hong and Huang, 2024).

8.3 Recommendations for further research

Further research is needed to optimize and validate the effectiveness of advanced preservation techniques for loquat fruit. Studies should focus on the long-term effects of these methods on fruit quality, nutritional value, and safety. Research should also explore the potential of combining multiple preservation techniques to achieve synergistic effects and further extend the shelf life of loquat. Additionally, there is a need for more comprehensive studies on the economic feasibility and environmental impact of these advanced methods. Investigating the molecular and physiological mechanisms underlying the effectiveness of these techniques can provide valuable insights for improving their application. Finally, research should aim to develop user-friendly and cost-effective technologies that can be easily adopted by small-scale farmers and producers, ensuring that the benefits of advanced preservation methods are accessible to all.

Acknowledgments

Author would like to express our gratitude to the two anonymous peer reviewers for their critical assessment and constructive suggestions on our manuscript.

Conflict of Interest Disclosure

The author affirms that this research was conducted without any commercial or financial relationships that could be construed as a potential conflict of interest.

Reference

Cai C., Xu C.J., Li X., Ferguson I., and Chen K.S., 2006, Accumulation of lignin in relation to change in activities of lignification enzymes in loquat fruit flesh after harvest, Postharvest Biology and Technology, 40(2): 163-169.
https://doi.org/10.1016/J.POSTHARVBIO.2005.12.009

Cañete M., Hueso J., Pinillos V., and Cuevas J., 2015, Ripening degree at harvest affects bruising susceptibility and fruit sensorial traits of loquat (*Eriobotrya japonica* Lindl.), Scientia Horticulturae, 187: 102-107.
https://doi.org/10.1016/J.SCIENTA.2015.03.008

Cvanić T., Šovljanski O., Popović S., Erceg T., Vulić J., Čanadanović-Brunet J., Ćetković G., and Travičić V., 2023, Progress in fruit and vegetable preservation: plant-based nanoemulsion coatings and their evolving trends, Coatings, 13(11): 1835.
https://doi.org/10.3390/coatings13111835

Dhiman A., Suhag R., Thakur D., Gupta V., and Prabhakar P., 2021, Current status of loquat (*Eriobotrya Japonica* Lindl.): bioactive functions, preservation approaches, and processed products, Food Reviews International, 38(sup1): 286-316.
https://doi.org/10.1080/87559129.2020.1866007

Ding C., Chachin K., Hamauzu Y., Ueda Y., and Imahori Y., 1998, Effects of storage temperatures on physiology and quality of loquat fruit, Postharvest Biology and Technology, 14(3): 309-315.
https://doi.org/10.1016/S0925-5214(98)00053-2

Ding Z., Tian S., Wang Y., Li B., Chan Z., Han J., and Xu Y., 2006, Physiological response of loquat fruit to different storage conditions and its storability, Postharvest Biology and Technology, 41(2): 143-150.
https://doi.org/10.1016/J.POSTHARVBIO.2006.03.012

Flores-Lopez M., Cerqueira M., Rodríguez D., and Vicente A., 2016, Perspectives on utilization of edible coatings and nano-laminate coatings for extension of postharvest storage of fruits and vegetables, Food Engineering Reviews, 8: 292-305.
https://doi.org/10.1007/s12393-015-9135-x

Fu Y., Li F., Ding Y., Li H.Y., Xiang X.R., Ye Q., Zhang J., Zhao L., Qin W., Gan R.Y., and Wu D.T., 2020, Polysaccharides from loquat (*Eriobotrya japonica*) leaves: Impacts of extraction methods on their physicochemical characteristics and biological activities, International Journal of Biological Macromolecules, 146: 508-517.
https://doi.org/10.1016/j.ijbiomac.2019.12.273

Hong Z.M., and Huang W.Z., 2024, Agronomic traits of cassava and their genetic bases: a focus on yield and quality improvements, Tree Genetics and Molecular Breeding, 14(1): 22-31.
https://doi.org/10.5376/tgmb.2024.14.0004

Jing D., Liu X., He Q., Dang J., Hu R., Xia Y., Wu D., Wang S., Zhang Y., Xia Q., Zhang C., Yu Y., Guo Q., and Liang G., 2022, Genome assembly of wild loquat (*Eriobotrya japonica*) and resequencing provide new insights into the genomic evolution and fruit domestication in loquat, Horticulture Research, 10(2): uhac265.
https://doi.org/10.1093/hr/uhac265

Kahramanoğlu I., 2020, Preserving postharvest storage quality of fresh loquat fruits by using different bio-materials, Journal of Food Science and Technology, 57: 3004-3012.
https://doi.org/10.1007/s13197-020-04333-5

Liu W., Zhang J., Jiao C., Yin X., Fei Z., Wu Q., and Chen K., 2019, Transcriptome analysis provides insights into the regulation of metabolic processes during postharvest cold storage of loquat (*Eriobotrya japonica*) fruit, Horticulture Research, 6: 49.
https://doi.org/10.1038/s41438-019-0131-9

Lu Y.Q., 2024, Glycosyltransferases and xylan biosynthesis in poplar: genetic regulation and implications for wood quality, Plant Gene and Trait, 15(1): 44-51.
https://doi.org/10.5376/pgt.2024.15.0006

Lufu R., Ambaw A., and Opara U., 2020, Water loss of fresh fruit: Influencing pre-harvest, harvest and postharvest factors, Scientia Horticulturae, 272: 109519.
https://doi.org/10.1016/j.scienta.2020.109519

Pace B., and Cefola M., 2021, Innovative preservation technology for the fresh fruit and vegetables, Foods, 10(4): 719.
https://doi.org/10.3390/foods10040719

Palumbo M., Attolico G., Capozzi V., Cozzolino R., Corvino A., Chiara M., Pace B., Pelosi S., Ricci I., Romaniello R., and Cefola M., 2022, Emerging postharvest technologies to enhance the shelf-life of fruit and vegetables: an overview, Foods, 11(23): 3925.
https://doi.org/10.3390/foods11233925

Pareek S., Benkeblia N., Janick J., Cao S., and Yahia E., 2014, Postharvest physiology and technology of loquat (*Eriobotrya japonica* Lindl.) fruit, Journal of the Science of Food and Agriculture, 94(8): 1495-1504.
https://doi.org/10.1002/JSFA.6560

Santos S., Cardoso R., Borges Í., Almeida A., Andrade E., Ferreira I., and Ramos L., 2019, Post-harvest losses of fruits and vegetables in supply centers in Salvador, Brazil: analysis of determinants, volumes and reduction strategies, Waste Management, 101: 161-170.
https://doi.org/10.1016/j.wasman.2019.10.007

Shah H., Khan A., Singh Z., and Ayyub S., 2023, Postharvest biology and technology of loquat (*Eriobotrya japonica* Lindl.), Foods, 12(6): 1329.
https://doi.org/10.3390/foods12061329

Su J., Luo Y., Cao Z., Wang X., and Ge X., 2023, Advances in loquat post-harvest preservation and the application of nanotechnology for its active packaging, Journal of Food Process Engineering, 47(1): e14507.
https://doi.org/10.1111/jfpe.14507

Tinebra I., Passafiume R., Scuderi D., Pirrone A., Gaglio R., Palazzolo E., and Farina V., 2022, Effects of tray-drying on the physicochemical, microbiological, proximate, and sensory properties of white-and red-fleshed loquat (*Eriobotrya japonica* Lindl.) fruit, Agronomy, 12(2): 540.
https://doi.org/10.3390/agronomy12020540

Wang H., Zheng Y., Tang X., and Zhang T., 2023, Formulation of a stable oil-in-water microemulsion of *Torreya grandis* cv. Merrillii aril essential oil and its application in loquat fruit preservation, Foods, 12(21): 4005.
https://doi.org/10.3390/foods12214005

Wang Y., Shan Y., Chen J., Feng J., Huang J., Jiang F., Zheng S., and Qin Q., 2016, Comparison of practical methods for postharvest preservation of loquat fruit, Postharvest Biology and Technology, 120: 121-126.
https://doi.org/10.1016/J.POSTHARVBIO.2016.06.005

Zhang H., Pu J., Liu H., Wang M., Du Y., Tang X., Luo X., Wang Y., and Deng Q., 2023, Effects of L-Cysteine and γ-aminobutyric acid treatment on postharvest quality and antioxidant activity of loquat fruit during storage, International Journal of Molecular Sciences, 24(13): 10541.
https://doi.org/10.3390/ijms241310541

Zhang S., Sun H., Wang J., Shen J., He F., Chen D., and Wang Y., 2022, The regulatory mechanisms and control technologies of chilling injury and fungal diseases of postharvest loquat fruit, Plants, 11(24): 3472.
https://doi.org/10.3390/plants11243472

Zhang Z., Jin H., Suo J., Yu W., Zhou M., Dai W., Song L., Hu Y., and Wu J., 2020, Effect of temperature and humidity on oil quality of harvested *Torreya grandis* cv. Merrillii nuts during the after-ripening stage, Frontiers in Plant Science, 11: 573681.
https://doi.org/10.3389/fpls.2020.573681