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STUDIES ON HOLISTIC METHODS TO EXTEND THE SHELF LIFE AND INCREASE THE QUALITY OF GUAVA (*PSIDIUM GUAJAVA* L.)

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Abstract– The tropical fruit guava (*Psidium guajava* L.) is renowned for its distinct flavour and health benefits. Guava's high perishability, however, makes it difficult for the fruit sector to preserve its quality and increase its shelf life. In recent years, researchers have concentrated on creating integrated systems that include multiple pre-harvest, post-harvest, and storage strategies in order to enhance the quality and shelf life of guava. Interventions made prior to harvest are essential to improving guava quality. Improving fruit size, colour, and nutritional value can be accomplished through enhancing irrigation, fertilization, and insect control procedures. Furthermore, the application of growth regulators, such as plant hormones and bio stimulants, has produced encouraging results in terms of improving fruit quality traits including firmness, sugar content, and scent. Premature fruit ripening and degradation may be avoided by using proper harvesting methods, such as selective plucking based on maturity indices. Moreover, guava's shelf life may be increased by using methods including hot water treatment, wax coating, and changed environment packing to successfully suppress fungal development, postpone senescence, and prolong the life of the fruit. Guava quality and shelf life are substantially impacted by storage conditions. Fruit quality may be kept intact for a longer amount of time by maintaining proper levels of temperature and humidity as well as by utilising cutting-edge storage techniques like controlled environment storage and ethylene scrubbers. Additionally, by suppressing microbiological development and postponing physiological degradation, the incorporation of natural substances like as essential oils and edible coatings has the potential to extend the shelf life of guava. Guava quality and shelf life have been shown to be improved by integrated techniques that incorporate numerous treatments. The industry may increase fruit quality, minimize post-harvest losses, and satisfy customer needs for fresh, nutritious, and longer-lasting guava by applying pre-harvest practices, adopting proper post-harvest handling procedures, and utilizing optimal storage strategies. However, further study is required to improve these methods, create standardized procedures, and make sure that they can be used successfully and sustainably in the production of commercial guavas.

INTRODUCTION

Tropical fruit known as guava (*Psidium guajava* L.) is prized for its distinct flavour, scent, and health benefits. Guava's limited shelf life, however, presents a problem for growers, distributors, and customers. Researchers have looked into combined strategies to enhance guava quality and lengthen shelf life to meet this issue. To create synergistic effects and improve preservation outcomes, integrated methods combine a variety of procedures and treatments. These methods seek to preserve the guava's important qualitative characteristics, including as taste, texture, colour, and nutritional value, while also preventing microbial development and postponing senescence processes.

In order to adopt integrated techniques in guava preservation, a variety of methodologies have been examined. The application of post-harvest therapies is a prominent field of research. The use of physical and chemical treatments to improve the quality and shelf life of guava has been the subject of several investigations. As an illustration, hot water treatments, such as hot water immersion or hot air treatments, have been investigated to stop fruit from rotting and enhance quality overall. These treatments successfully lessen microbial burden, postpone ripening, and prevent pathogen growth (Viduranga *et al.*, 2019).

The application of modified atmosphere packaging (MAP) is a key component of integrated techniques. MAP entails changing the storage

environment's makeup to give the fruit the ideal habitat. MAP can efficiently decrease respiration rate, delay ripening, and prevent microbial development by regulating variables including humidity, oxygen, and carbon dioxide levels. Studies have shown the major advantages of MAP in keeping the quality of guava while prolonging its shelf life (Nisperos-Carriedo *et al*., 2010).

Furthermore, as part of integrated efforts to improve guava quality and shelf life, the use of natural chemicals and biocontrol agents has been investigated. Researchers have looked at the antibacterial qualities and capacity of essential oils obtained from herbs like oregano, thyme, and cinnamon to prevent fruit rotting (Albuquerque *et al*., 2016). Yeast and bacteria are examples of biocontrol agents that have demonstrated promise as environmentally acceptable substitutes for chemical treatments by actively rejecting pathogens or creating antimicrobial substances to safeguard guava fruits during storage (Srivastava *et al*., 2016).

Finally, combined solutions that include post-harvest treatments, modified environment packing, the use of natural chemicals, and the use of biocontrol agents' present viable methods to enhance guava quality and lengthen shelf life. These methods aid in lowering post-harvest losses, boosting market accessibility, and improving customer satisfaction.

Integrated Approaches

To create synergistic effects and improve preservation results, integrated methods combine a variety of methodologies and tactics. These methods seek to preserve the essential qualities of guava, including as taste, texture, colour, and nutritional value, while also preventing microbial development and postponing senescence processes. Use of post-harvest treatments is a significant topic of research in integrated systems. The use of physical and chemical treatments to improve the quality and shelf life of guava has been the subject of several investigations. In order to prevent fruit rot and enhance overall quality, hot water treatments, such as hot water immersion or hot air treatments, have been studied. These treatments successfully lessen microbial burden, postpone ripening, and prevent pathogen growth.

Integrated techniques have concentrated on using modified atmosphere packaging (MAP) in addition to post-harvest treatments to increase the shelf life of guava. MAP entails changing the storage environment's makeup to give the fruit the ideal habitat. MAP can efficiently decrease respiration rate, delay ripening, and prevent microbial development by regulating variables including humidity, oxygen, and carbon dioxide levels. Studies have shown the major advantages of MAP in extending guava's shelf life while maintaining its quality (Dagar *et al*., 2020).

Furthermore, as part of integrated efforts to improve guava quality and shelf life, the use of natural chemicals and biocontrol agents has been investigated. Fruit rot can be prevented by using essential oils made from herbs like oregano, thyme, and cinnamon, which have antibacterial characteristics.

Yeast or bacteria are examples of biocontrol agents that have shown promise as environmentally benign alternatives to chemical treatments. To safeguard guava fruits during storage, they can create antibacterial chemicals or compete to exclude pathogens (Sharma *et al*., 2019).

Integrated methods that include post-harvest treatments, changed environment packing, the use of natural compounds, and biocontrol agents present viable techniques to enhance guava quality and lengthen shelf life. These methods aid in lowering post-harvest losses, boosting market accessibility, and improving customer satisfaction.

Plant growth regulators that improve the quality and shelf life in guava

Plant growth regulators (PGRs) are essential for enhancing fruit quality and shelf life, especially that of the guava (*Psidium guajava*). PGRs are chemicals, either artificially made or naturally occurring, that control a number of physiological processes in plants, including growth, development, and ripening. The use of certain PGRs in guava has been investigated to improve fruit quality characteristics and lengthen post-harvest storage.

A chemical that occurs naturally in plants, ethylene, causes fruit to ripen and plants to age. The ripening process can be slowed, extending the shelf life, by blocking ethylene activity or synthesis. For instance, it has been demonstrated that the use of 1-methylcyclopropene (1-MCP), an inhibitor of ethylene activity, successfully delays fruit softening, lowers decay, and preserves the quality of guava during storage (Russo *et al*., 2019).

Antioxidants are another class of PGRs utilized to preserve guava. Reactive oxygen species (ROS) and oxidative processes, which contribute to fruit

degradation, are scavenged by antioxidants. In order to prevent post-harvest deterioration, retain firmness, and improve the nutritional value of guava, antioxidants including salicylic acid (SA) and ascorbic acid (vitamin C) have been used (Sawicki *et al*., 2020).

Gibberellins (GAs), a class of plant hormones, have also been investigated for their effect on the calabash fruit's quality. According to research by Lara-Guzmán *et al*. (2018), the exogenous application of GA to guava has been found to increase fruit size, improve colour development, boost soluble solids content, and postpone fruit softening.

Future Trends and Technology Approaches to Improve the Quality and Shelf Life in Guava

Researchers are investigating upcoming trends and technologies to improve the fruit's quality and lengthen its shelf life as the demand for high-quality and longer-lasting guava (*Psidium guajava*) continues to grow. These developments are made to reduce post-harvest losses, increase supply chain effectiveness, and satisfy customer demand for healthy and fresh guava.

Nanotechnology adoption is one of the key preservation trends of the future. The use of nanoparticles to enhance fruit quality and stop microbial development has showed promise. Examples include silver nanoparticles and chitosan nanoparticles. These nanoparticles can provide antibacterial and antioxidant qualities to edible coatings or packaging materials, prolonging the shelf life of guava (Mahmoudi *et al*., 2021).

A further new technique that may be used to monitor and regulate the quality of guava throughout storage and transit is the use of smart packaging solutions. These intelligent packaging systems evaluate numerous characteristics including temperature, humidity, and gas composition using sensors, indicators, and data analysis tools. As a result of rapid actions to maintain ideal storage conditions and extend the shelf life of guava, real-time monitoring is possible (Qin *et al*., 2021)

For enhancing guava quality and safety, non-thermal processing methods including pulsed electric field (PEF) and high-pressure processing (HPP) are also receiving interest. These approaches can minimize enzymatic activity, inactivate spoilage bacteria, and maintain the nutritional value of guava. In contrast to conventional thermal processing techniques, HPP and PEF offer the benefit of being non-thermal, which helps preserve the sensory qualities and nutritional value of guava (Damar *et al*., 2022).

Guava variants with improved shelf life and quality attributes are being developed using genetic engineering and biotechnology as well. To increase resistance to pests, illnesses, and post-harvest problems, researchers are looking at genetic modification. The texture, flavour, and nutritional value of guava may also be improved using targeted gene expression and metabolic engineering techniques (Chen *et al*., 2022).

Latest Technologies

Emerging technologies are also included into integrated ways to enhance guava quality and shelf life. For example, fruit preservation has showed promise for nanotechnology. The shelf life of guava can be increased by adding nanoparticles with antibacterial and antioxidant capabilities, such as silver nanoparticles and chitosan nanoparticles, to edible coatings or packaging materials (Mahmoudi *et al*., 2021). High-pressure processing (HPP) and pulsed electric field (PEF) are two non-thermal processing technologies that have come into use as alternatives to conventional thermal processing. These methods efficiently limit enzymatic activity, inactivate spoilage bacteria, and maintain the nutritional value of guava (Damar *et al*., 2022).

Research on Integrated Approaches to Improve the Quality and Shelf Life in Guava

Post-harvest remedies are the subject of one field of research. The use of physical and chemical treatments to improve guava quality and lengthen its shelf life has been investigated in a number of researches. For instance, it has been demonstrated that hot water treatments may successfully lower decay and preserve the guava's overall quality. To reduce microbial burden, postpone ripening, and prevent the growth of pathogens, hot water immersion or hot air treatments have been utilized (Viduranga *et al*., 2019).

The use of modified atmosphere packaging (MAP) to extend the shelf life of guava has also attracted interest. To optimize conditions for preservation, MAP entails changing the makeup of the storage environment around the fruit. MAP may efficiently slow down the ripening process, lower respiration rate, and suppress microbial development byregulating variables including oxygen and carbon dioxide levels as well as

humidity. According to research by Nisperos-Carriedo *et al.* (2010), this method greatly increases the shelf life of guava while maintaining its quality.

To improve guava quality and increase its shelf life, the use of natural chemicals and biocontrol agents has also been investigated. Plants like oregano, thyme, and cinnamon produce essential oils that have antibacterial qualities and the capacity to prevent fruit rot. To give antibacterial and antioxidant properties and lengthen the shelf life of guava, these natural components can be added to edible coatings or packaging materials (Albuquerque *et al*., 2016).

The use of biocontrol agents, such as helpful bacteria and yeast, has also been researched as an environmentally benign substitute for chemical treatments. To safeguard guava fruits during storage, these biocontrol agents can create antimicrobial chemicals or actively compete with pathogens to exclude them. Research has shown that they can preserve the quality of guava while prolonging its shelf life and preventing deterioration (Srivastava *et al.,* 2016).

Technology advancements have encouraged the development of novel methods to enhance guava quality and shelf life in addition to post-harvest treatments. Fruit preservation has the potential to be improved via nanotechnology. To offer antibacterial and antioxidant properties, edible coatings or packaging materials can integrate nanoparticles, such as silver nanoparticles and chitosan nanoparticles. It has been shown that these nanoparticles can prevent microbial development, postpone fruit ripening, and lengthen guava fruit's shelf life (Mahmoudi *et al.,* 2021).

The use of non-thermal processing methods, such as high-pressure processing (HPP) and pulsed electric field (PEF), is another growing technology. These approaches can minimise enzymatic activity, inactivate spoilage bacteria, and maintain the nutritional value of guava. Non-thermal processing procedures offer the benefit over conventional thermal processing methods in that they maintain the guava's sensory qualities and nutritional content (Damar *et al*., 2022).

Additionally investigated to enhance guava quality and shelf life are genetic engineering and biotechnology. To improve resistance against pests, illnesses, and post-harvest disorders, researchers are looking at genetic modification. The texture, flavour, and nutritional value of guava may also be improved via targeted gene expression and metabolic engineering techniques (Chen *et al.,* 2022).

In conclusion, a variety of techniques and technologies are used in research projects targeted at enhancing the guava's quality and shelf life. Post-harvest procedures including hot water treatments and packing in changed atmospheres have produced encouraging outcomes. Guava quality may be improved and its shelf life increased by using natural ingredients, biocontrol agents, nanotechnology, non-thermal processing methods, and genetic engineering. These developments help satisfy customer demand for fresh and wholesome product while lowering post-harvest losses, guaranteeing a consistent supply of high-quality guava, and minimizing post-harvest losses.

Post-harvest and Pre-harvest Techniques to Improve the Quality and Shelf Life of Guava

The guava (*Psidium guajava* L.) has a very limited shelf life and is a very perishable fruit. Therefore, employing efficient pre-harvest and post-harvest procedures is essential to improving guava fruits' quality and extending their shelf life. Some of the most important methods that have been researched and used to accomplish these objectives are covered in this article.

Pre-harvest methods

1. Correct stage of fruit harvesting: Guava fruit quality and shelf life must be preserved by picking them at the right stage of ripeness. Fruits should be picked when they attain physiological maturity, which is characterized by fully developed colour and flavour in addition to full-sized fruits. Poor quality and a shorter shelf life might come from harvesting too soon or too late.
2. Optimized irrigation and nutrient management: Throughout the growing season, a sufficient supply of water and nutrients is necessary for the growth of high-quality guava fruits. Based on soil and leaf analyses, proper irrigation and balanced fertilization can help produce fruit with the ideal size, texture, and nutritional value, eventually improving post-harvest quality.

Post-harvest techniques

1. Guava fruits should be stored cold since they are very perishable and prone to bacterial and fungal development. The shelf life of guava fruits can be greatly increased by cold storage at temperatures between 8 °C and 10 °C because it slows the ripening process and prevents microbial activity.

However, extended cold storage might result in chilling harm, therefore it's crucial to plan your storage time wisely.

2. Guava fruits can be packaged using modified atmosphere packaging (MAP) to preserve fruit quality and increase shelf life. MAP entails changing the gas composition around the fruits by elevating carbon dioxide levels while lowering oxygen levels. This method preserves the quality of guava fruits during storage by reducing respiration rates, delaying fruit ripening, and preventing microbial development.
3. Post-harvest procedures: Several post-harvest procedures have been researched to extend the shelf life and improve the flavour of guava fruits, including hot water treatment, waxing, and application of edible coatings. While waxing and edible coatings offer a protective layer, minimizing water loss and preserving fruit firmness and beauty, hot water treatment can reduce fungal infections.

Natural substances and bio controlling substances

In order to improve guava quality and lengthen shelf life, researchers have also looked at the use of natural substances and biocontrol agents. Fruit rot can be prevented by using essential oils made from herbs like oregano, thyme, and cinnamon, which have antibacterial characteristics. To increase the shelf life of guava and provide antibacterial and antioxidant properties, these natural chemicals can be added to edible coatings or packaging materials (Albuquerque *et al.,* 2016). According to Srivastava *et al*. (2016), biocontrol agents, such as helpful microorganisms like yeast and bacteria, have shown encouraging results in preventing decay and increasing the shelf life of guava while maintaining the fruit's safety and quality.

CONCLUSION

In summary, integrated strategies to enhance the guava's (*Psidium guajava*) quality and shelf life have shown to be successful in resolving the issues posed by post-harvest losses and retaining the freshness and nutritional content of the fruit. Researchers have made tremendous progress in improving guava quality and prolonging its shelf life by fusing several technologies and tactics.

The use of plant growth regulators (PGRs), such as ethylene inhibitors, antioxidants, and gibberellins, is one of the most important integrated techniques. These PGRs have been shown to prevent fruit from rotting, delay fruit ripening, and preserve fruit firmness, colour, and nutritional value while in storage. Specific PGRs, such as salicylic acid, ascorbic acid, and 1-methylcyclopropene (1-MCP), when applied, have demonstrated promising benefits in increasing the shelf life of guava. The quality and shelf life of guava have also been greatly improved by post-harvest procedures such as hot water treatments, modified atmosphere packing (MAP), the use of natural chemicals, and biocontrol agents. While MAP enables the optimization of storage conditions to delay ripening and prevent microbial growth, hot water treatments efficiently control microbial load and hinder the development of pathogens. The use of biocontrol agents and the infusion of natural substances such essential oils has demonstrated antibacterial qualities and the capacity to decrease decay, further extending the shelf life of guava. Moreover, new opportunities for enhancing guava quality and shelf life have been made possible by the implementation of cutting-edge technologies including nanotechnology, non-thermal processing methods, and genetic engineering. While non-thermal processing methods like high-pressure processing (HPP) and pulsed electric field (PEF) help inactivate spoilage microorganisms and preserve the nutritional content of guava, nanoparticles added to edible coatings or packaging materials offer antimicrobial and antioxidant effects. With the use of genetic engineering, it may be possible to increase guava types' nutritional value, texture, flavour, and resistance to pests, diseases, and post-harvest disorders.

It is significant to stress that an in-depth knowledge of guava physiology, post-harvest biology, and the unique needs of the fruit are necessary for integrated methods to succeed. To maximise the effectiveness of these strategies, factors including temperature, humidity, gas composition, and storage conditions must be carefully regulated. To guarantee widespread acceptance and impact, it is also crucial to design solutions that are affordable, sustainable, and adaptable to various production sizes and geographical locations. To sum up, integrated strategies that include the use of plant growth regulators, post-harvest treatments, new technology, and genetic engineering show tremendous potential for enhancing the quality and prolonging the shelf life of guava. These methods help to reduce post-

harvest losses, increase supply chain effectiveness, and satisfy customer demand for healthy, fresh guava. Growers, distributors, and consumers will all gain from further study and innovation in this area as it will improve our knowledge of how to improve guava quality and shelf life.

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