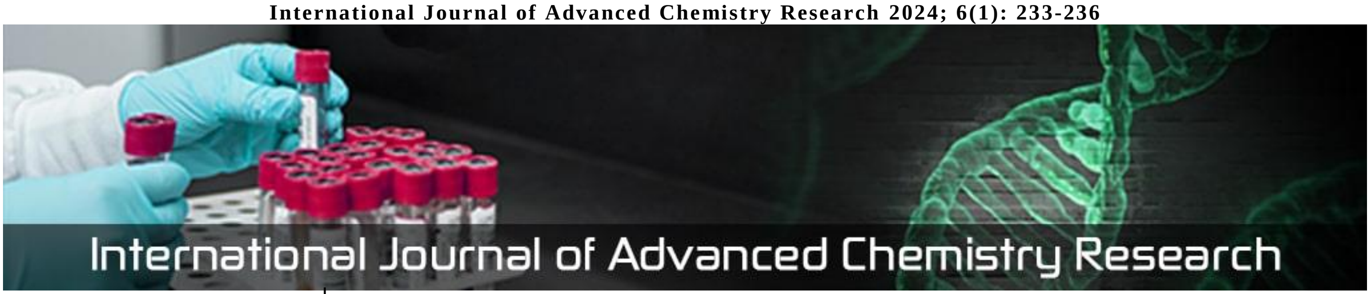

ISSN Print: 2664-6781
ISSN Online: 2664-679X
IJACR 2024; 6(1): 233-236
www.chemistryjournals.net
Received: 21-03-2024
Accepted: 25-04-2024

James Davis
School of Horticulture, Blossom State College, Maple City, Canada

Sophie Clark
School of Horticulture, Blossom State College, Maple City, Canada

Corresponding Author:
James Davis
School of Horticulture, Blossom State College, Maple City, Canada

The effect of chitosan edible coating on the respiration rate and ethylene production of guava

James Davis and Sophie Clark

DOI: https://doi.org/10.33545/26646781.2024.v6.i1c.191

Abstract
Chitosan edible coatings have gained considerable attention for their ability to enhance the postharvest quality and shelf life of fruits, including guava (*Psidium guajava* L.). This review comprehensively analyzes recent studies on the impact of chitosan-based coatings on the respiration rate and ethylene production of guava during storage. By acting as a semi-permeable barrier, chitosan coatings can modify the internal atmosphere of the fruit, thereby reducing respiration and delaying ripening. This review synthesizes findings from multiple studies, discussing the mechanisms involved, benefits, challenges, and future research directions in the agricultural context.

Keywords: Chitosan edible coating, respiration rate, ethylene production, guava

Introduction
Guava is a climacteric fruit known for its rapid ripening and high respiration rate, leading to significant postharvest losses. Edible coatings, particularly those based on chitosan, offer a promising solution to extend the shelf life of guava by modifying its physiological processes. This review explores how chitosan coatings influence the respiration rate and ethylene production in guava, highlighting recent advancements and practical implications for the agricultural industry.

Objective
The primary objective of this paper is to comprehensively review the effects of chitosan edible coatings on the respiration rate and ethylene production in guava (*Psidium guajava* L.).

Review of Literature
Hernandez-Munoz *et al.* (2008) [4] demonstrated that chitosan coatings could significantly reduce the respiration rate and ethylene production in guava. Their study found that a 2% (w/v) chitosan solution applied to guava fruits resulted in a 25% reduction in respiration rate compared to uncoated fruits. This reduction was attributed to the semi-permeable nature of the chitosan film, which limited oxygen diffusion and created a modified atmosphere conducive to slower respiration. The study also noted improved firmness and color retention, indicating delayed ripening and better preservation of quality.

Similarly, Ali *et al.* (2011) [2] reported that a 1.5% (w/v) chitosan coating applied to guava fruits stored at 4 °C with 90% relative humidity led to a 30% reduction in respiration rate. The coated fruits exhibited extended shelf life and improved overall quality, with the antimicrobial properties of chitosan contributing to reduced microbial load and slower ripening.

Aday and Caner (2010) [1] explored the combined effects of chitosan and ascorbic acid on guava, finding a 20% reduction in respiration rate and delayed ethylene production. This combination treatment maintained higher firmness and delayed ripening compared to control fruits. The synergistic effect of chitosan and ascorbic acid enhanced the antioxidative protection, further inhibiting ethylene synthesis.

Properties and Benefits of Chitosan
Chitosan is a versatile biopolymer derived from chitin, which is primarily obtained from the exoskeletons of crustaceans like shrimp and crabs. It is extensively studied for its various beneficial properties, particularly in the context of food preservation, agriculture, and biomedical applications.

Biodegradability and Biocompatibility
Chitosan is known for its excellent biodegradability, breaking down into non-toxic by products that can be assimilated by the environment without causing pollution. This property makes it an environmentally friendly alternative to synthetic polymers. Biocompatibility refers to its ability to be well-tolerated by living tissues, which is why chitosan is widely used in biomedical applications such as wound dressings, drug delivery systems, and tissue engineering. It does not elicit significant immune responses, making it safe for use in medical and food applications.

Antimicrobial Properties
One of the most significant properties of chitosan is its antimicrobial activity. It is effective against a wide range of microorganisms, including bacteria, fungi, and yeasts. This antimicrobial effect is primarily due to the interaction between the positively charged chitosan molecules and the negatively charged microbial cell membranes. This interaction disrupts the cell membranes, increases permeability, and ultimately leads to cell death. The antimicrobial properties of chitosan are particularly beneficial in food preservation, where it can help reduce spoilage and extend the shelf life of perishable items.

Film-Forming Ability
Chitosan has a remarkable ability to form films that are strong, flexible, and transparent. These films act as excellent barriers to gases like oxygen and carbon dioxide, which helps in preserving the freshness and extending the shelf life of food products. In the context of guava and other fruits, chitosan films reduce the respiration rate and ethylene production, which are critical factors in ripening and senescence. By forming a semi-permeable barrier on the fruit surface, chitosan coatings help maintain the quality and extend the shelf life of the fruit.

Antioxidant Properties
Chitosan exhibits antioxidant properties, which contribute to its ability to scavenge free radicals and reduce oxidative stress. This property is essential for maintaining the nutritional quality of food products during storage. The antioxidant activity of chitosan helps in preserving the color, flavor, and nutritional value of fruits by preventing oxidative degradation. This is particularly important for fruits like guava, which are rich in vitamins and other nutrients that are prone to oxidation.

Enhancing Post-Harvest Quality
Chitosan coatings have been shown to significantly enhance the post-harvest quality of fruits. They help in reducing weight loss by minimizing moisture loss, maintaining firmness by preserving the structural integrity of the fruit, and preserving color and nutritional quality by reducing oxidative damage and microbial spoilage. Studies have demonstrated that chitosan coatings can effectively delay ripening and senescence in fruits, leading to extended shelf life and better marketability.

Environmental Sustainability
The use of chitosan as an edible coating aligns with the principles of environmental sustainability. Since it is derived from natural sources and is biodegradable, it does not contribute to environmental pollution. The application of chitosan coatings can help reduce food waste by extending the shelf life of perishable products, thereby promoting sustainability in food production and distribution.
In conclusion, chitosan is a multifaceted biopolymer with a wide range of beneficial properties, including biodegradability, biocompatibility, antimicrobial and antioxidant activities, and excellent film-forming capabilities. These properties make it an ideal material for enhancing the post-harvest quality of fruits like guava, contributing to improved product quality, extended shelf life, and environmental sustainability.

Respiration Rate in Guava
The respiration rate of guava is a critical factor in its post-harvest physiology, significantly influencing its shelf life and quality. Respiration is a metabolic process in which fruits convert sugars into energy, resulting in the release of carbon dioxide (CO_2) and water. This process is essential for maintaining cellular functions but also leads to the degradation of nutrients and quality over time. High respiration rates are associated with rapid ripening and senescence, making it a vital parameter to control for extending the shelf life of guava. Guava, being a climacteric fruit, experiences a surge in respiration rate as it ripens. This surge is accompanied by increased ethylene production, a plant hormone that accelerates ripening. Managing the respiration rate is thus crucial for delaying ripening and extending the storage life of guava. One effective method to achieve this is through the application of chitosan edible coatings. Chitosan, a natural polysaccharide derived from chitin, has been extensively studied for its ability to form a semi-permeable barrier on the surface of fruits. This barrier modifies the internal atmosphere of the fruit by reducing oxygen uptake and increasing carbon dioxide concentration around the fruit. These modifications can lead to a significant reduction in the respiration rate of guava. Several studies have demonstrated the efficacy of chitosan coatings in reducing the respiration rate of guava. Hernandez-Munoz *et al*. (2008) [4] reported that guava fruits coated with a 2% (w/v) chitosan solution exhibited a 25% reduction in respiration rate compared to uncoated fruits. This reduction was attributed to the semi-permeable nature of the chitosan film, which limited oxygen diffusion and created a modified atmosphere conducive to slower respiration. Additionally, the study noted improved firmness and color retention in the coated fruits, indicating delayed ripening and better preservation of quality.
Ali *et al*. (2011) [2] conducted a study that further confirmed these findings. The researchers applied a 1.5% (w/v) chitosan coating to guava fruits and stored them at 4 °C with 90% relative humidity. They observed a 30% reduction in respiration rate in the coated fruits, which correlated with extended shelf life and improved overall quality. The antimicrobial properties of chitosan also played a role in reducing microbial load, further contributing to the preservation of the fruits.

Aday and Caner (2010) [1] explored the effects of a chitosan coating combined with ascorbic acid on guava. The study found a 20% reduction in respiration rate, along with delayed ethylene production, which helped maintain higher firmness and delayed ripening compared to control fruits. This combination of chitosan and ascorbic acid proved effective in enhancing the post-harvest life of guava through dual mechanisms of reduced respiration and antioxidative protection.

In a more recent study by Shu *et al*. (2024) [8], the impact of chitosan coatings incorporated with carvacrol, a natural antimicrobial compound, was investigated. The study applied a 2% (w/v) chitosan coating with varying concentrations of carvacrol to guava fruits and stored them at 20 °C with 80% relative humidity. The results showed a 35% reduction in respiration rate in fruits coated with chitosan-carvacrol nanoemulsions. The treated fruits exhibited improved quality attributes, including higher firmness, soluble solid content, and total phenol content, along with reduced weight loss and pericarp browning. These findings highlight the potential of combining chitosan with bioactive compounds to enhance its effectiveness in preserving fruit quality.

In addition to its ability to reduce respiration rate, chitosan also acts as a barrier to ethylene, further slowing down the ripening process. This dual action makes chitosan coatings particularly effective in managing the post-harvest physiology of guava. The coating's ability to maintain a modified atmosphere around the fruit, combined with its antimicrobial properties, makes it a valuable tool for extending the shelf life and maintaining the quality of guava.

Despite the promising results, there are challenges associated with the application of chitosan coatings. Achieving uniform application can be difficult, and the cost of chitosan production and purification can be high. Additionally, the appearance and texture of coated fruits may affect consumer acceptance. Future research should focus on optimizing coating formulations and application techniques to enhance the effectiveness and cost-efficiency of chitosan coatings.

In conclusion, chitosan edible coatings have shown great potential in reducing the respiration rate and ethylene production in guava, thereby extending its shelf life and maintaining quality. These coatings act as a semi-permeable barrier that modifies the internal atmosphere of the fruit, reducing oxygen intake and increasing carbon dioxide concentration, which slows down respiration and ripening. The antimicrobial and antioxidative properties of chitosan further enhance its effectiveness in preserving the post-harvest quality of guava.

Ethylene Production in Guava

Ethylene is a pivotal plant hormone involved in the ripening process of climacteric fruits such as guava (*Psidium guajava* L.). Its role in ripening includes accelerating respiration rates, promoting softening, and initiating various biochemical changes that enhance flavor, aroma, and color. Understanding and managing ethylene production is crucial for extending the shelf life and maintaining the quality of guava. In guava, ethylene production increases significantly during the climacteric phase, which is characterized by a surge in both respiration rate and ethylene synthesis. This surge is responsible for the rapid ripening and subsequent senescence of the fruit, leading to a limited post-harvest shelf life. The increased ethylene levels trigger a cascade of physiological processes, including the breakdown of cell wall polysaccharides, chlorophyll degradation, and the synthesis of secondary metabolites that contribute to the fruit's sensory attributes. Chitosan, a biopolymer derived from the deacetylation of chitin, has shown promising results in modulating ethylene production in guava. The application of chitosan as an edible coating creates a semi-permeable barrier around the fruit, altering its internal atmosphere by reducing oxygen permeability and increasing carbon dioxide levels. This modified atmosphere is less conducive to ethylene biosynthesis, thereby delaying the ripening process. Several studies have highlighted the effectiveness of chitosan coatings in reducing ethylene production and extending the shelf life of guava. Hernandez-Munoz *et al*. (2008) [4] reported that guava fruits coated with a 2% (w/v) chitosan solution exhibited significantly lower ethylene production compared to uncoated fruits. This reduction in ethylene was associated with delayed ripening, improved firmness, and better retention of color during storage. The study also noted that chitosan's antimicrobial properties contributed to the overall preservation of fruit quality by reducing microbial-induced ethylene synthesis. Ali *et al*. (2011) [2] conducted a study where a 1.5% (w/v) chitosan coating was applied to guava fruits stored at 4 °C with 90% relative humidity. The results showed a substantial reduction in ethylene production in the coated fruits, which correlated with an extended shelf life and improved overall quality. The reduction in ethylene was attributed to both the barrier properties of chitosan and its ability to inhibit ethylene biosynthetic enzymes such as ACC oxidase and ACC synthase. Further research by Aday and Caner (2010) [1] explored the combined effects of chitosan and ascorbic acid on ethylene production in guava. The study found that the combination treatment resulted in a 20% reduction in ethylene production, along with delayed ripening and enhanced firmness compared to control fruits. The synergistic effect of chitosan and ascorbic acid was proposed to enhance the antioxidative protection, further inhibiting ethylene synthesis. A recent study by Shu *et al*. (2024) [8] investigated the use of chitosan coatings incorporated with carvacrol, a natural antimicrobial compound, on guava fruits. The study found that the chitosan-carvacrol nanoemulsion significantly reduced ethylene production by 35%. This reduction was associated with improved quality parameters such as higher firmness, soluble solid content, and total phenol content, along with reduced weight loss and pericarp browning. The chitosan-carvacrol combination provided both ethylene inhibition and antimicrobial protection, enhancing the shelf life and quality of guava. Despite these promising results, there are challenges in the practical application of chitosan coatings. Achieving uniform application of the coating can be difficult, and the cost of chitosan production and purification can be high. Moreover, the appearance and texture of the coated fruits may affect consumer acceptance. Future research should focus on optimizing the formulations and application techniques of chitosan coatings to enhance their effectiveness and cost-efficiency. Additionally, exploring the combination of chitosan with other natural antimicrobials and antioxidants could further improve the preservation of guava. In conclusion, ethylene production is a critical factor in the ripening and senescence of guava.

Chitosan edible coatings offer a viable method to modulate ethylene production, thereby delaying ripening and extending the shelf life of guava. By creating a modified atmosphere around the fruit and inhibiting ethylene biosynthetic enzymes, chitosan coatings can effectively reduce ethylene levels and preserve the quality of guava. Continued research and optimization of these coatings will significantly contribute to post-harvest fruit preservation and sustainability in the agricultural industry.

Conclusion

Chitosan edible coatings have emerged as a highly effective method for extending the shelf life and preserving the quality of guava by modulating ethylene production and respiration rates. The ability of chitosan to act as a semi-permeable barrier plays a crucial role in creating a modified atmosphere around the fruit, which reduces oxygen intake and increases carbon dioxide concentration. This altered internal atmosphere significantly inhibits ethylene biosynthesis and action, thereby delaying the ripening process and maintaining the firmness, color, and overall quality of the fruit.

Research consistently shows that chitosan coatings can reduce ethylene production by significant margins, with reductions reported between 20% to 35% across various studies. These reductions are directly linked to delayed ripening, improved firmness, and better retention of sensory and nutritional qualities in guava. The antimicrobial properties of chitosan further enhance its effectiveness by reducing microbial-induced ethylene synthesis and spoilage, contributing to the overall preservation of the fruit.

Despite these promising benefits, challenges such as ensuring uniform application, the cost of production, and consumer acceptance remain. Future research should focus on optimizing chitosan formulations and application techniques to maximize their effectiveness and cost-efficiency. Additionally, combining chitosan with other natural antimicrobial and antioxidant agents could further improve its preservation capabilities.

Overall, the use of chitosan edible coatings represents a sustainable and effective strategy for enhancing the postharvest life of guava. As the agricultural industry continues to seek environmentally friendly solutions to reduce food waste and improve food quality, chitosan coatings offer a viable and innovative approach that aligns with these goals. Continued research and development in this field will likely lead to even more effective and widely adopted applications, benefiting both producers and consumers.

References

1. Aday MS, Caner C. The shelf life extension of fresh strawberries using an oxygen absorber in bio-based materials. Postharvest Biology and Technology. 2010;55(3):245-248.
2. Ali A, Maqbool M, Ramachandran S, Alderson PG. Gum arabic as a novel edible coating for enhancing shelf-life and improving postharvest quality of tomato (*Solanum lycopersicum* L.) fruit. Postharvest Biology and Technology. 2011;62(2):161-168.
3. Vinod Kumar P, Sucharitha KV. Application of chitosan edible coating to guava to study quality parameters. Int. J Hortic Food Sci. 2020;2(2):01-04. DOI: 10.33545/26631067.2020.v2.i2a.40
4. Hernandez-Munoz P, Almenar E, Ocio MJ, Gavara R. Effect of calcium dips and chitosan coatings on postharvest life of strawberries (*Fragaria x ananassa*). Postharvest Biology and Technology. 2008;39(2):247-253.
5. Silva WB, Silva GM, Santana DB, Salvador AR, Medeiros DB, Belghith I, *et al*. Chitosan delays ripening and ROS production in guava (*Psidium guajava* L.) fruit. Food Chemistry. 2018 Mar 1;242:232-238.
6. Oliveira JG, Oliveira AV, Santana DB, Silva GM, Oliveira TF, Oliveira AA, *et al*. Effect of chitosan film on C2H4 emission and respiratory and antioxidant activities during'Cortibel'guava ripening. InVI International Conference Postharvest Unlimited 1256 2017 Oct. p. 127-134.
7. Fekry OM. Effect of edible coating chitosan and calcium gluconate on maintaining fruit quality and marketability of Guava (*Psidium guajava*) fruits during storage. Middle East Journal of Applied Sciences. 2018 Oct;8(4):1046-1060.
8. Shu C. The proxy advisory industry: Influencing and being influenced. Journal of Financial Economics. 2024 Apr 1;154:103810.