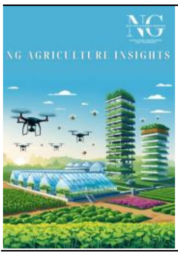

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Role of Edible Waxes in Reducing Post-Harvest Losses: A Supply Chain Perspective

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ABSTRACT

One of the biggest problems of the global supply chain is post-harvest losses in the farm produce, especially in the production of fruits and vegetables. Edible Waxing Edible waxing, the use of thin coatings of food-grade materials, is also a great method to minimise these losses by maintaining quality in handling, storage and distribution. This review analyses the categories, characteristics, as well as mode of action of both natural and synthetic waxes, together with their technologies of application. It addresses the use of edible waxes in terms of increasing shelf life, visual appeal and minimising physiological injury at farm-gate packaging, retail and display. The food resources that are economic benefits in terms of reduction of spoilage, plus increased grading of products, are considered along with environmental and consumer factors, which include environmental and food regulatory compliance. Amid increasing requests concerning safer and greener solutions in post-harvesting processes, edible waxes have become one of the highly applicable and affordable interventions. Their further development is important to enhance food security, reduce food loss and waste and foster resilient agri-food systems across the planet.

Keywords: Food Preservation, Post-Harvest Technology, Shelf Life Extension, Supply Chain Management

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1. INTRODUCTION

Although fruits and vegetables are major commodities that still challenge food systems globally in a major way in the developing world lacks infrastructure as well as cold chain resources in general. The Food and Agriculture Organisation (FAO) reports that between 40 per cent and 45 per cent of fruits and vegetables are lost to spoilage, dehydration, microbial decay and mechanical damage between the time they are picked and the time they are eaten. Although fruits and vegetables are major commodities, they are also the most perishable: recent trials show that uncontrolled moisture loss and microbial decay destroy 40 – 45 % of production in the Global South (Rux et al., 2022). Such wastages not only limit the supply of food, but also cause poverty to the farmers and retailers, as well as affecting resource inefficiency along the supply chain.

The use of edible waxes is one of the solutions to this problem that is widely used nowadays: thin food-grade coatings that are applied to the surface of fresh vegetables and fruits. These waxes help maintain the moisture, respiration, as well as appearance of perishable commodities by creating a barrier, thereby controlling moisture loss. Due to their strategic use in prolonging freshness and reducing spoilage, they will be particularly useful in long-distance logistics and customer presentation. Post-harvest losses erode farm

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profitability and have been cited as one of the push factors behind rural youth migration (Sai et al., 2024); less provision of skill-based training on new farm technologies (Saha et al., 2024) and the difficulties faced by emerging agripreneurs (Das et al., 2025). Edible waxing cannot be restricted to the traditional crops only, such as apples and citrus; it is rapidly becoming a part of the technological post-harvest handling complex throughout the supply chain. Farm-gate treatment to export packaging and supermarket supply, the use of wax has come to become a deciding intervention that aids the quality of the products, their economic values, and consumer satisfaction.

2. CLASSIFICATION AND FUNCTIONAL PROPERTIES

2.1. Natural Waxes

The natural waxes have renewable biological sources, making them widely used since they are non-toxic and gentle to the environment. Honeybees also secrete beeswax, which makes a good moisture-retentive, pliable covering for delicate fruits. Carnauba wax, a product of the Copernicia prunifera palm leaves, has a high melting point and lustrous sheen, and it is especially applicable to uses in commerce where the appearance is especially important. Carnauba wax gives an intense gloss and has been shown to hold mandarin weight loss below 4 % after three weeks of storage (Gutiérrez-Pacheco et al., 2020). Shellac is made of the secretions of the lac insect and creates a hard, shiny coating with moderate water and gas barrier performances. In organic and up-market produce markets, the naturally produced waxes are popular because of the consumer-friendly image.

2.2. Synthetic Waxes

Synthetic waxes, on the other hand, are normally made through petroleum products and designed to perform uniformly. Paraffin and polyethene wax are types of food-grade products, mostly found in large fruit packing sites, as they are durable, cheap, and highly capable of forming strong films. Paraffin-based films lower cumulative weight loss in cucumbers by up to 80 % over 15 days (Bahnasawy & Khater, 2014). Other formulations are composite or blended waxes incorporating both natural and synthetic waxes into an improved barrier property and adhesion to the synthetic base. Though these are effective, there have been concerns regarding the long-term effects of synthetic waxes on health and the environment, hence the need to seek less toxic alternatives.

2.3. Functional Mechanisms

The efficiency of edible waxes is associated with the fact that they can perform more than one preservation role. Moisture retention is one of the important functions as it prevents water loss and keeps food items free of shrinkage during the time of storage and transportation. Also significant is the control of the exchange of gases that occurs; waxes slow the pace of ripening and senescence by decreasing the intake of oxygen and releasing carbon dioxide in the process of respiration. Another important role entails the improvement of the look of the surface- waxes give the surfaces a glossy appearance, making the product more saleable through visual appeal. In addition, due to certain wax coatings, a passive antimicrobial barrier is given, which discourages the growth of microbes at the surface, albeit this is often of a minimal character, and can be complemented by natural antimicrobial agents or ingredients in more sophisticated preparations.

Figure 1. Inline spray system depositing a mist of carnauba-based wax onto oranges before forced-air drying (Vegetablemachines, n.d.)

3. WAX APPLICATION TECHNIQUES AND TECHNOLOGIES

3.1. Manual and Semi-Automated Methods

In small-scale operation and more traditional post-harvest applications, wax can be applied by such manual techniques as dipping, brushing or spraying by hand. In dipping, dipping, the produce is immersed in a wax emulsion and left to dry either naturally or by air-drying gently. This technique can provide complete coverage of surfaces, though there are some disadvantages that include poor distribution of films in the thickness and an increase in the wax usage. How Brushing techniques, where soft brushes or rollers are applied over wax are applied but can be very labour-intensive and can be inconsistent. These techniques are ideal within small volumes; however, they are inefficient and expensive when applied to commercial volumes.

3.2. Industrial Waxing Techniques

In large commercial packing plants, automated or mechanised procedures are employed, which are consistent and keep the labour to a minimum. One of the most popular methods includes spraying tunnels where fruits are usually sprayed using nozzles that spray thin layers of fine wax. They are commonly combined with conveyor belts and roller dryers and allow continuous transport, coating is controlled, and drying is fast. There is also the possibility of having modern systems with electrostatic sprayers, whereby the charged particles are used to guarantee an effective product adhesion and homogeneous distribution of the wax, especially on irregularly shaped produce. Electrostatic spray tunnels deposit coatings that are both uniform and thin (≤10 µm), a configuration that maintains firmness without creating anaerobic pockets (Rux et al., 2022). Oil-in-water nano-emulsions—typically produced by high-pressure homogenisation—enable uniform deposition of essential-oil-loaded waxes that remain stable for at least 30 days at 4 °C (Wu et al., 2016). Such systems have a much higher throughput; they can handle thousands of units in an hour, and so they are suited to export pack centres and retail high-volume supply chains.

3.3. Performance Considerations

The performance of any waxing procedure relies on a number of performance indicators. The thickness of the film has to be even, as this can cause moisture retention or cosmetic non-uniformities. Appropriate following on the fruit surface will rely on variables such as the fruit surface adaptation, the making of the wax and its adjusting pressure. The other major factor is drying efficiency, or insufficient drying may encourage microbial growth or deposits. The system should also be adaptable to varied kinds of produce since wax behaviour may quite differ between various fruits like apples, citrus fruits, cucumber and bell pepper. Maintenance and calibration of equipment are also necessary to maintain performance in terms of standards of food safety standards.

4. SUPPLY CHAIN INTEGRATION AND IMPACT

4.1. Waxing at Farm-Gate and Packing Centres

The initial integration concern in the supply chain regarding edible waxes is the integration point after harvesting, which is usually found at the farm-gate collection points or the main packhouse centres. Washing, sorting and grading of produce occurs at this stage, and waxing is therefore perfect at this stage. The early application of wax contributes towards freshness before the product enters the stages of changing hands during transportation and storing. To exporters and large wholesalers, the inclusion of waxing in packhouse activities becomes a guarantee of produce, persistence of appeal and duration on shelves, especially in cases where the produce is being shipped over long distances or even across borders.

4.2. Influence During Storage and Transportation

Fruits and vegetables are continuously under pressure from moisture loss, temperature variations and microbial contamination during storage and distribution. Waxes are important in that they reduce these risks, serving as a protective shield. Edible waxes also assist in preservation in cold chain systems, where slowing deterioration was achieved by using chilled temperatures, preventing chilling injuries and dehydration in sensitive crops such as cucumbers and bell peppers. To regulate respiration and ethylene sensitivity in slowing over-ripening and spoilage, waxes are indispensable in ambient storage and transport conditions of the supply chain experienced in domestic supply chains.

4.3. Market Shelf-Life and Retail Presentation

The look of the products is one major determinant of consumer choice at the retail side. Wax coats are applied to retain visual freshness as they contribute to firmness, avoid wrinkling of the surface, and help in improving the gloss. This makes sure that fruits and vegetables become appealing and healthy even after a number of days in the store. In the markets where the perception of freshness is highly impacting the purchase behaviour, waxed plants are more attractive to the consumers, and the product has better turnover and fewer markdowns. The retailers will enjoy the lowered shrinkage level and more control over inventory, and consumers will get produce that lasts longer in their respective homes.

4.4. Economic Impact on Supply Chain Actors

The economic aspect is that edible waxing helps eliminate losses at multiple points in the chain of supply chain. The post-harvest wastes are reduced, and the amount of produce available in the market rises. The distributors and exporters experience enhanced shelf stability, increased flexibility in their logistics operations and low rejection rates when delivered. The sellers experience increased shelf life and less spoilage expense, which implies a direct increase in the profits. Also in export chains, taxes on waxy fruits usually pass through the quality assurance checks as demanded by the importing country, thereby increasing value, as well as expansion of the market. Reviews across tropical horticulture confirm similar economic benefits in citrus, mango and avocado chains (Moradinezhad et al., 2025).

5. CONCLUSION

Edible waxing has become one of the most important post-harvest technologies that help decrease losses considerably and increase the commercial potential of fresh produce. Wax coatings form a protective film over the surface of the produce, thus reducing moisture absorption, preventing the fruit and vegetables from becoming ripe and, hence, retaining the visual aspect that is vital in ensuring quality throughout the chain. As diverse as the term itself, edible waxes are used in one form or involved in the packing processes at the farm level of production to the export of products to international destinations in preserving freshness, minimising wastage and ensuring better economic returns to the farmer, distributor, as well as retailer of the products. In consideration of both sustainability and efficiency of global food systems, the use of edible waxing is one of the most suitable concepts that incorporates the use of resources in an optimal manner and prolongs shelf life. It is, however, subject to the sophistication of its use, observing the regulatory measures, responsiveness to consumer demands, primarily with the increasing demands of natural and biodegradable materials. In the future, it will be important to maintain breakthroughs in formulation, application technology, and sustainability, as well as to derive maximum benefit from this useful post-harvest treatment.

REFERENCES

Bahnasawy, A. H., & Khater, E. G. (2014). Effect of wax coating on the quality of cucumber fruits during storage. *Journal of Food Process Technology*, *5*(6), 339. https://doi.org/10.4172/2157-7110.1000339

Das, N., Modak, S., Prusty, A. K., Saha, P., & Suman, S. (2025). Understanding and overcoming key challenges of agripreneurs in southern Odisha: A case study. *Indian Journal of Extension Education*, *61*(2), 118–122. https://doi.org/10.48165/IJEE.2025.612RN05

Gutiérrez-Pacheco, M. M., Ortega-Ramírez, L. A., Silva-Espinoza, B. A., Cruz-Valenzuela, M. R., González-Aguilar, G. A., Lizardi-Mendoza, J., Miranda, R., & Ayala-Zavala, J. F. (2020). Individual and combined coatings of chitosan and carnauba wax with oregano essential oil to avoid water loss and microbial decay of fresh cucumber. *Coatings*, *10*(7), 614. https://doi.org/10.3390/coatings10070614

Moradinezhad, F., Adiba, A., Ranjbar, A., & Dorostkar, M. (2025). Edible coatings to prolong the shelf life and improve the quality of subtropical fresh/fresh-cut fruits: A review. *Horticulturae*, *11*(6), 577. https://doi.org/10.3390/horticulturae11060577

Rux, G., Labude, C., Herppich, W. B., & Geyer, M. (2022). Investigation on the potential of applying bio-based edible coatings for horticultural products exemplified with cucumbers. *Current Research in Food Science*, *6*, 100407. https://doi.org/10.1016/j.crfs.2022.100407

Saha, P., Prusty, A. K., Nanda, C., Ray, S., & Sahoo, B. (2024). Professional insights provided by women extension personnel in Odisha. *Indian Journal of Extension Education*, *60*(3), 101–105. https://doi.org/10.48165/IJEE.2024.603RN03

Sai, M., Prusty, A. K., Padhy, C., & Reddy, I. C. (2024). Migration behavior of rural youth from agriculture in North Coastal Andhra Pradesh. *Indian Journal of Extension Education*, *60*(4), 30–34. https://doi.org/10.48165/IJEE.2024.60406

Vegetablemachines. (n.d.). *Automatic citrus fruits washing and waxing processing line* [Photograph]. Vegetablemachines. https://www.vegetablemachines.com/solution/citrus-fruits-washing-and-waxing-processing-line/

Wu, C., Wang, L., Hu, Y., Chen, S., Liu, D., & Ye, X. (2016). *Edible coating from citrus essential-oil-loaded nanoemulsions: Physicochemical characterization and preservation performance*. *RSC Advances*, *6*, 20892-20900. https://doi.org/10.1039/C6RA00757K