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Applications of nanoparticles to enhance shelf life of guava (*Psidium guajava* L.) fruits

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Abstract

It has been found that nanoparticles can improve the shelf life and sustain the quality of fruits. They can be used as coatings to form a barrier that prevents the growth of microorganisms, oxygen, and moisture. The antibacterial and antioxidant qualities of many nanoparticle forms, including zinc oxide and titanium dioxide, have been examined. Because these nanoparticles reduce oxidative damage and stop the growth of pathogenic microorganisms that cause deterioration, they can help increase the shelf life of fruits and vegetables. Review in this fascinating field may have implications for food preservation. A variety of techniques can be employed to preserve edible quality and extend the shelf life of nanoparticles. Making a coating of nanoparticles to put on the fruits surface is one such method. Through acting as a barrier, this coating contributes in the suppression of oxidation, microbial growth, and moisture loss. A different approach that potentially offer similar advantages is to directly incorporate nanoparticles into the packaging materials. The particular application procedure may change based on the kind of nanoparticles being applied and the goal of the application. Fruits and vegetables are able to maintain their quality by using nanostructured matter integrated versatile coverings. Fruits can have a much longer shelf life due to edible nanocoating which keeps the fruits moist and fresh. This is because the fruit's colour and texture are preserved as coating serves as a barrier, maintaining molecules and water vapor away from the fruit and keeping it in.

Keywords: Guava, titanium dioxide, zinc oxide, nanoparticles, fruit coating

Introduction

By maximizing concentration and blocking the ripening process, these coatings provide barrier qualities on the surface of fruits and vegetables and create a favourable microenvironment. Using a chemical reduction technique, a bio-nano combination based on intercalated nanoparticles of guava extract was produced for use in fruit coating. The postharvest loss of fresh fruits and vegetables are estimated to be 20–30%. Given the perishable nature of fruits and vegetables, the use of cold storage is necessary to delay changes related to ripening, such as ethylene making, softening, pigment changes, respiration rate, acidity changes and decrease in weight. However, cold storage is not enough to preserve fruits and vegetables quality at optimum levels during transportation and marketing, often leading to the incidence of severe chilling injury symptoms. So, the appropriate postharvest technologies combined with cold storage are needed (Nouri *et al.*, 2017, Salehi *et al.*, 2017) [6, 7]. Titanium dioxide has been frequently used as a clean, renewable a photo catalyst due to its optical characteristics, high chemical stability, and lack of toxicity in recent years. One of the most crucial ingredients in colours, materials for plastics, papers, inks, food colorants, and skin care products is titanium dioxide nanoparticles. They protect skin from UV rays and whiteness. Researchers are currently interested in this topic because of the rise in microbial resistance to metal ions, antibiotics, and the emergence of resistant strains. Additionally, titanium dioxide Nanoparticles have shown to have strong antibacterial activity (Miller *et al.*, 2012) [4]. TiO_2 nanoparticulate, utilized in antibacterial coatings and wastewater treatment, has been studied as an anti-cancer agent. It has been observed that Nanoparticles produces reactive oxygen species when exposed to ultraviolet radiation. The creation of nanoparticles with varying chemical compositions, sizes, and regulated monodisperse is a significant field of research in nanotechnology. With its applications in science and technology to create novel materials at the nanoscale, nanotechnology is emerging as a quickly expanding area.

Applications of nanotechnology in biology and pharmacology have grown significantly.

Guava (*Psidium guajava* L.), commonly known as "Amrood" in India, is a popular fruit crop cultivated across various states in the country. India is one of the largest producers of guava fruits globally, and the fruit holds immense significance in the domestic market as well as for export. Guava cultivation is widespread in states such as Uttar Pradesh, Bihar, Maharashtra, Andhra Pradesh, and others, due to the favourable agroclimatic conditions for its growth. Different varieties of guava, including Allahabad Safeda, Lucknow 49, Lalit, Arka Mridula, and others, are cultivated in different regions based on their adaptability to local conditions and market preferences. The production of guava fruits plays a vital role in the livelihoods of numerous farmers and contributes significantly to the country's agricultural economy. The common term "guava" refers to the fruits of *Psidium guajava* L., a Myrtaceous plant that has spread to many tropical and subtropical regions. It has been reported that guava fruits possesses antibacterial, anti-inflammatory, antidiarrheal, and anticancer properties. Safe coating is a layer-forming material used to enrobe food products. Safe coating can fortify or replace natural layers on food that can be consumed or not afterward. The uses of safe coating can overcome many problems in food marketing. Most of the issues are associated with food deterioration and changes that may happen during production, transportation, and storage periods. Food deterioration and changes include loss of moisture, gas, solute, and oil due to food migration. Safe coating can improve the structural integrity of food, prevent the loss of volatile compounds that are responsible for flavour and conveying food additives. Aside from maintaining quality related to food deterioration and changes, safe coating also improves food quality associated with its aesthetic appearance by minimizing physical damage development in food, hiding scars, and enhancing the surface shine of the fruit food. Guava (*Psidium guajava* L.) is an important fruit crop grown under a wide range of the tropical and subtropical regions in the world (Chopda and Barrett, 2001) [3]. Guava fruit is very perishable during storage at room temperature due to rapid ripening and deterioration, which decreases the potential for commercialization of the fruits.

Cold storage is not enough to preserve the quality. So, coating with thin layer film of natural materials extended fruit life under cold storage. In many fruits, it is used as alternative to natural waxes that are removed during washing. Various compounds have been used as edible coatings; most of them are based on proteins, lipids or polysaccharides. Edible coatings are natural products and not chemically synthesized. Using different formulation of coating materials increased wax permeability and forms a homogenous coating especially when mixed with nanoparticles materials that improves the permeability and distribution on fruit surface.

Types of Medicinal Leaves that can be used for Nano Coatings

Neem (*Azadirachta indica*) leaves: Neem leaves are known for their antimicrobial and insect-repellent properties. They contain compounds like azadirachtin, nimbi, and nimbidin, which can potentially enhance the effectiveness of nano coatings.

Tulsi (*Ocimum tenuiflorum*) leaves: Tulsi, also known as Holy Basil, has diverse medicinal properties. It contains eugenol, methyl eugenol, and other bioactive compounds that exhibit antimicrobial, antioxidant, and anti-inflammatory activities.

***Aloe vera* gel:** Aloe vera is renowned for its soothing properties and is commonly used in skincare products. The gel extracted from aloe vera contains polysaccharides, vitamins, and minerals that can contribute to the formation of a nano coating.

Curry leaves: Curry leaves *(Murraya koenigii)* are commonly used as a flavouring agent in Indian cuisine. They contain compounds like carbazole alkaloids, flavonoids, and essential oils that possess antioxidant and antimicrobial properties.

Basil leaves: Basil (*Ocimum basilicum*) leaves have been used in traditional medicine for their potential health benefits. They contain volatile oils, such as eugenol and linalool, which have antimicrobial and antioxidant properties.

Procedure for Preparation of Nano Coating

The various steps involved in the preparation of different types of nano coating and medicinal leaf extract to increase the shelf life of guava fruits are as follows.

1. **Preparation:** Start by collecting the necessary materials, including nanoparticles (such as silver, copper, zinc, or titanium dioxide), medicinal leaves extract (e.g., guava leaf extract), and a suitable solvent or carrier solution.
2. **Extraction of medicinal leaves:** Prepare the medicinal leaves extract by grinding or crushing the leaves and then extracting their active compounds using a suitable solvent (such as ethanol, water, or a combination of both). This extract will be used as a component in the nano coating. Abubakar *et al*., 2020 [1]
3. **Synthesis of nanoparticles:** Synthesize nanoparticles through appropriate methods like chemical reduction or sol-gel synthesis. The chosen method will depend on the type of nanoparticles you want to use.
4. **Preparation of Nano coating solution:** Mix the synthesized nanoparticles or commercially available nanoparticles with the medicinal leaves extract. The ratio of nanoparticles and extract will vary based on the desired concentration and effectiveness of the nano coating. You may need to optimize this ratio through experimentation.
5. **Application of Nano coating:** Dip or spray the guava fruits or parts into the nano coating solution. Make sure to cover the entire surface evenly with the solution. A brush can also be used to ensure uniformity.
6. **Drying and curing:** Allow the coated fruits or parts to dry naturally or use a suitable drying method to remove excess moisture. The drying process may also contribute to the formation of a more stable nano coating.
7. **Evaluation and storage:** Assess the effectiveness of the nano coating in terms of improved shelf life, preservation of edible quality, and potential antimicrobial or antifungal properties. Store the coated

guava fruits under appropriate conditions and monitor their quality over time.

Conclusion

The application of nanoparticles to enhance the shelf life of guava fruits represents a promising avenue for addressing food spoilage challenges and improving the overall sustainability of the food supply chain. This innovative approach leverages nanotechnology to mitigate the impact of microbial activity and oxidative stress on guava fruits, thereby extending their shelf life and preserving their quality. One key benefit of using nanoparticles in this context is their antimicrobial properties. Nanoparticles with antimicrobial characteristics, such as silver or copper nanoparticles, can be incorporated into packaging materials. These nanoparticles act as a barrier, inhibiting the growth of bacteria, fungi, and other microorganisms that contribute to the deterioration of guava fruits. By reducing the microbial load on the fruit's surface, the nanoparticles effectively slow down the spoilage process, enabling an elongated shelf life. Nanoparticles have the potential to mitigate oxidative stress, a significant factor in fruit ripening and decay. Reactive oxygen species (ROS) play a role in the degradation of cellular components, leading to the loss of texture, flavour, and nutritional value in fruits. Nanoparticles with antioxidant properties can scavenge ROS, helping to preserve the integrity of guava fruits. This dual functionality—antimicrobial and antioxidant—makes nanoparticles a versatile tool in enhancing the shelf life of guava fruits. The incorporation of nanoparticles into packaging materials also aligns with sustainability goals. By extending the shelf life of guava fruits, there is a reduction in food waste, as fewer fruits spoil before reaching consumers. This not only contributes to economic efficiency but also addresses environmental concerns associated with food disposal. Additionally, the potential use of biodegradable nanoparticle-infused packaging materials could further minimize the environmental impact.

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