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# Use of Nanotechnology to Reduce Postharvest Losses in Horticultural Crops

**Pratap Kadam, Bharat Taynath, Vrushali Bhanbhane, Prabhavati Ghotgalkar**

ICAR- National Research Centre for Grapes, Pune, India

**SUMMARY**

Horticulture science is defined as the science and art of growing and caring for fruits, vegetables, flowers, and decorative plants. Because the human population is continuously expanding, providing sufficient and nutritious food will become a major issue in the near future. Incorporating the discoveries of fresh scientific research such as biotechnology and nanotechnology into products to increase production efficiency and decrease post-harvest waste could be considered the greatest answer to this problem. Nanotechnology, which makes use of specific properties of nanoparticles, has the potential to be a tremendously beneficial technology in all disciplines of science and industry. Many applications of nanotechnology in agricultural sciences have now been established. Controlling the growth and development of microorganisms, introducing a new generation of packaging coverage (films) and controlling the influence of gasses and harmful rays (UV), increasing strength, quality, and packaging beauty, and using multiple chips (Nanobiosensors) for labeling products are all examples of how nanotechnology can help us extend the shelf life of horticultural products.

## INTRODUCTION

Nanotechnology is becoming increasingly important for industry and growth. Today's shared technology and innovations are creating tomorrow's agri-food industries and communities. Postharvest research and infrastructure investments produce significant rates of return, frequently higher than on-farm production alone. Nanotechnology is a new field, Richard Feynman initially mentioned nanotechnology in his 1959 address, "There is plenty of room at the bottom." He suggested constructing a set of one-tenth scale machine tools similar to those available in any machine shop to control atoms and molecules directly. Nanotechnology combines fundamental science, materials science, and engineering at nanoscale scales to develop and create molecule-sized structures and devices. Nanotechnology provides novel biomolecular study tools. Scientists and engineers in chemistry, biology, photonics, and microelectronics developed nanotechnology. Nanofabrication combines biology, engineering, and materials science. Agriculture is part of the biotech sector. Biotechnology, bioengineering, and nanobiology intersect to tackle real agricultural challenges since biology is at the micron and below scale where nanotechnology lives. In developing nations, horticultural waste is estimated at 20-30%, so reducing it by 5-10% will yield huge savings. Increasing production efficiency and reducing post-harvest waste with biotechnology and nanotechnology could be the greatest solutions. Nanotechnologies promise to improve health, prosperity, quality of life, and the environment. This research discusses nanotechnology's usage to increase horticulture crops' postharvest shelf life. The applications' potential and challenges in this new emerging area are examined.

### Nanotechnology: What is It?

Nanoscale structure, device, and system design, characterization, manufacturing, and application. A nanometer, often known as an nm, is one billionth of a meter. Nanometers are defined as structures with dimensions ranging from 1 to 100 nanometers. Nanotechnology, which makes use of specific properties of nanoparticles, has the potential to be a tremendously beneficial technology in all disciplines of science and industry. Understanding and regulating matter at the nanoscale is of particular interest to researchers in the sciences, health, agriculture, and industry because the properties of a material at the nanoscale might change greatly from those at a larger size. As explained below, nanotechnology may be useful in extending the shelf life of horticultural products in four ways.

**Controlling the Growth and Development of Microorganisms**

According to a Euro barometer poll conducted near the end of the last century, the most critical problem for 68 percent of customers was the safety of the fruit they ate. And, while this response came after the BSE crisis, it came before the dioxin crisis in Europe. In the human food chain, several microbiological, physical, and chemical risks occur, contributing to this important safety issue. Many agrichemicals used in fruit cultivation and storage have been banned due to concerns about pesticides and other chemical residues. A consumer's health can be jeopardized if physical pollutants (foreign components) like shattered glass or wood or soil or plastic or metal particles such as nuts, bolts, and nails become embedded in fruits.

*Botrytis cinerea*-caused gray mold disease is a major postharvest pathogen all over the world. During the growth season and during postharvest storage, it causes rot on a wide range of economically significant fruits and vegetables. It is also a significant impediment to long-distance transit and storage. This fungus infects plants, stems, flowers, and fruit via direct penetration or wounds induced by agricultural techniques. Controlling this illness during storage is especially crucial since it develops at low temperatures (e.g., -0.5°C) and spreads swiftly among fruits and vegetables. Fungicide treatments, on the other hand, can reduce losses and ensure product protection, but they are only approved for a few food crop species.

Furthermore, public awareness of the harmful effects of synthetic fungicide residues on human health and the environment has resulted in the deregulation of major chemical fungicides. Another significant issue is the emergence of infections that are resistant to synthetic fungicides. As a result, there is a rising emphasis in the fresh fruit and vegetable business on ecologically friendly solutions, and the hunt for safer alternatives to chemical fungicides has gained a lot of attention. Coatings provide several advantages, including reduced water loss, delayed ripening, reduced freezing and mechanical harm, reduced decay, and increased shine or gloss to the coated items. Coatings can also be utilized to transport beneficial elements such as antimicrobials, color or scent enhancers, anti-oxidants, or anti-ripening compounds.

Coatings might indirectly cause flavor alterations due to delayed ripening or anaerobic respiration and elevated ethanol concentrations. Polysaccharides, proteins, lipids, or a combination of these components can be used to create coatings. Chitosan (Poly b-(1-4)N-acetyl-d-glucosamine), a deacetylated version of chitin, is a natural antibacterial molecule that has been shown to prevent fruit and vegetable postharvest deterioration. The use of Chitosan to prevent pre and postharvest illnesses improved the quality of fruits and vegetables, and it has gained popularity due to its low toxicity to mammals and as an environmentally benign method of plant disease control. Chitosan may have two effects on host-pathogen interactions: antifungal activity and stimulation of plant defense mechanisms. At the moment, there is a lot of interest in using natural compounds such as bioactive Chitosan polymers.

Chitosan is a linear amino polysaccharide comprised of glucosamine and N-acetylglucosamine units that is generated by alkaline deacetylation of chitin extracted from crustacean exoskeletons such as shrimp and crabs, as well as some fungal cell walls. In in vitro and in vivo experiments, Badawy and Rabea (2009) showed that different molecular weight chitosans might directly inhibit the growth of *B. cinerea*. The antifungal effects varied according to concentration and molecular weight. Furthermore, chitosan potently generated defense reactions in tomato fruit, and a molecular weight of 5.7104 g/mol was the optimal molecular size for in vivo application and triggering various host defense mechanisms. They proposed that chitosan increases tomato fruit resistance to gray mold produced by *B. cinerea* and is promising as a natural ingredient to partially replace the use of synthetic fungicides in fruits and vegetables. Many fruits and vegetables are being treated with antifungal nanotechnology.

A microbiological technique has been devised to generate zinc oxide nanoparticles. Some nanoparticles have been employed for antifungal in vitro cultivation and postharvest of bananas, carrots, tomatoes, onions, and other fruits and vegetables.

**Introducing a new generation of packaging films and the ability of polishes to control the impact of gasses and harmful rays**

It is possible to maintain product quality and freshness during the time required for commercialization and consumption by using the correct materials and packaging technology (Stewart et al., 2002). Polymer composites are geometries-specific combinations of polymers with inorganic or organic additives (fibers, flakes, spheres, particulates). The use of nanoscale fillers is resulting in the development of polymer nanocomposite, which constitute a radical alternative to traditional polymer composites. The use of nanocomposite has the potential to broaden the use of edible and biodegradable films. Unfortunately, the application of biodegradable films for food packaging has been severely limited thus far due to natural polymers' low barrier qualities and weak mechanical capabilities. As a result, natural polymers were commonly combined with other synthetic polymers or, less frequently, chemically changed in order to broaden their usage in more specialized or severe conditions. It will aid in the reduction of packaging waste associated with processed foods as well as the preservation of fresh foods, hence increasing their shelf life.

Nano-composites also have other advantages, such as low density, transparency, good flow, improved surface characteristics, and recyclability. Nanomaterials have received increased interest in recent years due to their potential impact on a wide range of businesses and markets. Because of its physical and chemical stability, low cost, ease of availability, and non-toxicity, $TiO_2$ has been the focus of photocatalysts under UV irradiation. Ethylene can be oxidized by nano$TiO_2$ with light catalysis into water and $CO_2$. Photoactivity, photocatalysis, and antibacterial activity of silver ions Nano-Ag, which has a small dimension, quanta, and a large exterior area effect, may be more efficient against bacteria than $Ag^+$. Furthermore, nano-Ag absorbs and degrades ethylene.

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**Improving Strength, Quality, and Packaging Beauty**

A concerted effort to extend shelf life and improve food quality while minimizing packaging waste has sparked interest in the development of innovative bio-based packaging materials, such as edible and biodegradable films made from renewable resources. Because of their biodegradable nature, the usage of these materials could, to some part, ease the waste problem. The food business has seen extensive use of nanotechnology. According to Li and Wang's investigation, Fuji apples preserved with Nano-SiOx/chitosan had good quality (2006). Green tea with nano-packing retained more vitamin C, chlorophyll, polyphenols, and amino acids than green tea with standard packing. The goal of this study was to create a new nanopacking material and see how it affected the preservation of Chinese jujube during room temperature storage. The concept of nanocomposites promises an exciting path for developing novel and unique materials, including natural polymers.

Materials with a wide range of qualities have been developed, and more are on the way. Natural polymers and sheets of crystalline solid layers (clays or LDHs) are combined to create nanocomposite materials with a wide range of property characteristics. They can even compete with synthetic polymeric materials in packaging, both in terms of price and performance. Despite the numerous opportunities for packaging in bio-based nanocomposite materials, the future scenario is impossible to foresee. We can only speculate at this point that basic traditional packaging will be replaced by multipurpose intelligent packaging. The next generation of packaging materials will be capable of meeting the needs of preserving fruits, vegetables, beverages, wine, and other commodities. It will be feasible to create packages with improved mechanical, barrier, and thermal performance by incorporating appropriate nanoparticles. Nano-structured materials will protect food from the invasion of germs and microorganisms. If a food has gone bad, embedded nano-sensors in the package will inform the consumer. Hydrocolloids perform a variety of functions, including hardness, crispness, compactness, thickening quality, viscosity, adhesiveness, gel-forming ability, and mouthfeel.

Functional elements such as vitamins, antimicrobials, antioxidants, flavorings, and preservatives exist in diverse molecular and physical forms as key components of fruits. Because functional components are rarely employed in their unadulterated form, they are frequently part of a delivery system. A delivery system serves many purposes, one of which is to carry a functional element to its intended location. Other functions of a delivery system include protecting an ingredient from chemical or biological degradation, such as oxidation, and controlling the rate of release of the functional ingredient under specific environmental conditions, in addition to being compatible with fruit product attributes such as taste, texture, and shelf life. Nanodispersions and nanocapsules are great mechanisms for delivering functional components since they can successfully execute all of these objectives. Association colloids, nanoemulsions, and biopolymeric nanoparticles are examples of nanostructures. Colloids of association: Association colloids include surfactant micelles, vesicles, bilayers, reverse micelles, and liquid crystals. A colloid is a stable substance with tiny particles distributed throughout. An association colloid is a colloid whose particles are built up of even smaller molecules. Association colloids have been used for many years to deliver polar, nonpolar, and amphiphilic functional components.

They range in size from 5 to 100 nm and are usually transparent solutions. The main drawbacks of association colloids are that they can interfere with the flavor of the components and can spontaneously dissociate if diluted. Nanoemulsions: An emulsion is a mixture of two or more liquids that do not mix easily, such as oil and water. As a result, a nanoemulsion is an emulsion in which the diameters of the dispersed nanolaminates are smaller. A nanolaminate is an extremely thin food-grade sheet (1-100 nm/layer) with physically or chemically linked dimensions made up of two or more layers of material having nanometer dimensions. A nanolaminate has a variety of major food-industry applications due to its benefits in the creation of edible films. Foods with edible films include fruits, vegetables, meats, chocolate, candies, baked products, and French fries. These films can protect meals from moisture, lipids, and gases, or they can improve the textural features of fruits while also acting as transporters of colors, tastes, antioxidants, minerals, and antimicrobials.

**Labeling Products with Multiple Chips (Nanobiosensors)**

Food products using biodegradable sensors-electronic tongue technology when the pH changes due to contamination or spoiling, the sensor changes color. "Release on command" preservative packaging is controlled by a nanobio switch (Netherlands). In food products, nanotechnology entails using biological substances such as sugars or proteins as target-recognition groups for nanostructures that might be employed as biosensors on foods, for example. These biosensors could be used to detect food viruses and other impurities, as well as to track food goods. Nanotechnology may potentially be effective in encapsulating systems for environmental protection. It can also be used to create food additives such as tastes and antioxidants.

The idea is to improve the functionality of such compounds while reducing their concentration. As the incorporation of novel substances into foods becomes more popular, more research into delivery and controlled-release systems for nutraceutical will take place. Among the uses of nanobiosensors are the recognition of plant and insect viruses using molecularly imprinted polymers, the detection of food-borne toxins with multifunctional nanoparticles, the development and characterization of nanocomposite materials for the detection of pore-forming toxins, and the recognition of viruses using antibody sensor arrays on self-assembled Nanoscale Block Copolymer Patterns.

## CONCLUSION

It was concluded that several nanomaterials have significant potential in postharvest technology management. Several studies have found that nano-packing materials have significantly improved physicochemical and physiological quality when compared to standard packing materials. Furthermore, in comparison to alternative storage methods, which are time-consuming, expensive, and alter color and flavour, these nano-packing materials have the advantages of simple processing and industrial feasibility. As a result, nano-packing may be an appealing option for improving the preservation properties of fruits, vegetables, and other valuable horticultural commodities during extended storage. Furthermore, additional research is required to elucidate the precise nano-packing technique on stored products in order to assist the future application of nanotechnology across a broader spectrum. Although promising discoveries were mentioned, the road to successful postharvest nanotechnology is still lengthy.

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