AgriCos e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 05 Issue: 01 January 2024 Article No: 23

Postharvest Treatments for Maintaining Quality of Fresh Vegetable

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SUMMARY

Postharvest technologies have revolutionized the horticultural industry, enabling the production and widespread distribution of fresh produce that meets global demands. These technologies play a crucial role in controlling the ripening and senescence processes of harvested products, ensuring their quality and nutritional value. Failing to manage these processes properly can lead to significant losses in both quality and quantity, posing risks to food safety and financial losses for all stakeholders in the supply chain. To address these challenges, optimal postharvest treatments have been developed. These treatments aim to slow down senescence and maturation processes, prevent physiological disorders, and minimize the growth of microorganisms and contamination. While temperature management is a fundamental aspect of postharvest technologies, other methods such as heat, irradiation, edible coatings, antimicrobials, antioxidants, and anti-browning agents have also been developed. This article explores emerging technologies like irradiation and ozone, which have the potential to maintain the quality of fresh produce and reduce losses and waste.

INTRODUCTION

Fresh vegetables are a vital source of nutrients for our health, but they require coordination between various parties to ensure their quality and prevent food loss. This coordination can be simple or complex depending on the supply chain. Traditionally, the quality of fresh produce was determined by its appearance, texture, flavor, and nutritional value. However, safety and traceability have become increasingly important. Eating raw or minimally processed produce can expose us to foodborne illnesses caused by pathogens like *Listeria monocytogenes*, *Salmonella enteritidis* phage, and *Escherichia coli* O157:H7 and O104:H4. These pathogens can contaminate produce at any stage of the supply chain, leading to spoilage and losses. To minimize spoilage and reduce the risk of pathogens, postharvest treatments are necessary. These treatments can involve physical, chemical, and gaseous methods, combined with proper temperature management. Advanced and innovative treatments will be crucial for successfully handling, storing, and transporting vegetable products in a sustainable manner. This article provides information on emerging technologies that can help maintain quality and reduce waste in fresh produce.

1. Physical treatments

1.1 Hot Water Treatments:

The global trade of vegetables is significantly limited due to quarantine and phytanitary restrictions. These measures were put in place to prevent the transmission of fungal and bacterial diseases in fresh and processed vegetables. However, these trade restrictions can only be lifted if there are effective treatments available for fresh produce after harvest. Currently, fungicides and pesticides are commonly used to control pests and fungus on vegetables, but their use is increasingly being scrutinized due to concerns about their potential to cause cancer and harm the environment. As a result, alternative methods such as hot-water treatment, dips, short hot-water rinsing, and brushing treatments are being employed to reduce the need for synthetic treatments. Hot air or steam treatments are also utilized to minimize rot and infestation on fresh produce, ensuring quarantine security, preserving fruit quality during cold storage, and extending shelf life.

1.2 Edible coating

Edible coatings are thin layers that are applied to the surface of fresh produce. They serve to improve the natural protective layer of the produce or replace it if it has been removed. The purpose of these coatings is to prevent the loss of moisture and maintain the quality of the product while it is being stored. By acting as a barrier to moisture and gases, they create a controlled environment around the produce that slows down processes like respiration and oxidation. This helps to preserve the color, texture, and aroma of the produce. Additionally, the coatings can protect against physical damage and serve as carriers for beneficial compounds like antioxidants and antimicrobials. Various types of edible coatings, such as chitosan, Aloe vera, polyvinyl acetate, mineral oils, cellulose, and protein-based coatings, have been found to have positive effects on fresh produce, including good barrier properties, no residual odor or taste, and effective antimicrobial activity.

1.3 Irradiation Treatments:

Many factors, including the growth of harmful microorganisms, can impact the quality and safety of slightly processed foods like fresh vegetables. Ionizing irradiation, a non-thermal technique, has been proven to be successful in reducing losses after harvest and controlling pests and microorganisms that can spoil stored products. Irradiation has been found to greatly increase the shelf life of vegetables, extending it by 3-5 times.

1.4 Ultraviolet Light Treatments:

UV light decontaminate the fresh vegetables through inactivation of natural infections, control of fungal decay and inhibition of pathogenic bacteria. Hormetic UV light treatment explores the effects of UV light in decreasing decay after harvest, triggering the production of natural plant defences like phytoalexins, enzymes, and other beneficial plant compounds, and slowing down the ripening and aging processes. This UV light treatment offers a promising and alternative technology for reducing microbial presence in products without compromising their quality.

2. Chemical treatments

2.1 Nitric Oxide Treatments:

Nitric oxide (NO) is a crucial signaling molecule that plays a role in various developmental and physiological processes in vegetable crops, both before and after harvesting. It acts in opposition to ethylene production by suppressing the enzymes responsible for ethylene biosynthesis. The production of NO within plants is a strategy to delay the climacteric phase, reduce yellowing, and slow down the degradation of chlorophyll in vegetables. Using NO fumigation has proven to be more effective in prolonging the ripening process and extending the shelf life of vegetables. However, since NO is volatile and can be toxic in high concentrations, it is important to closely monitor its levels to prevent harmful effects. This is necessary to ensure that the intended benefits, such as controlled ripening and extended shelf life, are achieved in vegetables.

2.2 Oxalic Acid Treatments:

Oxalic acid, a naturally occurring organic acid found in plants, has gained significant interest in its application to vegetables before storage. This acid has shown the ability to slow down the ripening and aging process, prevent postharvest diseases, reduce enzymatic browning, and alleviate chilling damage. Using oxalic acid as a treatment for select vegetables can be a beneficial strategy to improve their shelf life and quality during storage. However, further research is needed to understand how oxalic acid effectively maintains the freshness of vegetables after harvest.

2.3 Calcium Treatments:

Calcium (Ca) has the ability to slow down the ripening and aging processes in vegetables by potentially controlling signaling responses and inhibiting the production of ethylene and respiration. Applying Ca treatments after harvesting vegetables helps prevent softening by strengthening the cell walls, preventing cell wall breakdown, and maintaining proper functioning of cellular membranes and turgor pressure. Additionally, calcium treatments can preserve flavor and nutritional content, enhance the antioxidant capacity of tissues, and reduce the occurrence of physiological disorders and decay in vegetables. Various methods such as dipping, washing, vacuum or pressure infiltration, mixing with wax coatings, or electrostatic powder coating can be used to apply postharvest Ca^2 to vegetables. Notably, significant progress has been made in maintaining vegetable quality and prolonging postharvest lifespan by combing Ca^2 with other techniques. However, the optimal concentration, application form, source, and combination with other techniques need to be determined based on the specific vegetable and fresh-cut product.

3. Gaseous treatments

3.1 1-MCP Treatments:

The rapid ripening and aging of vegetables caused by the plant hormone ethylene significantly impact their physiology, shelf life, storage, postharvest losses, and management practices. One of the most effective approaches to slow down these processes is to inhibit the effects of ethylene. A substance called 1-methylcyclopropene (1-MCP) has been discovered and developed as the most potent inhibitor of ethylene action. It can influence various ripening and aging processes in vegetables, such as changes in pigmentation, softening, cell wall metabolism, flavor and aroma, and nutritional qualities.

3.2 Ozone Treatments:

Ozone, which is a highly reactive form of oxygen, breaks down quickly to form diatomic oxygen. It acts as both an oxidant and a disinfectant by reacting with specific organic matter and microorganisms. The use of ozone in food processing has become more widespread in recent times, especially since it was deemed safe by the FDA in 2001. Ozone has a long history of being used as a water disinfectant worldwide. Its application in the food industry has expanded to include prolonging shelf life, preserving food, sterilizing equipment, and improving waste management. Ozone has been tested and successfully used to control diseases and for storage purposes in crops like carrots, onions, and potatoes. It can also be used to decontaminate surfaces that come into contact with food, break down ethylene, eliminate odors in mixed storage, remove spores in storage areas, and reduce pesticide levels in fresh produce. Additionally, ozone treatment has been found to stimulate the production of natural compounds that help plants resist postharvest diseases. The advantage of ozone is that it effectively kills microorganisms without leaving any harmful residues in treated food, making it an environmentally friendly alternative to other chemicals used for the same purpose.

3.3 Controlled Atmosphere Temperature-Treatment Systems (CATTS):

Researchers have studied the use of multiple physical treatments together or one after the other to effectively control quarantine pests while maintaining the quality of the product. They developed a treatment called CATTS (Controlled Atmosphere Temperature Treatment System) to address issues with commodities being sensitive to prolonged exposure to high temperatures and pests being able to endure extreme conditions. This system takes advantage of the fact that most fresh vegetables can tolerate short-term low oxygen, high carbon dioxide environments, while pests cannot handle the heat stress in these conditions.

CONCLUSION

A wide range of physical and chemical treatments are available to preserve and prolong the freshness of fresh vegetables. However, the suitability of specific treatments may vary depending on the type of vegetable and the condition it is in. It is important to evaluate the effectiveness of existing treatments for addressing emerging quality issues. Postharvest treatments, like controlled atmosphere (CA) and modified atmosphere packaging (MAP), along with proper temperature control, play a crucial role in preserving the physical, nutritional, and sensory properties of vegetables and reducing decay. Other methods such as irradiation, hot water and air treatment, antimicrobial agents, and edible coatings can be employed alongside the preservation process for particular vegetables. Innovative technologies that target ethylene oxidation, inhibitors of ethylene action, and ripening modulators are used to preserve the freshness and nutritional content of produce. These postharvest treatments are generally coupled with proper temperature control during storage to ensure the quality of fresh vegetables.

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