Advances in Postharvest Management of Cherry Tomato

Anubha 1, Lee ete 1 & Smruthi Jayarajan 1, 2
1Amity Institute of Horticulture Studies & Research, Amity University Uttar Pradesh, Noida- 201301
*Corresponding author’s email: sjayarajan@amity.edu

Abstract. The cherry tomato (Lycopersicon esculentum) stands as a highly consumed fresh vegetable globally, renowned for its climacteric ripening nature and nutritional richness. Despite its popularity, the inherent challenges of a short shelf life, susceptibility to microbial decay, and mechanical damage contribute to significant postharvest losses. The continuous demand for fresh fruit vegetables containing health-promoting compounds, such as vitamin C, flavonoids, and carotenoids, has fuelled market growth due to both recognized health benefits and vibrant visual appeal. The current review delves into postharvest handling practices crucial for maintaining cherry tomato quality and extending shelf life. Key practices include harvesting, precooling, cleaning, disinfecting, sorting, grading, packaging, storing, and transportation and the advancement in this field. The impact of these practices on the overall postharvest mass loss, particularly in tropical and subtropical climates, is emphasized, with a focus on mitigating biotic and abiotic stresses. The study reviews a spectrum of postharvest technologies for postharvest management of cherry tomato encompassing both physical and chemical treatments. Physical treatments include Low-Temperature Conditioning, Controlled Atmosphere (CA), Modified Atmosphere Packaging (MAP), Encapsulation and Ultraviolet Irradiation. Chemical treatments involve Edible Coating, melatonin, salicylates and jasmonate, polyamines, and various other chemical substances. Both physical and chemical treatments facilitate controlled gas diffusion, establishing equilibrium between external and internal gases, enhancing shelf life, and preserving quality. In conclusion, this study provides valuable insights into postharvest management practices and innovative technologies, addressing challenges associated with postharvest management in cherry tomatoes.

Keywords: Bilayer coating, Postharvest technologies, Encapsulation, Edible coating, Shelf-life, Storage

1. Introduction

Cherry tomato (Lycopersicon esculentum) is one of the most prized fruits in the world because of its unique flavour, hardness, and size compared to regular-sized tomato varieties [1]. The global appeal of Cherry tomatoes stems from their distinct umami taste, delightful fragrance, and natural phytonutrients containing phenolic compounds, vitamin C, lycopene, and β- carotenoids, which are recognized for their advantageous effects on health [2].

The main factors contributing to the reduction in commercial value of tomatoes after harvesting include softening due to impacts or over-ripeness, cracking, moisture loss, damage from cold temperatures, as well as alterations in composition and decay [3]. This is aimed at controlling postharvest losses while preserving the quality attributes such as flavor, color, nutritional content, firmness, shelf life, and processing characteristics of fresh produce throughout its storage duration [4].

The damage incurred during transit can impact the sugar and acid levels, ripening process, core breakdown, and overall firmness of fresh fruits and vegetables [5]. As a climacteric and highly perishable vegetable, cherry tomatoes typically have a brief shelf life, generally lasting around 2-3 weeks. In tomatoes, ripening is linked to the breakdown of chlorophyll and the conversion of xanthophylls into carotenoids (lycopene and β-carotene).

Cherry tomatoes play a role in averting chronic ailments like cardiovascular issues, neurodegenerative conditions, and cancer. Maintaining a balanced diet, including cherry tomatoes, is vital for weight management and enhancing overall energy levels [6]. Lycopene is an essential carotenoid for the ultimate nutritional and commercial quality of this plant product since it also causes the tomato to turn red as a result of the separation of the chromoplasts and chloroplasts [7]. Snacking tomatoes, such as cherry and grape varieties, are characterized by their small size and are known to possess elevated levels of sugars and acids, which significantly contribute to their distinct flavor profile [8].

The ripening process of tomatoes is influenced by temperature and humidity, which regulate the speed
at which the fruit matures, leading to eventual softening of the flesh and making it unsuitable for consumption [9].

Ethylene regulates the climacteric ripening process that tomatoes typically follow, which includes a variety of physical, chemical, biological, and physiological changes [2]. Since the plant hormone ethylene, commonly referred to as the ripening hormone, is essential to the ripening process of fruits and vegetables, controlling its production is necessary to extend the shelf-life of these products [10]. The system would prioritize the manipulation of the production and/or accumulation of titratable acids, total soluble solids, lycopene, and ascorbic acid [11].

2. Advancement in Postharvest Technology

Many of the nation's big retail establishments sell cherry tomatoes at a premium. It's critical to increase tomatoes' shelf life for both home and international markets.

Postharvest losses and food waste significantly contribute to food and nutritional insecurity. Implementing systems to minimize postharvest losses not only has environmental advantages but also helps reduce carbon dioxide emissions by preventing food waste. Efforts have been made to assess the storage quality and shelf-life of both organically and conventionally produced fruits.

The main factors contributing to the reduction of commercial value in tomatoes after harvest include softening due to physical impact or over-ripeness, cracking, dehydration, damage from cold temperatures, and alterations in composition leading to decay. It is imperative to explore alternative methods aimed at minimizing postharvest losses and extending the shelf life of perishable horticultural produce. Such efforts are crucial for small-scale farmers to enhance their profitability and address the challenges linked to food insecurity prevalent in rural areas.

2.1 Chemical Approaches in Postharvest Technology

Any thin substance that is used to wrap or coat a product to increase its shelf life and may be ingested with the product is referred to as edible films and coatings. By shielding them from physical, chemical, and microbiological alterations such moisture loss, enzymatic browning processes, and lipid oxidation, they can enhance the quality of some foods, such as fruits and vegetables.

The term "edible coating" refers to the thin layer that is created by the edible ingredients covering the fruit and vegetables, whereas "edible film" refers to the layer that has been made and applied to the raw material beforehand. The liquid edible coatings are applied to the raw material by submerging it in the mixture. After being formed into a solid sheet, edible films are wrapped around the product [12]. Coatings made from natural materials have proven effective in preserving a range of fruits and vegetables. Typically, these coatings mitigate weight loss, decelerate respiration rates, postpone ripening and aging processes, and mitigate microbial deterioration, thus extending the shelf life of these items. Additionally, they have the potential to improve the visual appeal of coated produce, making them more attractive to consumers [13].

Edible coatings consist mainly of natural substances, making them safe to consume and providing an environmentally friendly option for preserving food. These coatings primarily consist of lipids, polysaccharides, and proteins. However, they may also contain additional components like resins, solvents, and plasticizers to impart specific properties. Plasticizers contribute to flexibility, solvents improve tensile strength, and resins aid in preventing water vapor from permeating the coating [13].

2.1.1 Dipping

The fruit is submerged in a container of coating solution when using the dipping method. Foods with complex or rough surfaces that need a comprehensive coating (anti-microbial, antioxidant, nutritious, etc.) benefit greatly from this technique [14].

Figure 1. A: Uncoated cherry tomato, B: Dipping the commodity, C: Coated cherry tomato

Generally speaking, food coating may be divided into three categories according to how it interacts with the coating substance and its intended use.
When food comes into close touch with the main film, it protects it from biological or mechanical harm while being stored and transported. Edible biopolymers, plasticizers, and wax are a few examples [15].

The evolution of food preservation techniques from traditional methods to synthetic plastics and the current resurgence of interest in edible coatings underscore the ongoing challenge of balancing convenience, effectiveness in preservation, and sustainability in food packaging. While plastic cling film offers undeniable advantages in terms of preserving food freshness and cost-effectiveness, its environmental disadvantages are substantial.

### 2.1.2 Bilayer coating

Bilayer coating, which is a revolutionary approach to preserve the quality of fruits, is the alternating deposition of two or more coating components on the commodity's surface. This allows for the formulation of a coating material with desired attributes [16]. Hydrophilic coatings offer strength, structural integrity, and are great at blocking oxygen, odours, and oils. However, because of their hydrophilic nature, they are ineffective in blocking moisture [17]. Coatings based on hydro colloids lessen textural deterioration and bioactive component loss during storage [18]. Moreover, fruits can have their shelf life extended by encasing some naturally occurring antioxidant chemicals in bilayer films. Based on the alternative 22 deposition of several biopolymers, the Layer by Layer (LbL) technique enables more efficient control over the 23 physicochemical attributes and activity of edible coatings [19].

![Figure 2. A: Uncoated cherry tomato; B: Coating solution 1; C: Single layer coating; D: Dipping into 2nd coating solution; E: Bilayer coating](image)

<table>
<thead>
<tr>
<th>Crop</th>
<th>Scientific Name</th>
<th>Chemical Used</th>
<th>Impact</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cherry tomato</td>
<td><em>Solanum lycopersicum L. var. cerasiforme</em></td>
<td>Extraction of gelatin from chicken feet, extraction of starch from lotus stems (LSW)</td>
<td>Across the whole visible light spectrum, starch content can be decreased by UV light transmission. For fifteen days of storage, tomatoes retain a greater degree of firmness and pH, and have less weight loss. Coatings with the capacity to increase shelf life.</td>
<td>Andriani &amp; Handayani (2021) [16]</td>
</tr>
<tr>
<td>Cherry tomato</td>
<td><em>Solanum lycopersicum L. var. cerasiforme</em></td>
<td>Chitosan (CTS) and sodium alginate (SA)</td>
<td>A smooth and uniform-looking CTS–SA bilayer film crosslinked by OFA was successfully created.</td>
<td>Zhu et.al (2019) [26]</td>
</tr>
<tr>
<td>Cherry tomato</td>
<td><em>Solanum lycopersicum L. var. cerasiforme</em></td>
<td>Melatonin (100 μM)</td>
<td>Significantly stop the development of grey mold caused by the phenylpropanoid pathway disruption caused by Botrytis cinerea.</td>
<td>Paulsen et.al (2019) [23]</td>
</tr>
<tr>
<td>Tomato</td>
<td><em>Solanum lycopersicum L.</em></td>
<td>Carnauba wax &amp; Conventional carnauba wax emulsion (CWM)</td>
<td>Preserving tomato quality impacts gas permeability, or the creation of oxygen and carbon dioxide, color, and minimizes weight loss. It also decreases spoilage, increases fruit shine, and extends shelf life.</td>
<td>Andriani &amp; Handayani (2021)</td>
</tr>
<tr>
<td>Tomato</td>
<td>Solanum lycopersicum L.</td>
<td>Polysaccharides/lipids (Carboxymethyl cellulose (CMC) + (CEO) Cardamom essential oil)</td>
<td>When stored at 25 ± 2°C, it has a strong ability to prolong the shelf life of fresh tomatoes. For a period of 15 days during storage, the nano emulsion layer helps to decrease weight loss (7.32 ± 2.4%), hardness (1.3 times), total dissolved solids, and acidity of tomatoes. It also lowers oxidative stress and boosts antioxidant enzymes.</td>
<td>Andriani &amp; Handayani (2021)</td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
</tr>
<tr>
<td>Tomato</td>
<td>Solanum lycopersicum L.</td>
<td>Whey protein isolate used, glycerol monostearate (GMS), clove oil (CO), xanthan gum (XG)</td>
<td>The coating is non-reactive, biodegradable, and has the ability to reduce the conversion of starch to sugar. It can also limit respiration.</td>
<td>Andriani &amp; Handayani (2021)</td>
</tr>
<tr>
<td>Tomato</td>
<td>Solanum lycopersicum L.</td>
<td>Melatonin (100 μM)</td>
<td>Increased resistance to cold injuries, Increased synthesis of proline, nitric oxide, and endogenous polyamines was the outcome of ZAT2/6/12 upregulation.</td>
<td>Jayarajan &amp; Sharma (2021)</td>
</tr>
<tr>
<td>Tomato</td>
<td>Solanum lycopersicum L.</td>
<td>Melatonin (100 μM)</td>
<td>Greater ability to withstand cold via activating the GABA shunt route</td>
<td>Jayarajan &amp; Sharma (2021)</td>
</tr>
<tr>
<td>Tomato</td>
<td>Solanum lycopersicum L.</td>
<td>Melatonin (100 μM)</td>
<td>Decreased frequency of Botrytis rot by increased antioxidant enzyme activity.</td>
<td>Jayarajan &amp; Sharma (2021)</td>
</tr>
<tr>
<td>Tomato</td>
<td>Solanum lycopersicum L.</td>
<td>Melatonin (50 μM)</td>
<td>Prolongation of shelf life and prevention of senescence</td>
<td>Jayarajan &amp; Sharma (2021)</td>
</tr>
<tr>
<td>Tomato</td>
<td>Solanum lycopersicum L.</td>
<td>Melatonin (50 μM)</td>
<td>Enhanced postharvest shelf life and encouraged ripening by upregulating the expression of the gene responsible for color development and ethylene synthesis.</td>
<td>Jayarajan &amp; Sharma (2021)</td>
</tr>
<tr>
<td>Tomato</td>
<td>Solanum lycopersicum L.</td>
<td>Melatonin (50 μM)</td>
<td>Triggered carotenoid synthesis.</td>
<td>Jayarajan &amp; Sharma (2021)</td>
</tr>
</tbody>
</table>

3. **Physical Approaches in Postharvest Technology**

Fresh produce is stored in controlled atmospheres (CA) and modified atmospheres (MAP) to extend shelf life by lowering physiological activity overall, minimising mechanical damage, and reducing water stress in tomatoes and other postharvest commodities. The ideal ratio of CO2 to O2 varies greatly throughout cultivars [20].

Horticultural items are packaged on permeable films using MAP technology. Three key components interact to create a modified environment inside the package: product respiration, package permeability, and storage temperature. The modified atmosphere has a lower O2 concentration and a higher CO2 concentration compared to normal air. Because it reduces the pace at which products respire, this changed environment helps prolong the shelf life of products by delaying senescence and degeneration.
By preventing the loss of sensory quality and weight, MAP preserved the firmness and natural red colour of tomatoes. When MAP was compared to unpacked cherry tomatoes, it had no influence on the antioxidant capacity or the amount of lycopene [20].

The idea of food packaging known as "active packaging" was created in reaction to shifts in consumer behaviour and industry developments. Its goal is to increase the safety and quality of fresh products [21]. In order to improve quality, boost safety, and extend the shelf life of fresh fruits and vegetables, active packaging can assist in achieving the RMA during their commercial life [21].

Substance adsorption (such as oxygen, ethylene, moisture, carbon dioxide, flavours, and smells) and substance release (such as carbon dioxide, antimicrobial agents, antioxidants, and tastes) are the primary methods associated with active packaging [21]. Fruit and the environment can interact with ethylene scavengers in a package to maintain the fruit's quality. Numerous writers have investigated potassium permanganate's (KMnO4) capacity to act as an oxidant and lower the amount of ethylene present in the air surrounding horticultural products [22]. A variety of fresh food may be treated using passive MAP, which is more affordable than active MAP [20].

Biodegradable materials are of interest to the packaging industry due to consumer trends and environmental concerns. In certain environmentally friendly applications, plant-based films may be a better option than synthetic packaging [22].

Another workable option for producers and end users to store fruit is to apply powdered microencapsulated essential oils in sachets to be added or fastened to packaging [23]. In addition to preventing the volatile chemicals from degrading, the encapsulation of essential oils in biopolymers can regulate their release and enable controlled actions during packing [23].

Microcapsules offer several notable benefits, and the primary reasons for employing microencapsulation can be outlined as:

- Shielding unstable or sensitive materials from external factors prior to use.
- Improving processability, including enhanced solubility, dispersibility, and flow characteristics.
- Extending shelf life by preventing degradation reactions such as oxidation and dehydration.
- Enabling controlled, sustained, or timed release of active ingredients.
- Facilitating safe and convenient handling of hazardous substances.
- Masking unwanted odours or tastes.
- Immobilizing enzymes and microorganisms.
- Enabling controlled and targeted delivery of drugs.
- Transforming liquids into solids [27].

Figure 3. Active packaging with Encapsulation; A: Encapsulation of essential oil in sachet; B: Harvested commodity; C: Packaging material

EOs include built-in antioxidants and antimicrobials, making them effective and safe natural food preservatives. Essential oils' limited solubility and volatile nature might make it difficult to include them into packaging. Adding essential
## Table 2. Packaging material and packaging material and their effect on cherry tomato

<table>
<thead>
<tr>
<th>Crop</th>
<th>Type Of Packaging</th>
<th>Storage Condition</th>
<th>Results</th>
<th>Reference(s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cherry tomato (Solanum lycopersicum var. cerasiforme)</td>
<td>Active packaging with application of microencapsulated essential oil</td>
<td>25°C for 21 Days</td>
<td>Packaging with a single layer of air-dried coating worked well. After drying, the double-layer emulsion showed increased stability and produced a more uniform and continuous matrix shape.</td>
<td>Adilson Roberto Locali- Pereira et.al (2021) [1]</td>
</tr>
<tr>
<td>Cherry tomato (Solanum lycopersicum var. cerasiforme)</td>
<td>Activated packaging boxes with triticale films containing KMnO4 were prepared.</td>
<td>Room temperature and at 4 °C for 20 Days</td>
<td>Fruit degradation may be prevented by using triticale flour films in active packaging boxes, which can provide superior fruit quality and extended shelf lives while still being ecologically beneficial.</td>
<td>Aragüez et.al, (2020) [24]</td>
</tr>
<tr>
<td>Cherry tomato (Solanum lycopersicum cv. Tiny Bell)</td>
<td>Passive modified atmosphere packaging. Active sachets with antifungal effects and an C2H4 scavenger</td>
<td>7 °C for 21 Days</td>
<td>Under the examined packaging circumstances, RTE Cherry tomatoes wrapped in PE exhibited a minimum of 21 days of shelf life.</td>
<td>Paulsen et.al (2019) [23]</td>
</tr>
</tbody>
</table>

Oils to emulsions—which are frequently stabilised by various biopolymers and can be dried to produce coatings or particles that enclose the oil droplets—is one method for enhancing the stability and dispersibility of essential oil. Because SA may form a gel when divalent cations are present, it is a biopolymer that is frequently utilised for encapsulation. Since SA-based films are hydrophilic matrices, a polyvalent cationic cross-linking technique often improves their water barrier qualities [24].

## 4. Conclusion

These advancements underscore the imperative for effective preservation methods in agriculture, safeguarding fruits against potential physiochemical and biological postharvest damage. The quality and effectiveness of film development, coating, and packaging technologies are pivotal in assessing the horticulture goods' mechanical damage susceptibility, nutritional value, marketability, shelf life, and waste reduction. Given the limited availability of low-temperature facilities in developing countries, the integration of natural compounds like melatonin and salicylic acid has demonstrated significant benefits in extending the shelf life of cherry tomatoes.

Enhancing tomato flavor requires a deeper understanding of these interactions to devise targeted breeding strategies, and effective pre and postharvest management or processing techniques that align with consumer preferences. Consumer sensory evaluation plays a crucial role in shaping product preferences, highlighting the need for future research to explore the complex relationships between technical factors, volatile remodelling, and consumer responses.

## Acknowledgement

I express my gratitude to the Amity Institute of Horticulture Studies and Research for hosting the international conference on "Recent Advances in Horticulture Research (ICRAHOR-2024)".

## Conflict of interest

The authors declared no conflict of interest.

## References


