

## AGRICULTURE FORUM FOR TECHNICAL EDUCATION OF FARMING SOCIETY

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### Methods to Extend Shelf Life of Fruits and Vegetables

#### Authors

**Dr Mashetty Rakesh Kumar<sup>1</sup>, Prof. Rithe Rupali  
Dattarao<sup>2</sup>, Dr. Gouthami Y<sup>3</sup>, Dileep Kumar<sup>4</sup>**

<sup>1</sup>Assistant Professor, Department of Horticulture,  
NSBCOA, Markhel Affiliated to VNMKV, Parbhani,  
Maharashtra – 431718

<sup>2</sup>Assistant Professor, Department of Horticulture, College  
of Agriculture Selu Dist. Parbhani Maharashtra  
(BCOA Selu).

<sup>3</sup>Assistant Professor, Department of Post Harvest  
Technology, JCDR Horticulture College, Affiliated to  
Dr. Y S R Horticultural University

<sup>4</sup>Ph.D. Research Scholar (Fruits Science), C.S.A University  
of Agriculture & Technology, Kanpur Nagar

#### INTRODUCTION

Fruits and vegetables are indispensable components of a balanced human diet as they provide essential vitamins, minerals, dietary fiber, and antioxidants that promote health and prevent diseases. Despite their nutritional importance, these commodities are highly perishable in nature and have a limited shelf life due to continuous metabolic activities such as respiration and transpiration even after harvest. The rate of deterioration is further accelerated by improper harvesting, handling, transportation, and storage practices.

Shelf life extension involves slowing down physiological processes such as respiration and ripening, reducing moisture loss, minimizing microbial growth, and protecting produce from physical damage. Effective post-harvest management practices are therefore essential to maintain quality and extend the usability period of fruits and vegetables without compromising their sensory and nutritional attributes.

Fruits and vegetables are highly perishable agricultural commodities due to their high moisture content, delicate structure, and active metabolic processes even after harvest. These characteristics make them highly susceptible to rapid deterioration caused by physiological, biochemical, and microbial activities. In developing countries like India, post-harvest losses of fruits and vegetables are significantly high, ranging from 20 to 40 percent, which results in economic losses to farmers and contributes to food insecurity. Extending the shelf

life of fresh produce is therefore essential to maintain quality, reduce quantitative and qualitative losses, and ensure year-round availability of nutritious food. A range of physical, chemical, and biological methods are employed to enhance shelf life while preserving nutritional value, texture, flavor, and appearance. This article elaborates on the major techniques used to prolong the storage life of fruits and vegetables along with their advantages and limitations.

#### 2. Causes of Deterioration

The deterioration of fruits and vegetables is influenced by several interrelated physiological and environmental factors that act simultaneously after harvest. Respiration is one of the primary processes responsible for deterioration, in which stored carbohydrates are broken down to release energy, leading to the depletion of food reserves and eventual senescence. Higher respiration rates result in faster spoilage.

Transpiration is another major factor that causes loss of water from produce, leading to wilting, shriveling, and loss of freshness. Ethylene production, a natural plant hormone, plays a crucial role in accelerating ripening and senescence, especially in climacteric fruits such as bananas and mangoes. Microbial spoilage caused by fungi and bacteria further accelerates decay, particularly under warm and humid conditions. Additionally, mechanical damage during harvesting, packaging, and transportation creates entry points for pathogens and increases the rate of deterioration.

### **3. Pre-Harvest Factors Affecting Shelf Life**

Pre-harvest conditions play a significant role in determining the post-harvest life of fruits and vegetables. The selection of appropriate crop varieties with inherent longer shelf life and resistance to diseases is an important factor. Balanced nutrient management, particularly the adequate supply of calcium and potassium, improves the structural integrity and storage quality of produce.

Proper irrigation scheduling helps maintain optimal moisture levels, preventing stress conditions that may affect post-harvest quality. The use of plant growth regulators can influence fruit development and delay senescence. Effective pest and disease management practices ensure that the harvested produce is free from infections, thereby reducing post-harvest losses and extending shelf life.

### **4. Post-Harvest Methods to Extend Shelf Life**

#### **4.1 Temperature Management**

Temperature management is one of the most critical factors in extending the shelf life of fruits and vegetables. Lowering the storage temperature slows down respiration rate, enzymatic activities, and microbial growth, thereby delaying ripening and senescence. Refrigeration is widely used for storing perishable commodities, although different crops require specific temperature ranges for optimal storage. For instance, apples can be stored at temperatures ranging from 0 to 4°C, whereas tomatoes require relatively higher temperatures of 12 to 15°C to avoid chilling injury.

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#### **4.2 Controlled Atmosphere Storage (CA Storage)**

Controlled atmosphere storage involves the regulation of gases such as oxygen, carbon dioxide, and nitrogen within storage chambers to create an optimal environment for prolonging shelf life. By reducing oxygen levels and increasing carbon dioxide concentration, the respiration rate of produce is significantly slowed down. This method is particularly effective for fruits like apples and pears and is widely used in commercial storage systems.

#### **4.3 Modified Atmosphere Packaging (MAP)**

Modified atmosphere packaging is a technique in which the composition of gases inside a package is altered to create favorable conditions for storage. The reduction in oxygen and increase in carbon dioxide levels inside the package help in slowing down respiration and inhibiting microbial growth. This method is commonly used for fresh-cut fruits and vegetables to maintain freshness and extend shelf life during transportation and retail storage.

#### **4.4 Use of Chemical Treatments**

Chemical treatments are widely used to enhance the shelf life of fruits and vegetables by controlling physiological and microbial processes. The application of calcium chloride improves cell wall strength and firmness, thereby reducing softening. Potassium permanganate is used as an ethylene absorbent to delay ripening. The use of 1-Methylcyclopropene (1-MCP) inhibits ethylene action and significantly delays ripening and senescence. Additionally, fungicides are applied to control post-harvest diseases and reduce microbial spoilage.

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#### **4.5 Edible Coatings and Waxing**

Edible coatings and waxing involve the application of a thin protective layer on the surface of fruits and vegetables, which acts as a barrier to moisture loss and gas exchange. These coatings help in reducing respiration rate and delaying ripening. Wax coatings are commonly applied to apples and citrus fruits, while natural coatings such as aloe vera gel are gaining popularity due to their biodegradable and non-toxic nature.

#### **4.6 Irradiation**

Irradiation is a modern preservation technique that involves the use of ionizing radiation to eliminate microorganisms and delay ripening processes. This method effectively reduces microbial load and extends shelf life without significantly affecting the nutritional quality of the produce. It is approved for use in several fruits and vegetables and is considered safe when applied within recommended limits.

#### **4.7 Drying and Dehydration**

Drying and dehydration are traditional as well as modern preservation methods that involve the removal of moisture from fruits and vegetables to inhibit microbial growth and enzymatic activities. Methods such as sun drying, mechanical drying, and freeze drying are used depending on the type of produce and desired quality. Dehydrated products have a longer shelf life and are easier to store and transport.

#### **4.8 Cold Chain Management**

Cold chain management refers to the maintenance of a continuous low-temperature environment

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throughout the supply chain, from harvesting to consumption. This includes pre-cooling immediately after harvest, refrigerated transportation, and cold storage facilities. Proper cold chain management minimizes losses, maintains quality, and ensures that fresh produce reaches consumers in optimal condition.

#### **4.9 Use of Biotechnology and Advanced Techniques**

Recent advancements in biotechnology have enabled the development of crop varieties with delayed ripening and enhanced storage life through genetic modification. Nanotechnology is being used in packaging to improve barrier properties and detect spoilage. Smart packaging systems equipped with sensors can monitor the freshness and quality of produce in real time, offering new opportunities for reducing post-harvest losses.

#### **4.10 Proper Packaging**

Proper packaging plays a crucial role in protecting fruits and vegetables from mechanical damage and environmental stress during handling and transportation. The use of ventilated crates ensures adequate air circulation, while cushioning materials prevent bruising. Biodegradable packaging materials are increasingly being adopted to reduce environmental impact while maintaining product quality.

#### **5. Traditional and Low-Cost Methods**

In rural and resource-limited areas, traditional and low-cost storage methods are widely used to extend shelf life. Storage in earthen pots helps maintain a cool and humid environment, which slows down moisture loss. Zero Energy Cool Chambers provide

an effective and affordable solution for short-term storage without electricity. Storing produce in shaded and well-ventilated areas reduces heat buildup and delays spoilage. The use of ash or sand layers is particularly effective for storing root and tuber crops by minimizing moisture loss and microbial attack.

#### **6. Role of Supply Chain Management**

Efficient supply chain management is essential for minimizing post-harvest losses and maintaining quality. Proper grading and sorting ensure uniformity and removal of damaged produce, while efficient transportation reduces transit time and mechanical damage. Minimizing handling operations helps prevent bruising and contamination. Strengthening market linkages enables farmers to sell their produce quickly, reducing the risk of spoilage and increasing profitability.

#### **7. Advantages of Shelf Life Extension**

Extending the shelf life of fruits and vegetables offers several advantages, including significant reduction in post-harvest losses and improved economic returns for farmers. It ensures the availability of high-quality produce to consumers and facilitates off-season supply. Additionally, it contributes to reducing food wastage and enhancing food security, particularly in developing countries.

#### **8. Challenges**

Despite the availability of various technologies, several challenges hinder the effective extension of shelf life. The high cost of advanced storage technologies such as controlled atmosphere storage and refrigeration limits their adoption by small-scale

farmers. Lack of infrastructure, particularly in rural areas, poses a major constraint. Limited awareness and technical knowledge among farmers further restrict the use of improved post-harvest practices. Additionally, energy requirements for cold storage systems remain a concern in regions with unreliable power supply.

### **CONCLUSION**

Extending the shelf life of fruits and vegetables is crucial for ensuring food security, reducing post-harvest losses, and improving farmer income. A combination of traditional and modern techniques should be adopted based on local conditions, availability of resources, and economic feasibility. Strengthening cold chain infrastructure, promoting awareness, and encouraging the adoption of improved technologies can significantly enhance post-harvest management. Sustainable approaches that integrate scientific innovations with traditional knowledge will play a key role in minimizing losses and ensuring the availability of fresh and nutritious produce throughout the year.