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Review Article

Emerging Postharvest Technologies to Enhance the Shelf-Life of Fruit and Vegetables in Haryana: An Overview

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Abstract

Postharvest losses of fresh produce are a significant challenge, with an estimated 15-25% of crops lost between the farm and the consumer. This is a critical issue in Haryana, where fruits and vegetables make up a substantial portion of agricultural output. While advanced preservation techniques have been developed, the state faces a unique set of challenges, including a shortage of processing units, particularly in rural areas.Horticultural produce is highly perishable due to its high moisture content. Losses occur at every stage, from harvest and handling to processing and marketing. In Haryana, where fruits and vegetables make up over 90% of the state's horticultural production, these losses are particularly costly. The state's production of fruits and vegetables was 1.22 million tonnes and 4.78 million tonnes, respectively, in 2011-12. Without proper postharvest infrastructure and technology, a significant portion of this valuable harvest is lost

Keywords: *Post harvest losses, horticultural crops, emerging technologies, infrastructure.*

Introduction

Horticultural products face a critical challenge: their inherent perishability. With high moisture content at maturity, these crops are susceptible to decay at every stage of their journey, from the moment they are harvested to the point of consumption. This vulnerability leads to significant quantitative and qualitative losses, estimated to be between 15% and 25% globally, a staggering figure that represents wasted food, resources, and labor. Minimizing these losses is not just a good idea; it's an economic imperative. It's far more efficient and timely to protect what we've already produced than to try and compensate for the losses by increasing production (Palumbo *et al.,* 2022). This strategy requires a robust and coordinated effort, beginning with a strong postharvest infrastructure. The cornerstone of this infrastructure is education and awareness. We must equip every individual involved in the supply chain—producers, wholesalers, processors, retailers, and consumers—with the knowledge they need. This includes understanding the biological and environmental factors that cause produce to deteriorate, such as temperature, humidity, and microbial contamination. By understanding these factors, handlers can implement appropriate postharvest tools and technologies. This could be as simple as using proper storage containers and handling techniques or as advanced as employing modern cold chain logistics and controlled atmosphere storage. Ultimately, a collective commitment to minimizing losses through education and technology will not only reduce food waste but also ensure a more sustainable and economically viable food system for everyone.

Table 1: Production of Major Fruits and Vegetables in Haryana during 2011-12 and 2023-24

Horticultural produces	**Production in million tones**	
Fruits	**2011-12**	**2023-2024**
Citrus	214168	359084
Guava	87056	183643

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Mango	77360	98338
Ber	42934	28856
Aonla	12633	9564.1
Vegetables		
Potato	618845	843230
Cauliflower	584277	602632
Tomato	417443	466882.5
Onion	589830	542588
Radish	424680	340379
Carrot	366643	302484
Cabbage	269752	370266
Brinjal	281510	177674

Source:- Department of Horticulture, Haryana

Fruits and Vegetables

Agricultural produce faces significant challenges after harvest, with losses occurring throughout the handling, transportation, and storage processes. This results in a considerable gap between the amount of food produced and what is actually available to consumers (Ullah *et al.,* 2018). A substantial portion of this produce also suffers from quality deterioration by the time it reaches the market, which negatively impacts its competitiveness and reduces farmers' profits.

Several factors contribute to these losses:

- **Mechanical Damage:** Bruising, cracking, and cuts often occur during handling and transport, making the produce more susceptible to microbial spoilage.
- **Physiological Changes:** Natural processes like respiration, ethylene release, and changes in pigments and flavor can lead to undesirable quality as the produce ripens.

The current postharvest management system in the country is far from satisfactory, exacerbated by poor infrastructure and the involvement of multiple middlemen. To achieve national food and nutritional security, we need to implement effective strategies to reduce postharvest losses from the farm to the final consumer. Fortunately, various research institutions, including ICAR, CSIR institutes, and agricultural universities, have developed several postharvest management technologies that can be used to address these problems. By efficiently managing produce during harvest, grading, packaging, transport, storage, and marketing, we can prevent these losses, improve food quality, and ensure better returns for farmers.

Pre-Harvest Chemicals Spray

Auxins, gibberellins, cytokinins, ethylene, growth retardants and inhibitors, and abscisic acid are commonly used for the regulation of various physiological processes to increase production and enhance the postharvest life of horticultural produce (Table 2). Some of the standard practices that can be used are (Kaur and Kaur, 2019):

- Pre-harvest application of GA3 at the mature stage delays ripening, improves storage life in mango and guava, and also improves colour in citrus.
- Pre-harvest sprays of 0.6% calcium chloride 10-12 days before harvest improve shelf life and reduce physiological weight losses in grapes and ber.
- The application of 2, 4-D @ 20 ppm may be gainfully utilized to reduce fruit drop in Kinnow, Malta, Sweet Oranges, and Limes.
- Foliar application of urea (10%) may be practised to control unwanted rainy season guava crops.

Table 2 Plant growth regulators / chemicals and their effective use

Growth regulator	Crop	Conc. (ppm)	Application time	Remarks
NAA	Guava	400	2 weeks after fruit set	Effective in avoiding rainy season crop
Ethephon	Pear	150-200	1½-2 months	After fruit set Improves fruit set and yield

2, 4-D	Citrus	20	During the month of June	Reduces fruit drop
Urea	Guava and Pomegranate	10%	Full bloom stage	Effective in avoiding rainy season crop
CaCl2	Ber, guava, Grapes, Kinnow	0.6%	10-12 days	Prior to harvest Improves shelf life
GA3	Pear	15-20	20-25 days	After full bloom Improves fruit set and yield

HARVESTING TOOLS AND GADGETS

Care in harvesting and handling is necessary to preserve the subsequent quality of horticulture produce. Rough handling at the farm directly affects market quality. Lack of knowledge of harvesting and handling techniques results in substantial wastage of produce. At present, aonla, ber, and jamun are harvested by shaking the trees and fruits falling on the ground are collected. Mango, citrus, pomegranate, bael, sapota and acid lime are individually hand-plucked after giving a twist. These methods damage the fruits which thus become prone to postharvest losses. The citrus, pomegranate, and sapota fruits should be harvested by cutting them with scissors and secateurs, retaining a small fruit stalk (0.5cm). Using simple gadgets/techniques while harvesting can reduce the damage considerably. Some of the straightforward gadgets for harvesting are listed below:

- Decapper for mango (CISH, Lucknow).
- Fruit pickers attached with net bag for mango and ber (IIHR, Bangalore, IARI, New Delhi, and CISH, Lucknow)
- Onion/potato diggers (CPRI, Shimla and CIAE, Bhopal)
- Tripod ladder, clippers, flexible fruit harvesting PVC pipes (CIPHET, Ludhiana and CIAE, Bhopal)
- Plastic crates for collection and transportation (Available in the market)

Handling and Transport

Adopt Modern Handling and Packaging

Use Plastic Crates/Bins: Transitioning from traditional methods to plastic crates and bins across the entire supply chain—from farmers to wholesalers and retailers—can significantly reduce physical damage.

Invest in Mechanization: Promote the use of vegetable washing machines at the farm level and encourage mechanized sorting, grading, and washing in production areas and markets.

Choose Appropriate Packaging: Select packaging materials that protect specific products (Sharma, *et al.,* 2019). For example:

Punnets are ideal for delicate items like strawberries and mushrooms.

Individual skin wrapping works well for citrus fruits.

Tray packaging is recommended for okra, tomatoes, and pre-cut vegetables.

CF boxes are suitable for fruits like guava, kinnow, pomegranate, and mango.

OPTIMIZE TRANSPORTATION

Utilize Refrigerated Vans: For long-distance transportation of fruits and vegetables, refrigerated vans and containers are essential to maintain a consistent temperature, slowing down spoilage and preserving freshness. By implementing these strategies, producers can drastically improve the condition of their crops, ensuring better quality, higher market competitiveness, and increased profits.

Curing

Curing is a critical postharvest process that should be performed immediately after harvesting root, tuber, and bulb crops. This technique involves exposing the produce to high temperatures and relative humidity, which is essential for minimizing losses and maintaining quality. For root and tuber crops, curing promotes wound healing by developing new epidermal tissue. This forms a protective barrier that effectively prevents microbial infection and reduces moisture loss, extending the produce's shelf life. In bulb crops like onions and garlic, curing is the process of drying the neck tissues and outer leaves to create tough, dry scales (Liu *et al.,* 2020). This can be done directly in the field after harvesting and neck cutting. It is recommended to heap the onions and garlic and cover them with jute bags or thatch until the temperature reaches 30–35°C. Generally, a process

of 5-10 days of field curing followed by 10 days of shade curing is advised. To further reduce storage losses, it is crucial to follow a comprehensive protocol that includes curing, neck cutting (leaving about 2.5 cm), sorting, grading, and proper packaging. By implementing these steps, handlers can significantly improve the longevity and marketability of their produce.

Postharvest Ripening

Postharvest losses in India are a significant issue, driven by a combination of traditional practices and a lack of proper infrastructure. One major concern is the use of harmful methods for ripening. For example, calcium carbide, a highly carcinogenic chemical, is often used to ripen fruits like mangoes and bananas (Sohail, *et al.,* 2015). This dangerous practice can be replaced with safer alternatives. Ethylene-based ripening systems, such as ethereal at 500 ppm, are a proven and safe method. Establishing banana ripening chambers and ethylene generation systems near production and marketing hubs would provide a healthier and more reliable alternative (Allia *et al.,*2022).

Beyond ripening, other postharvest issues also need attention:

- **Ripening and Spoilage Control:** Simple treatments like sprays of calcium salts and growth regulators can effectively slow down the ripening process and extend the shelf life of produce.
- **Pest and Disease Management:** Pests like fruit flies in mangoes and guavas can be detected by scanning harvested fruits. Removing affected produce early on can significantly reduce postharvest losses and improve market prices for farmers (Pawar, 2012).
- **Optimizing Storage Conditions:** Storing potatoes presents a unique challenge. While storing them at 0-4°C prevents sprouting, it leads to the undesirable development of sugars, a negative quality for both processing and fresh consumption. Storing them at 10°C avoids this sugar formation but causes severe sprouting. The solution lies in using sprout inhibitors. Chlorpropham (18.0 g.a.i/tonne), for instance, has been proven effective in maintaining tuber firmness and preventing sprouting, sugar formation, and weight loss. To address these challenges, the government should facilitate the availability of safe chemicals like chlorpropham to help curb sprouting in potatoes, onions, and garlic, thereby supporting farmers and improving food security.

Degreening

Some special treatments, like degreening, designed to improve the eating quality of fruit, need popularization. This process applies to citrus fruits, especially those with a light green colour on half of the surface, which can be degreed completely in 48 hrs at 26-30ºC with ethylene gas. A degreening unit with a one-tonne fruit-holding capacity has been developed at NRCC, Nagpur. This technique could be popularized in Haryana.

Waxing

After removal from the cold storage, surface coating of fruits or vegetables with food-grade edible wax emulsions is a common postharvest practice. Food grade waxes replace some natural waxes removed during harvesting and sorting operations. They can help reduce water loss during handling, storage and retail marketing. It also helps seal tiny injuries and scratches on the surface of fruits and vegetables. It improves their cosmetic appearance and prolongs the storage life. The commercially available waxes are Citrashine, Stafresh, Sta-fresh 451, Semper fresh, Carnauba wax and Bee wax (Thakur *et al.,* 2017). These waxes can be used in commercial waxing of fruits like Kinnow and Guava. Among the vegetables, tomato, brinjal, capsicum, and cucurbits can also be waxed to improve storage life.

Vapour Heat Treatment (VHT)

Vapour Heat Treatment (VHT) is an effective technology for controlling fruit fly infestations after harvest, a critical step for both domestic consumption and international trade. The process works by exposing fruit to a specific temperature in saturated air for a set duration, killing all stages of the insects—eggs, larvae, pupae, and adults—without damaging the fruit itself. For fruits like guavas, mangoes, and papayas, a recommended VHT protocol involves heating them to 43°C in saturated air for 8 hours, followed by holding this temperature for an additional 6 hours. This technology is not just beneficial; it's a mandatory requirement for exporting mangoes to countries like Japan and the United States. By adopting VHT in mango and guava production areas, India could significantly expand its export market and ensure a higher-quality product. Currently, India lacks highly specialized VHT machinery, but this equipment can be imported to establish the necessary infrastructure. Implementing this technology would represent a major step forward in postharvest management, enhancing food safety and opening new opportunities for farmers in the international market.

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