Post Harvest Management: Ensuring Safety and Quality of Vegetables

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ABSTRACT

Post-harvest management of vegetable crops is critical for preserving quality, reducing losses, and assuring food safety from farm to table. This process consists of several processes, including harvesting, cleaning, sorting, grading, packaging, storage, and shipping. Each step must be carefully executed in order to retain the nutritional value and extend the shelf life of vegetables. Harvesting at the appropriate maturation stage is critical for maintaining high quality and minimizing damage. Vegetables should be cold immediately after harvest to reduce field heat, which slows metabolic processes and lowers respiration rates. Proper cleaning and sanitization are necessary to remove dirt and potential microorganisms, hence lowering the risk of spoilage and foodborne illnesses. Sorting and grading assist in categorizing vegetables based on size, shape, colour, and quality, which is important for marketability and consumer pleasure. Vegetable packaging should protect them from mechanical damage, moisture loss, and infection while still allowing for proper ventilation. The materials and procedures used for packaging have an important role in preserving freshness and minimizing waste. To postpone senescence and microbial growth, storage conditions such as temperature, humidity, and air composition must be regulated for various varieties of vegetables. Controlled environment storage and refrigeration are

common methods for extending shelf life. Efficient transportation logistics are also required to reduce travel time and avoid physical harm. Implementing optimal practices in post-harvest management not only minimizes losses and waste but also increases the availability of high-quality vegetables, helping to food security and economic sustainability.

INTRODUCTION

India is the world's second-largest producer of vegetables, trailing only China, due to its favourable agroclimatic conditions. In 2019-20, India produced 191.77 million tons of vegetables, becoming the world's second-largest producer (NHB, 2020).

Horticultural crops, such as fruits and vegetables, can develop wastelands, require less water, and offer employment opportunities. However, post-harvest losses can be significant, especially in developing countries with tropical climates. Developing countries are lagging behind advanced countries in technology, using innovative methods to reduce losses. Researchers are focusing on biotechnological tools to improve vegetable nutritional quality and shelf life, in response to climate change, population growth, and rising food demand (Abano *et al.*, 2014).

Postharvest losses occur after harvest and before customers receive the produce. They are more financially and labour-intensive than pre-harvest losses. Vegetables are highly perishable, and postharvest management involves cleaning, washing, selecting, grading, disinfection, drying, packaging, and storage. Management strategies can impact post-harvest quality, with stressed produce more vulnerable to infections. Mulching can prevent mould and rot, while Erwinia bacteria can cause rot in broccoli heads (Andersen and Craig, 1998).

Fresh food crops are viewed as small-scale systems postharvest, influenced by genetic features, regulatory processes, and environmental factors. Understanding postharvest occurrences requires a holistic approach, utilizing high-throughput omics techniques (Hertog *et al.*, 2011).

Fig. 1. Image source: https://www.mdpi.com/2311-7524/10/1/4

1. Factor affecting post -harvest life of vegetables:

Post-harvest losses are caused by a wide range of regionally and increasingly complicated factors. The following are the causes of postharvest losses in fig.2.

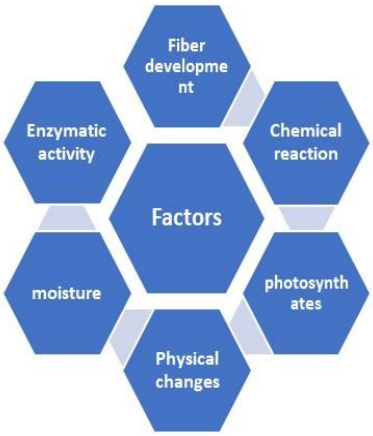

Fig. 2

2. Post harvest management practices:

a) Variety selection: Selecting cultivars with superior storage and processing qualities, as well as reduced susceptibility to handling, is crucial for many vegetables. Some tomato varieties with a long shelf life include Arka Vishal, Pusa Gaurav (Tomato), Arka Nidhi, and Arka Neelakanth (Brinjal).

b) **Harvesting time:** Postharvest quality of fruits and vegetables is determined by their appearance, texture, flavour, and nutritional value. They are divided into immature and mature categories. Optimal eating quality is achieved before full maturity, while delayed harvesting leads to lesser quality and faster deterioration.

Table 1. The approximate duration of growth under ideal conditions, from planting to market maturity, in days.

Crop	Early variety	Common type	Late variety
Broccoli, sprouting	70	_	150
Brussels sprouts	90	_	100
Cabbage	62	_	110
Carrots	60	_	85
Beans, bush	46	_	65
Beans, pole	56	_	72
Beans, lima, bush	65	_	78
Potatoes	90		120
pumpkin	110	_	120
okra	50	_	60
Onions	85	_	120

Adapted from Smith (2010).

3. Maturity indices: Maturity is classified into two categories: physiological and horticultural:

a) **Physiological maturity** refers to a fruit's ability to continue developing and mature before being harvested for consumption or processing.

b) **Horticultural maturity** refers to the stage of development when a plant and its parts are ready for harvest (Dhatt and Mahajan, 2007).

4. Post harvest Handling practices: Cleaning, washing, selecting, grading, disinfection, drying, packaging, and storage are all aspects of postharvest management. These remove undesired materials and improve product appearance while also guaranteeing that the Postharvest Management of Fruits and Vegetables Storage 68 product meets established quality criteria for both fresh and processed items. Postharvest techniques include managing and controlling variables such as temperature and relative humidity, selecting and using packaging, and applying extra treatments like fungicides (FAO, 2009).

a) Cleaning /Washing: Remove field heat and soil by gently washing vegetables with clean water. Produce is cleaned and washed to remove dirt, dust, insects, mould, and spray residues and enhance appearance. Onions, garlic, okra, and mushrooms are not washed after harvest. Surface decontamination can be achieved with chemically mild detergent (soap solution), glacial acetic acid, or NaCl (1%). Chlorinated water with 100 pp chlorine is effective for surface disinfection.

b) Hygiene and Sanitation: Produce handlers prioritize sanitation to prevent both postharvest infections and foodborne illnesses. Disease-causing organisms transmitted by fresh fruits and vegetables include E. coli 0157:H7, Salmonella, Chryptosporidium, Hepatitis, and

Cyclospora pose a risk to human health (FAO, 2004).

c) **Sorting or Grading:** Harvested vegetables are sorted to remove diseased, damaged, deformed, over-mature, insect-attacked, and decaying food. Discard diseased or insect-infested produce to prevent contamination of healthy produce. vegetables based on size, colour, and quality to facilitate packing and distribution prolong shelf life. Monitoring temperature and humidity levels helps prevent spoilage and maintains freshness. Adequate ventilation in storage areas helps control temperature and humidity, reducing the risk of Mold growth and maintaining product quality.

d) **Trimming and curing:** Trimming is done in crops such as cabbage and lettuce. Remove undesirable, discoloured, rotting, and damaged components. Trimming improves visual appearance, prevents produce deterioration, and makes for easier packaging and transportation. While Curing is the process of strengthening and wound periderm (skin) of these crops for a specified period of time under well-defined conditions of temperature and relative humidity. The ideal conditions for potato curing are roughly 200°C and 80% relative humidity.

e) **Pre-cooling:** Precooling is the process of eliminating field heat from harvested commodities, especially during hot weather. Pre -cooling reduces transpiration and respiration, resulting in delayed ripening and reduced demand on transport or storage cooling systems. There are numerous pre-cooling methods, including room cooling, hydro-cooling, contact icing, and vacuum cooling.

5. Temperature and humidity management: Environmental factors impact vegetable growth and development, with temperate species needing a narrower temperature range, while tropical species can reach 40 °C. Exposure to high temperatures can cause metabolic issues and promote fungal growth, causing yellowish-white fruit damage (Moretti *et al.*, 2010).

Table 2. Recommended temperature and relative humidity for vegetables and the approximate storage life under these conditions.

Crop	Temperature (°C)	Relative humidity (%)	Storage life (days
Tomato (red)	8–10	90–95	8–10
Potato (early)	7–16	90–95	10–14
Potato (late)	4.5–13	90–95	150–300
Spinach	0	0 95–100	10–14
Turnip	0	90–95	120
Water melon	10–15	90	14–21
Yam	16	70–80	60–210
Sweet corn	0–1.5	95–98	v
Sweet potato	13–15	85–90	120–210
Summer squash	5–10	95	7–14

Adapted from FAO (2004).

6. Post harvest disease management: Invasive fungus and bacteria cause disease in vegetables, leading to severe post-harvest losses. Vegetables are susceptible to microbial infection due to their succulence. Products are more susceptible to diseases due to mechanical injuries, disease contamination, and environmental factors such as heat. To treat post-harvest infections, fungicides

can be applied as sprays, dips, waxes, or packing materials (Magray *et a*l., 2017).

7. **Ethylene sensitivity:** Ethylene (ET) was the first phytohormone identified. It regulates a variety of developmental and physiological processes, including seed dormancy, germination, fruit ripening, and stress resistance. ET's participation in ripening can cause detrimental degradation of vegetables, fruits, and ornamental crops. Thus, ET biosynthesis and ET-dependent pathways have been targeted in breeding, biotechnological, and transgenic investigations to reduce waste and improve product shelf life (Pradhan *et al*., 2015).

8. **Quality control:** Regularly inspect stored vegetables for signs of spoilage, such as mould, softening, or discoloration. Remove damaged or spoiled vegetables promptly to prevent spread. The highest levels of production occurring in spring. whereas, Summer brings higher quantities of atmospheric ozone due to increased nitrogen species and volatile organic compound emissions. Concentrations are highest in late afternoon and lowest in early morning, particularly in industrialized areas. In high latitude locations, the reverse behaviour happens. Local winds or downdrafts from the stratosphere may also contribute to elevated ozone levels in a region (Moretti *et al*., 2010).

9. **Storage Conditions:** Proper storage of vegetables is crucial for extending shelf life, preventing market gluts, ensuring consistent supply, and increasing producer profits. Storage aims to minimize and manage respiration, disease infection, and maintain necessary life processes. Vegetable crops can be stored in several ways, including refrigeration, controlled atmospheres, and zero-energy cool chambers. Vegetables have varying storage requirements. Some require refrigeration (e.g., leafy greens, cucumbers) to maintain quality, while others (e.g., potatoes, onions) prefer cool, dry conditions.

10. **Packaging practices:** Packaging is crucial for managing perishable products, organizing and protecting produce for distribution, storage, and marketing. Materials like polyethylene film bags, upright cone baskets, and printed plastic bags reduce waste and extend storage life. Implementing palletization and containerization strengthens trade and reduces light transmission on potatoes and onions (Nath, 2013).

11. **Processing and Value addition in vegetables:** The processing industry is crucial for horticulture, reducing waste and overproduction, boosting income, stabilizing prices, and providing economic rewards, contributing to GDP *(*Nath *et al., 2016).*

12. **Transportation and Marketing strategy:** Transportation is crucial for postharvest management, storage, and distribution of horticulture products. Inappropriate handling and containers can lead to losses. Vegetable marketing suffers from intermediaries, reducing producer margins. Enforcing cooperative marketing systems at village and district levels promotes efficiency.

CONCLUSION

Effective post-harvest management of vegetable crops is critical for maintaining quality, increasing shelf life, and reducing losses from farm to consumer. Each process contributes significantly to the nutritional value and marketability of vegetables. Efficient packaging, storage, and transportation are critical parts of the post-harvest process. To reduce spoiling and microbial growth, storage conditions should be optimized for temperature, humidity, and air

composition. Technologies such as controlled environment storage and refrigeration help to extend the shelf life of many crops. Furthermore, optimized transportation operations reduce transit time and prevent physical damage, guaranteeing that veggies arrive in the best possible shape. The use of best practices in post-harvest management not only decreases losses and waste, but it also increases the availability of high-quality produce. This dramatically improves food security, economic sustainability, and consumer satisfaction. Continuous technological developments and education for farmers and handlers are required to improve post-harvest systems even more. Prioritizing these actions will improve the global vegetable supply chain's efficiency, resilience, and sustainability, benefiting producers, retailers, and consumers alike.

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