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Simple Postharvest Technologies for Extending Fruit Shelf Life and Reducing Losses

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Fruit quality, market value, farmer income, and nutritional security are all impacted by postharvest losses, which are a significant problem in fruit production. After harvest, fresh fruits continue to undergo respiration, ripening, moisture loss, and microbial deterioration, all of which can drastically shorten their shelf life. Fruit freshness can be preserved from the orchard to the customer by implementing suitable postharvest management methods. Harvesting at the appropriate maturity stage, careful handling, sorting, pre-cooling, appropriate packing, temperature control, and edible coatings are some of the straightforward and cutting-edge strategies for lowering postharvest losses that are highlighted in this article. There is also discussion of how these methods are used for important fruit crops such as grapes, bananas, mangoes, apples, and guavas. The focus is on low-cost, crop-specific technology that fruit growers and other stakeholders may use to maintain quality and increase marketability. Reducing food waste, boosting profits, and encouraging sustainable fruit production can all be achieved by combining fundamental postharvest procedures with relevant contemporary technologies.

Keywords: Postharvest losses, fruit quality, harvesting, postharvest management, edible coatings, sustainable fruit production.

Introduction

Fruits are an essential part of a balanced diet because they provide vitamins, minerals, dietary fibre, and other beneficial bioactive components. Millions of farmers in India depend on fruit production for their livelihoods, and it also makes a substantial contribution to agricultural revenue and nutritional security (Ray *et al.*, 2026). But successful fruit farming involves more than just growing high-quality fruits. After harvest, maintaining their quality is just as crucial. Even after they are picked, fresh fruits remain living commodities. They lose moisture, continue to breathe, ripen, and ultimately decay. These processes can be accelerated by improper harvesting, rough handling, inappropriate packaging, excessive temperatures, and inadequate storage facilities (Sarma *et al.*, 2025). Fruits may lose their colour, flavour, firmness, freshness, and market value before they are consumed. In addition to wasting the land, water, fertiliser, energy, and labour necessary to produce the fruits, postharvest losses put growers and traders in a tough financial position. It's not always necessary to use costly equipment or sophisticated infrastructure to reduce these losses. When used appropriately, a few straightforward techniques can help maintain fruit quality, increase marketable life, and boost farmers' profits.

Why Do Fruits Deteriorate After Harvest?

Numerous interrelated biological, physical, and environmental variables contribute to fruit degradation.

Ripening and respiration: Fruits continue to generate energy from stored sugars and other organic components after they are harvested. We refer to this process as respiration. Many

fruits undergo colour, texture, sweetness, and scent changes as they ripen. Up to a certain degree, ripening enhances the quality of food, but too much ripening causes softness and eventual spoilage.

Moisture loss: Fruits constantly lose moisture through their skin. Shrivelling, weight loss, and a lack of firmness may result from this. In warm, dry conditions, fruits with sensitive skins or a high surface-area-to-volume ratio may decay quickly.

Mechanical injury: During harvesting, loading, transportation, and packaging, bruising, cuts, cracks, and punctures frequently happen. In addition to losing water more quickly, damaged tissues are more susceptible to microbes that cause deterioration.

Microbial spoilage: Bacteria and fungi can infect fruit tissues that are vulnerable or damaged, resulting in rotting and unpleasant smells. Unsuitable storage conditions and inadequate cleanliness can promote their proliferation.

Inappropriate temperature and storage conditions: In general, high temperatures hasten ripening and respiration. Certain tropical and subtropical fruits, however, are susceptible to chilling harm due to their sensitivity to extremely low temperatures. As a result, proper storage conditions are more important for each fruit than just the lowest temperature.

Simple Technologies to Keep Fruits Fresh

1. Harvesting at the Right Maturity

Maintaining fruit quality starts with harvesting at the right time. While overmature fruits are more prone to bruising and deterioration during transit, immature fruits may not develop the proper flavour, colour, and texture. Fruit size, skin colour, firmness, days after flowering, and crop-specific maturity requirements are examples of appropriate indications that should be used to determine maturity. For instance, apples are harvested based on cultivar-specific maturity indicators, whereas mangoes meant for far-off markets are often harvested at physiological maturity. Harvesting during the cooler hours of the day might lessen exposure to field heat. Fruits should be carefully handled and placed in clean, hygienic containers.

2. Careful Handling and Sorting

Fruits' marketability might be negatively impacted by minor damage. Harvested produce should be protected from impact, compression, and excessive handling. Sorting aids in separating healthy fruits from those that are overripe, spoiled, damaged, or immature. Eliminating fruits that are obviously rotten also lessens the chance that nearby produce will deteriorate while being stored. Clean, reusable plastic crates are preferable to sacks, as they reduce crushing and surface damage. Containers should be smooth-edged and sanitised between uses.

3. Pre-cooling and Appropriate Storage

Fruits that have just been picked may have a lot of field heat. Pre-cooling can delay respiration and deterioration in compatible crops by removing this heat prior to storage or transportation. When temperature and relative humidity are controlled, refrigerated storage can prolong the commercial life of many fruits. However, different crops and cultivars have different storage needs. While many tropical fruits, such as bananas and mangos, need warmer settings to prevent chilling harm, apples may withstand temperatures as low as 0°C under suitable commercial storage conditions. Farmers can still prevent degradation in situations when cold storage is not an option by storing product in a clean, well-ventilated, shaded area, avoiding direct sunlight, and scheduling transportation as soon as is practicable. In arid climes, evaporative cooling may be beneficial, but its efficacy is dependent on the crop being stored, water availability, and ambient humidity.

4. Suitable Packaging and Transportation

Fruits are shielded from contamination, excessive moisture loss, and mechanical damage by packaging. During handling and transportation, properly constructed vented containers or cartons aid in lowering compression and promoting air movement. Containers should not be stacked higher than their load-bearing capacity, and fruits should not be packed too tightly. To lessen rubbing and impact damage, fragile fruits could need partitions or cushions. Fruit size, firmness, transportation distance, and market demands should all be taken into

consideration while choosing packaging. Quality can be maintained throughout transit by minimising needless delays, frequent loading, and exposure to direct sunlight. For highly perishable fruits like strawberries, grapes, and ripe papaya, a well-coordinated supply chain is especially crucial.

5. Edible Coatings: A Promising Modern Approach

Fruits can have thin layers of food-grade materials applied to their surface to create edible coverings. They can alter gas exchange, lessen moisture loss, and postpone various elements of ripening and quality degradation, depending on how they are formulated. Chitosan, starch, alginate, pectin, and formulations based on aloe vera are among the materials being researched for fruit coatings. Approved antibacterial or antioxidant compounds are also used in the development of some coatings. According to research, properly designed coverings can help preserve the quality of some fruits while they are being stored (Chavan *et al.*, 2025). For instance, edible coatings for guavas, bananas, mangoes, and other fruits have been studied. The fruit, coating composition, application technique, and storage conditions all affect how well they work. One fruit may not be a good fit for a coating that works well on another (Sharma *et al.*, 2025). Differentiating between ready-to-use commercial practice and experimental research is crucial. Farmers should adhere to the manufacturer's instructions and only use food-grade items that have been approved for the intended use. Fruits meant for sale or consumption shouldn't have experimental coating combinations applied to them without the necessary safety validation.

6. Improved Packaging and Atmosphere Management

By using packaging materials tailored to the specific product, modified-atmosphere packaging modifies the oxygen and carbon dioxide balance surrounding products. Under the right circumstances, it may help postpone deterioration by slowing respiration. However, the fruit must be properly matched to the gas composition, temperature, and film permeability. Off-flavours, interior damage, and other quality issues can result from either too little oxygen or too much carbon dioxide. Therefore, crop-specific testing and appropriate supply-chain management are the best ways to enable modified-atmosphere packaging. Careful handling, suitable packing, shade, and prompt marketing are still sensible first measures for small-scale growers. When the value and volume of produce handled justify the cost, more sophisticated packaging may be taken into consideration.

Practical Examples in Major Fruit Crops

Due to differences in their structure, respiration rate, and temperature sensitivity, different fruits require distinct postharvest management techniques.

Mango: Use crop-appropriate ripening and storage conditions, keep fruit shaded, avoid latex stains and bruising, and harvest at the right physiological maturity. Chilling injuries can result from extremely low temperatures.

Apple: Maintain proper cold storage conditions, minimise bruising after picking, and use cultivar-specific maturity indices. Commercial systems with the right equipment and monitoring can benefit from controlled-atmosphere storage.

Banana: Prevent impact damage, shield hands and bunches when handling, and keep temperatures appropriate for the ripeness stage. If green bananas are kept too cold, they may sustain a cold injury.

Guava: Because the fruit softens quickly as it ripens, harvest with caution. Transport the produce as soon as possible, avoid compression, and use shallow containers (Ray *et al.*, 2026). Adequate chilling can lessen degradation and maintain stiffness.

Grapes: When harvesting and packing, avoid crushing and berry separation. Maintaining bunch quality requires quick chilling, hygienic packing, and proper humidity control.

These examples show that rather than relying on a single, uniform approach, postharvest treatment needs to be customised for each fruit.

Practical Recommendations for Fruit Growers

A few simple steps can help fruit growers start lowering postharvest losses:

- Fruits should be harvested when they reach the proposed maturity stage.
- Make use of appropriate containers and hygienic harvesting equipment.
- Refrain from tossing, dropping, or packing too many fruits into containers.
- When sorting, remove fruit that is obviously decaying or damaged.
- Before marketing, minimize delays and keep harvested fruits shaded.
- Make use of packaging that allows for enough airflow and prevents crushing.
- Adhere to crop-specific storage temperature and humidity guidelines.
- Only use edible coatings, cold storage, or specialized packaging when it is appropriate, secure, and cost-effective.
- When harvesting, packing, storing, and transporting, keep manually clean.

The adoption of these methods can be further enhanced by cooperation among growers, training, and access to local extension services.

Conclusion

Fruits must be kept fresh after harvest in order to minimise preventable losses, increase farmers' profits, and provide consumers with wholesome food. Effective postharvest management starts with the fundamentals: harvesting at the right maturity, gentle handling, proper sorting, appropriate packaging, and appropriate storage, even though cutting-edge technologies like edible coatings, modified-atmosphere packaging, and refrigerated storage offer promising opportunities. All postharvest losses cannot be avoided by a single technology. The best strategy blends inexpensive, straightforward procedures with crop-specific preservation techniques based on market demands and local conditions. The horticulture industry can make greater use of harvested produce and advance a more effective and sustainable food system by enhancing postharvest handling from the orchard to the consumer.

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