

RESEARCH ARTICLE

REVIEW ON POST-HARVEST HANDLING OF FRUITS AND VEGETABLES TO MINIMIZE LOSS

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ABSTRACT

Post-harvest handling is carried out only after the harvest of fruits and vegetables. The harvesting method varies according to the nature of the crop and also based on the availability of resources. Fruits and vegetables have a limited shelf-life. So, they must be harvested at the proper stage of maturity. Post-harvest quality and shelf-life of fruits and vegetables mainly depend upon handling practices and various treatments been carried out after harvest. Poor handling practices and lack of various treatments lead to post-harvest loss. Losses in vegetables mainly occur due to direct packaging without removal of field heat, harvesting at an improper stage of maturity, etc. while losses in fruits mainly occur due to improper methods of harvest, packaging, etc. Proper handling practices like cleaning, sorting and grading, pre-cooling, packaging, storage, and transportation leads to minimization of loss. Also, various techniques like the application of modified atmosphere packaging (MAP) help in reducing the activity of microorganisms and increasing shelf life. The data were collected from different relevant sources.

KEYWORDS

Fruits, Vegetables, Post-Harvest, Loss, Quality

1. INTRODUCTION

Fruits and vegetables are important sources of vitamins, minerals, and fibers. Including, fruits and vegetables in our diet help us in fighting against several diseases. Various techniques are applied to fruits and vegetables after their harvest for preservation, quality control, etc. Post-harvest handling techniques are applied only after the harvest of the produce. If proper handling practices are not used then, losses occur. Post-harvest loss refers to measurable quantitative as well as qualitative loss from the point of harvest to the point of consumption (Kiaya, 2014). Being, living organisms fruits and vegetables can respire even after harvest (Adhikari and G.C., 2021). Harvesting at an improper stage also results in shorter storage life. The timely harvest of the produce prevents loss and ensures the good quality and safety of the produce. The major cause of post-harvest loss is considered as harvesting at an immature stage, direct packing, during transportation, etc (Adhikari and G.C., 2021). Post-harvest handling practices like cleaning, sorting and grading, pre-cooling, packaging, storage, transportation, are important to elongate the shelf life of the fruits and vegetables after harvest (Pokhrel, 2021). As improper handling practices lead to the loss of productivity. So, minimization of loss, improving quality, increasing profitability, improving the nutrition of the fruits and vegetables are the main objectives of post-harvest handling practices. Reducing post-harvest losses helps in increasing the production of fruits and vegetables (Gajanana and D.Sreenivasa, 2009). The original quality of fruits and vegetables is also preserved if proper handling practices are carried out. The use of proper handling practices fulfills the demand of the growing population by minimizing losses and making the availability of nutritive foods from raw commodities through processing. Somehow, it also helps to fetch higher income. In this paper, we will discuss some post-harvest handling practices that are carried out to minimize losses.

2. RESULTS AND DISCUSSION

2.1 Harvesting Practices

Table 1: Maturity Indices of Fruits

Fruits	Maturity indices
Apple	11-12% SSC, redness of peel
Banana	Dark green color changes to light green, angularity in cross-section of the finger disappears
Grapes	14-17.5% SSC
Mango	Color changes to yellow depending upon variety, changes in shape
Litchi	Color changes to bright red, TSS 30-40
Papaya	Outer skins turn to yellow
Kiwi	TSS 6.5%
Guava	Skin color changes from dark green to light green
Cherry	Color changes to light red, TSS 14-15%

Source: (Dhatt and Mahajan, 2007)

The stage at which fruits and vegetables are harvested determines whether they can meet market quality standards or not. Several methods like hand harvesting, using various tools, machines, can be implied for proper harvesting of the produce. Fruits are harvested at physiological maturity and vegetables at horticultural maturity. Harvesting must be done during the early morning as there is high humidity and fruits are heavy, turgid, and healthy (Kereth et al., 2013). Harvesting must not be done when the product is too wet, oil spotting and rind breakdown problem is seen on some citrus fruits if their harvesting is done in wet

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conditions (FAO, 1989). Fruits must be harvested firm so that they can withstand better handling, shelf-life can also be increased and allowing long-distance travel if required (Kadzere et al., 2006). Fruits are harvested based on size, color, taste, total soluble solids (TSS) whereas vegetables are based on consumers' preferences. Skin breaks, bruises, rots, decay, and other deterioration of the crops must be avoided for their long-term storage (Bachmann, 2000).

Table 2: Maturity Days of Vegetables from The Days of Planting

Crops	Early Variety	Late Variety
Radish	22	40
Potato	90	120
Tomato	65	100
Onion	85	120
Broccoli	70	150
Eggplant	70	85

Source: (El-Ramady et al., 2015)

2.2 Cleaning, Sorting, and Grading

Cleaning is done to remove dirt, stains, microorganisms, etc. from fruits and vegetables. The cleaning process can be carried out manually or automatically depending upon the volume of fruits and vegetables (Joy and Divya, 2016). Fruits and vegetables after washing are treated with chlorinated water that helps to reduce microbial growth. For reducing,

fungal infection in tomatoes before carrying out any postharvest treatments sodium hypochlorite solution has been used to sterilize tomatoes (Arah et al., 2016).

Sorting and grading fruits and vegetables are necessary for selling the products at the appropriate price in the market. Sorting is done as it helps in the removal of diseased, damaged products from the healthier ones. The chance of the spread of disease and infection from infected products to healthier ones is avoided through sorting (Prasad and Paul, 2021). Sorting is done manually before cleaning the product. Grading is defined as the separation of products based on specific characters like size, shape, color, and quality. Grading is important because it saves time and energy in processing operations and also helps in reducing handling losses during transportation. Fruits are graded manually. This method is costly and time-consuming. Electronic color grading is implied for highly perishable fruits and vegetables. This method has higher accuracy of grading and is costlier too (Londhe et al., 2013). Grades can be classified as A, B, C or 1, 2, 3 or large, medium, small, etc. Vegetables like tomatoes are graded based on color and bitter gourd, okra is graded based on size. It will be easier for consumers to buy properly graded fruits and vegetables without inspection.

2.3 Pre-Cooling

Pre-cooling is defined as the removal of field heat carried out after the harvest of the crop to slow down the rate of metabolism and to reduce the rate of deterioration. It is the first step carried out in temperature management. Pre-cooling methods like room cooling, forced air cooling, hydro cooling, ice-cooling, and vacuum cooling can be used for fresh produce based on the characteristics of produce (Mercier et al., 2019).

Table 3: Pre-cooling Methods Along with A Description

Pre-Cooling Methods	Description	Suitable for Fruits/Vegetables
Room Cooling	Crops are placed in a cold room where cold air passes through a fan which serves as a unit of refrigeration. This method requires low cost.	Cabbage, tomato, pumpkin, squash, raw mango, etc.
Forced Air Cooling	Crop receives cold air directly at high velocity. There is a high chance of desiccation of crops.	Cabbage, carrot, cauliflower, strawberries, etc.
Hydro Cooling	Crops are submerged in cold water. The heat exchanger is used to maintain water temperature. It helps in faster cooling and is mainly used for vegetables.	Pomegranate, asparagus, beans, cucumber, etc.
Ice Cooling	Crops packed in boxes are cooled by this method.	Asparagus, broccoli, green onions, etc.
Vacuum Cooling	Crops that don't have thick wax cuticles are cooled by this method. The main disadvantage of this method is crop weight is reduced by 1% for every 5 or 6 reductions in temperature.	Lettuce, leeks, Chinese cabbage, etc.

Source: (Gross et al., 2016)

Poor pre-cooling creates a loss of produce, creating a major economic problem (Mercier, 2019). Thus, the pre-cooling main objective is to minimize the effect of microbial activity, ethylene production, and the rate of respiration.

2.4 Packaging

Packaging can be defined as a system by which harvested produce will reach in a safe condition to the consumer from the production center. Packaging also plays an important role in the maintenance of the quality of the produce. Various packaging materials are used to wrap the fresh produce to save them from mechanical, biological damage during handling operations of fruits and vegetables. The packaging requirements depend on various factors such as susceptibility to water loss, microbial infections, heat accumulation, and primary consideration on the type of package needed. Packaging helps to protect the produce from physical, chemical, microbial attacks and helps to elongate the shelf life of the produce. Plastic bags (polyethylene films) are mainly used for the packaging of fruits and vegetables as film bags are clear, less expensive, and allow easy inspection of the items. Cabbage, potatoes, citrus, apples can be shipped easily in corrugated fiberboard boxes. Oranges, onions, are transported using jute sacks/bags woven from propylene whereas basket woven from palms is used for tomatoes packaging (Idah et al., 2007). Modified atmosphere packaging can be defined as the technique of sealing respiring produce in polymeric film packages to modify O₂ and CO₂ within package atmosphere that helps in extending shelf-life of the produce. Thus, packaging of fresh produce is one of the most important stages carried out during handling operation.

2.5 Storage

The state of keeping agricultural produce safely and preventing them from entry or multiplication of microorganisms is called storage. Crops having specific quality can only be stored properly. Controlled storage condition has made a year-long supply of fresh produce. Throughout, the world there is the availability of a wide range of storage structures to store horticultural produce (Victor Kiaya ACF, 2014). The main purpose of the storage is to slow down the rate of aging, make them available in the off-season, protect from frost, prevent shortages, and keep them in good conditions to fetch higher prices (Khan et al., 2017). Lack of knowledge on temperature requirement leads to loss of produce during storage.

Table 4: Storage of Vegetables

Vegetables	Temperature(°C)	Relative Humidity (%)
Beets	32	90
Cabbage	32	90-95
Cauliflower	32	90-95
Dry Beans	32-50	65-70
Potatoes	38-40	90
Green Tomatoes	55-60	85-90
Onions	32	65-70

Source: (SM, 2019)

Zero-energy storage is used to store fresh fruits and vegetables. Local materials such as bricks, sand is used to construct it. Sand is kept moist to reduce temperature (7-10 °C) and to increase humidity by sprinkling

water frequently. Cellar storage is used to store apples and citrus fruits in Nepal. Local materials like stones, mud, sand is used to construct it. Temperature is maintained between 75-90% in cellar storage (Bhattarai, 2018). Cool storage and underground pit storage are also used to store fruits like apples. In this way, fruits and vegetables are stored.

Table 5: Storage of Fruits

Fruits	Temperature (°C)	Relative Humidity (%)
Apple	0-1.66	85-90
Plum	0-1.66	85-90
Mango	7.20-8.80	85-90
Pomegranate	0-1.66	85-90
Litchi	0-1.66	85-90
Strawberry	0-1.66	85-90
Papaya	8.30-10.00	85-90

Source: (SM, 2019)

2.6 Transportation

Fruits and vegetables are transported mainly through road vehicles. Besides this, they are transported by air, inland waterways, seas, in a lesser amount. Losses up to 20% can occur during the transportation of commodities. Consumers' demand is based on the good appearance of products that is safe. So, those products that are bruised during transportation cannot meet consumers' demands. Lack of refrigerated transport, poor infrastructures facilities, loading and unloading operations, and lack of appropriate transport systems are the main problems that lead to loss of produce during transportation (Weigel, 2021). When ethylene producing commodities and ethylene sensitive commodities are transported together then, high ethylene producing commodities like ripe bananas, apples, etc. can have undesirable changes in color, flavor, and texture in ethylene sensitive commodities like lettuce, carrot, cucumber. Thus, to overcome such problems they should be placed separately. Produce should be stacked and packed properly in well-ventilated containers to minimize loss. Stacking must be done in such a way that it allows cold air to circulate properly through the vehicle is not full (Goldenberg, 1974). The system of refrigeration used in the vehicle must have sufficient cooling properties (Thompson, 2015). Therefore, to minimize transportation loss controlling relative humidity and temperature in containers and good access to roads with tiny or no quivering is necessary (SM, 2019). Transportation during the cool hour of the night or early morning can be effective to reduce wastage that occurs during transportation. Therefore, an efficient transportation system helps to minimize postharvest loss and will also balance the price fluctuation of various products accessible in the different markets of the country.

2.7 Marketing

Marketing is the process by which commodities are transferred from the producer to the consumer. It is the last process that is carried out in the post-harvest system. Marketing of horticultural commodities is quite difficult due to their perishable nature and seasonal production. Though large quantities of good quality fruits and vegetables have been produced if they don't have a fast and equitable supply of commodities to the consumer, losses will occur. This problem exists in developing countries due to a lack of market information and lack of communication between producers and consumers (Kader, 1983). The problem of transportation leads to the problem of marketing. The cost needed for grading, packaging, transportation, loading/ unloading is all involved in marketing. The reported that damage cost, intermediaries' gullible practices, perishable nature, transportation cost, etc (Kumar, 2012). are the major problems of marketing fruits and vegetables in farmer's markets.

Marketing channels reported by (1) producer- dealer-wholesaler-retailer-consumer (2) producer-dealer-retailer-consumer (3) produce-dealer-consumer (4) producer-consumer. Mostly, producers serve to produce to the distributors although they can sell at the local level (Neeraj et al., 2017). Wholesalers buy products in bulk amounts and sell them to retailers. Finally, retailers sell produce directly to consumers. The systematic marketing system helps in reducing post-harvest loss, reducing the price of consumers, facilitating export, and promoting food safety practices. Farmers are selling their produce directly to the consumers through traditional shops in the context of Nepal.

3. CONCLUSION

Post-harvest management is one of the most important factors to keep fruits and vegetables fresh for a long period. Fruits and vegetables are perishable, losses in vegetables primarily occur due to direct packaging without removal of field heat and in fruits due to improper method of harvest. Improper harvesting practices, cleaning, sorting and grading, pre-cooling, packaging, storage, transportation, and marketing lead to post-harvest losses of fruits and vegetables. Thus, if proper harvesting practices, proper cleaning, packaging, storage, and other handling practices help in diminishing post-harvest losses and will assure the shelf life of the produce.

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