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Review on Factors Affecting Postharvest Quality of Fruits

Review Article

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Abstract

The aim of this review was to know the factors that affect post harvest quality of fruits. The pre-harvest factors influencing postharvest quality were cultural practices, mineral nutrition, genetic factors and climatic factors. Post harvest factors influencing postharvest quality of fruits were maturity stage, method of harvesting, time of harvesting, precooking, sorting and grading, packaging and packaging materials, storage, type of storage, temperature and relative humidity during storage and transportation, transportation, road condition.

Keywords: Fruits; Quality; Pre-harvest factors; Post-harvest factors

Introduction

From many studies and field observations over the past 40 years, it has been reported that 40-50% of horticultural crops produced in developing countries are lost before they can be consumed, mainly because of high rates of bruising, water loss, and subsequent decay during postharvest handling [1]. Nutritional loss (loss of vitamins, antioxidant, and health-promoting substances) or decreased market value is another important loss that occurs in fresh produce. Quality of fresh produce is governed by many factors. The combined effect of all decides the rate of deterioration and spoilage [2-4]. These factors, if not controlled properly, lead to postharvest losses on large scale. According to Kader, approximately one third of all fresh fruits are lost before it reaches to the consumers [5]. Another estimate suggests that about 30-40% of total fruits production is lost in between harvest and final consumption [6]. Main causes of postharvest loss include lack of temperature management, rough handling, poor packaging material, and lack of education about the need to maintain quality [7].

Pre Harvest Factors Affecting Post Harvest Quality of Fruits

Postharvest management starts with pre-harvest managements. Once the fruits are harvested, the overall quality of fresh fruits can hardly be improved but it can be maintained. The final market value of the produce and acceptance by the consumers depends upon the grower's ability to apply best available pre-harvest technology followed by harvesting and then to apply best available postharvest handling practices. The pre-harvest factors influencing postharvest quality are frequency of irrigation, use of fertilizers, pest control, growth regulators, climatic conditions like wet and windy weather, natural climates such as hailing, high wind velocity, heavy rainfall, and tree conditions (age, training pruning, light penetration, etc), which influences overall fruit quality and suitability for storage by modifying physiology, chemical composition, and morphology of fruits. One such pre-harvest factor is spray of Gibberellic acid (10 ppm), if applied at color break stage, results in delay in color development and maintains firmness. This is important because it in extending harvesting period. Similarly, the use of calcium solution as foliar sprays increases firmness of fruits as well as extends the shelf life (Table 1).

Cultural operations

The capacity of leaf photosynthesis depends on the incidence

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Table 1: Pre harvest factors affecting postharvest quality of some fruits.

Sl No	Major Fruits	Factors discloses	Their effect	Control methods	References
1	Mango	Water stress	Affected final fruit size	Water availability	[36]
2	Apples	Storage	storage disorder	calcium treatment	
3	Peach	Genetic factor	physiological disorders	Breeding programmes	[37]
4	Orange	Plant growth regulator	maintained peel resistance	Application of GA_3	[38]

of light, whereby the shaded parts of the canopy assimilate less and need more leaves than the well illuminated part for optimal fruit development. Growers can rely on a number of methods which directly or indirectly influence photosynthesis and sink activity (fruit growth). Among these, the most important are tree height, distance, fruit thinning, pruning, fertilization, and application of growth regulators, irrigation and phytosanitary control [8]. Ringing (5 mm wide) the base of productive main branches of Sweet Orange trees, 3 weeks after anthesis, increases fruit retention by 38%, as compared to non-ringed trees. Heavy pruning diminishes leaf area, whole tree photosynthesis and translocation of photosynthates to fruits and roots, increasing the root/shoot ratio and favoring vegetative growth.

Mineral nutrition

The effect of soil on fruit quality is largely dependent on plant nutrient availability [9,10]. Differences in soil patterns also affect the internal quality of pears. Fruit from sandy soils have lower firmness and TSS levels [11]. Plant nutrition is an important factor that potentially affects both the quality and postharvest life of fruit. Optimum plant performance depends on a balanced availability of mineral nutrients that can be limited in many soils around the world [12]. Nitrogen (N) and potassium (K) are the principal nutrients needed by plants [13].

Climatic factors

Environmental factors such as light, CO_2, relative humidity, temperature and water availability are major direct or indirect constraints for plant photosynthesis. Environmental factors affect the content of bioactive compounds indirectly by giving the prerequisites for photosynthesis, and thereby providing energy or precursors of the synthesis of the bioactive compounds. Further, the syntheses of these compounds are also affected directly by various environmental factors [12]. Abiotic conditions, i.e. soil fertility and water availability, vary from year to year and site to site, and can affect the level and quality of fruit after harvest [14]. Increased exposure to light increases fruit size [15], total soluble solids and flesh firmness [16].

Genetic factors

The cultivar of the fruit species is one of the most important factors in determining the variation in, e.g., the fruit's soluble solids content and acidity [17]. Nowadays, horticultural breeding and biotechnology could play a significant role in improving and maintaining postharvest quality and the safety of fresh produce. Moreover, the growers have the choice of selecting preferred cultivars prior to planting crops [5].

Post Harvest Factors Affecting Post harvest Quality of Fruits

Maturity stage

This is the starting point of postharvest quality management. Therefore, it must be ensured that properly matured fruits should be harvested. It must be harvested when it attains the appropriate stage of development based on physiological and horticultural maturity. Harvest maturity varies in accordance with the crop concerned. The fruit is harvested at different stages of maturity depending on how far the fruit will be transported, how long it will be kept in storage and the requirements for the specific market [18]. Maturity always has a considerable influence on the quality of fresh produce as well as the storage potential and occurrence of many storage disorders [19]. Maturity at harvest has a major impact on quality and postharvest life potential of fruits and vegetables [20]. All fruits with a few exceptions avocados, bananas and pears reach their best quality stage when fully ripen on tree.

Methods of harvesting

Selection of suitable method for harvesting of the produce is necessary otherwise bruises or injuries during harvesting May later manifest as black or brown patches making them unattractive. Latex coming out of stem in mango should not be allowed to fall on fruits as it creates a black spot. Injury to peel may become an entry point for microorganisms, causing rotting. Some harvesting gadgets have been developed, e.g. mango harvester in Luck now (CISH).

There are basically three methods most commonly used for harvesting any fruits.

(a) Harvesting individual fruits with hand by pulling or twisting the fruit pedicel

(b) Harvesting individual fruits or fruit bunch with the help of fruit clippers/secateurs/scissors

(c) With harvester specially designed for harvesting

One important demerit of this method is pulling little peel along with pedicel end renders the fruits for quick spoilage (Table 2).

Time of harvesting

Harvesting time also affects quality. Fruits harvested before 10 AM in the morning and transported to pack house for sorting, grading, and packing yield better quality and lasts longer [21]. It is desirable that the fruits are harvested during the cooler parts of the day to reduce the risk of heat injury and sunburn [22]. Therefore, morning harvesting and within 10 AM transportation to destination pack house or market is always preferred in order to control damage due to high temperature. In case of grapes harvesting in India, it starts at 6 o'clock in the morning and harvested produce reach pack house by 10 AM. It facilitates faster pre-cooling also and yield better quality.

Pre-cooling

The quality of fresh fruits largely depends on pre-cooling before storage and marketing [21]. This is a compulsory postharvest treatment followed in developed countries for almost all perishable

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commodities. The rapid cooling of fresh produce from field temperature (pulp temperature at the time of harvesting) to its best storage temperature is called pre-cooling. It is an important postharvest operation recommended in almost all flowers, fruits, and few vegetables. Fruits and vegetables which require on farm pre-cooling if transport time to reach them to cold storage is more than a few hours. It is desirable that fresh produce like grapes, mandarins, berries, cherries, leeches, melons, stone fruits, okra, tomatoes, capsicum, chili peppers, cucumbers, green beans, peas, spinach should be cooled as rapidly as possible [23]. The main objective of any pre-cooling operation is to remove field temperature (field heat). This is important because it increases shell life of the produce. Removing field heat reduces rate of respiration and all biochemical reactions from newly harvested produce.

The act of cooling immediately after harvest is important to remove the field heat before the items are handled further. It is important that the cooling occurs as soon as possible after harvest. Delays in the pre-cooling will reduce the final quality and shorten the postharvest life [1]. Pre-cooling to remove field heat as quickly as possible after harvest is essential for slowing down the rate of deterioration of highly perishable products. The method chosen is largely determined by the type of product in question and the cost to benefit ratio [24,25].

Sorting and grading

This is one of the most important postharvest operations after harvesting. This is done primarily for quality packing and removal of diseased and defective produce from the lot. Proper sorting and grading gives assurance of quality produce [21]. This is either done in the farmer's field or in the pack houses. Both manual and mechanical graders are used for grading. All round-shaped fruits and vegetables are easily graded by mechanical graders. Grading may be based on color, size, and extent of defects, while sorting is totally dependent on man power for removal of diseased, defected, and damaged fruits. Grading is done by simple to highly sophisticated graders. Today, many sophisticated graders are in use for fresh produce such as GREEFA. Both size and color grading simultaneously is possible and is being used on commercial scale in apples.

Packaging and packaging materials

Fruits are fragile products and therefore need packaging to protect them from mechanical damage [26]. The packages should also be well ventilated [27]. It is important to avoid compression damages on the fruit during storage and transportation [26]. The packages should also hold a weight of maximum 20 kg, as the fruit can be damaged when a heavy box is dropped on top of another. When fruits are transported the main goal should be to have as low amount of losses as possible [26].

Packages used are big and heavy and result in significant fruit injury because of weight compression of upper fruits. Anwar, et al. also reported that most mangoes packed in wooden crates which apart from causing physical injuries and bruises during transit are being restricted in international markets on account of quarantine concerns and special disinfestations treatments necessary for international trade [28]. Both packing and packaging materials play many important roles in quality maintenance of fresh produce. Packing starts with placing the produce in the box. While placing, care must be taken to place in line, pedicel end of all fruits should be in one direction, separation layers or trays must be used where it is necessary. The box should not be underfilled or overfilled.

Storage

These practices are supported by Liu who reported that in developing countries the common storage facilities are air-cooled common storage houses which rely on natural cold air [29].

Almost all fruits are seasonal in nature. Every year, harvesting season falls during a fixed period, say 2-3 months. This may be little early or late due to prevailing weather conditions during growing periods. The demand of any fruit beyond the harvesting season is called off-season demand. This demand can be fulfilled only if fruits are stored in the harvesting season and sold during off-season. The management of temperature, ventilation, and relative humidity are the three most important factors that affect postharvest quality and storage life of horticultural produce. Recommended storage temperature and relative humidity for cabbage, lettuce and carrots are 0 to 2 °C and 95 to 100% respectively. Recommended storage temperature and relative humidity for mangoes, avocados, papayas and potatoes are 13-15 °C and 85-90%, respectively [23].

Temperature

Temperature is usually the most important environmental factor limiting shelf life of fresh fruits [30]. Since fruits are alive after harvest, all physiological processes continue after harvest such as respiration and transpiration (water loss), and supply of nutrient and water is not possible since produce is no more attached to the parent plant. Respiration results in produce deterioration, including loss of nutritional value, changes in texture and flavor, and loss of weight by transpiration. These processes cannot be stopped, but they can be reduced significantly by careful management of temperature and relative humidity during storage and transportation [21].

According to Hofman, et al. low temperature conditioning is more effective than heat treatment to prevent chilling injuries and increase the quality of fruits [27]. Growth and multiplication of microorganism responsible for rotting and spoilage are also associated with low temperature. At sufficiently low temperature, many disease-causing microbes stop growth and multiplication. Respiration rates vary tremendously for different products. It can also be affected by environmental conditions, mostly by temperature.

Table 2: Post harvest factors affecting postharvest quality of some fruits.

Sl No	Major Fruits	Factors	Their effects	Control methods	Reference
1	Mango	Packaging	Deterioration	Good package design	[39]
2	Banana	Harvesting methods	Bruising, Surface abrasions	management of harvesting and handling operation	[40]
3	Grape	Storage	grey mould	Control atmosphere (CA) storage	[40]
4	Orange	Maturity stage	Reduce quality	Fully ripened on tree	[41]

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Transportation

According to the FAO transportation is a big and often the most important factor in the marketing of fresh produce. Ideally, transport would take produce from the grower directly to the consumer [31]. Kader stated that in most developing countries, roads are not adequate for proper transport of horticultural crops [32]. Also, transport vehicles and other modes, especially, those suited for fresh horticultural perishables are in short supply for local and export to other countries and the majority of producers have small holdings and cannot afford to own their own vehicles.

Transportation is done in two phases-namely, from the field to the homestead and from the home/company collection area to the market. Transportation for small scale farmers is relatively safe, because the product is either carried to the market or simply transported on carts or bicycles, rather than on trucks. However, for medium-scale farmers or groups of farmers, the transportation of produce is more complicated, and the produce is more susceptible to mechanical and heat damage. The fruits are either loaded onto trucks on wooden stacks, or simply piled onto the trucks (Figure 1). Mechanical damage (fatigue) occurs during transportation because of vibrations that occur while traveling what are typically long distances, usually over untarred roads [33,34]. High temperatures and the buildup of gases that accelerate enzyme activity (and thus cause over-ripening or softening) and microbial activity are factors that contribute to the deterioration of fruit harvests [35].

Road condition and duration of transportation

Both road condition and duration of transportation affect quality of fresh produce [21]. In hilly tracks and rough road surface, more touching and bruising take place as compared to smooth surface. Longer duration during transportation also affects quality. Reefer van should not be hold unnecessary. It not only increases the cost of produce, but also affects quality.

Pattern of loading

Pattern of loading also plays crucial role in maintaining quality of fresh produce. Here pattern of loading means number of packed boxes in one layer (stacking height). In case of fresh produce, stacking height depends on extent of perishable nature of packed commodities and strength of packing materials. If produce are more perishable or box strength is weak, stacking height is kept low and vice versa. For example, height of grape boxes is kept low or it is packed in five ply corrugated boxes or thermocol boxes. This precaution must be taken to preserve postharvest quality of this highly perishable commodity. While loading, another important criteria is interlocking between the boxes. Loading and unloading fruits directly affect quality of fresh produce. It can be done either by hand or with the aid of a forklift. Forklift is used for palletized boxes and shipping containers only. Generally, fruits are stacked on pallets to ease the loading and unloading process and to prevent damage to the product and packages. Exposure to sun while awaiting loading at local mandis or transport can reduce quality drastically. The exposed portion turns black or brown and starts decaying. It is advised for non-reefer transport to move continuously while under sunlight and stop and park your vehicle under a tree shade, especially during sunny days.

Figure 1: The nature of produce transportation in East Africa: a) banana fruit loaded on a truck, b) orange fruit carried in a basket, and c) banana fruit loaded on a bicycle.

Future Directions

There are various ways of addressing the problem of produce loss in Developing countries the most important of which is improving the skills and knowledge of the stakeholders with respect to the postharvest handling of fruits. All stakeholders should be made aware of the best practices relevant to this sector and be able to implement them. Most important, however, is that appropriate government policies and regulations be established and implemented to stimulate national and regional development. The education of all farmers, laborers, and merchants with respect to the basic science and suitable handling of various fruits at all postharvest stages could significantly reduce losses currently experienced in the postharvest chain. This education could be delivered by governments, nongovernment organizations, farmer groups, and others, via mass media services, community lectures, demonstration farms, and school curricula [7].

Summary and Conclusions

Quality of fresh produce is governed by many factors. The combined effect of all decides the rate of deterioration and spoilage. These factors, if not controlled properly, lead to postharvest losses on large scale. Quality deterioration starts as soon as it is harvested and continued till consumed or finally spoiled if not consumed or preserved. The success or failure of any business plan related to fresh produce is totally dependent on the management of factors affecting the quality. To control the problem of factors that affecting postharvest quality of fresh fruits ,education of all farmers, laborers, and merchants with respect to the basic science and suitable handling of various fruits at all postharvest stages could significantly reduce losses currently experienced in the postharvest chain.

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