Storage of fresh fruits and vegetables

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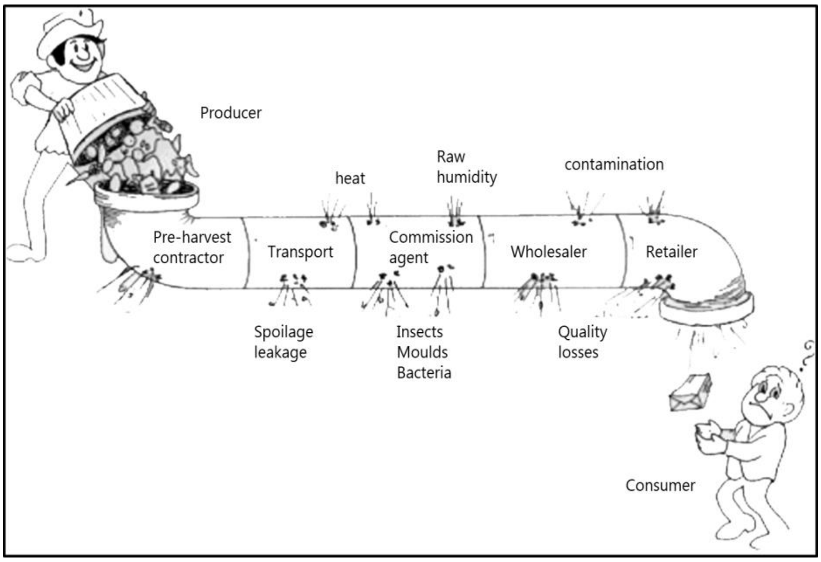
Introduction

India's diverse climate guarantees the production of all varieties of fresh vegetables & fruits. India’s global ranking in fruits and vegetables production is second after China. In 2015-16 produced 90.2 million MT of fruits in 6.3 million hectares area and 169.1 million MT of vegetables in 10.1 million hectares area (National Horticulture Database). Fruits and vegetables are responsible for 92.3 per cent of total horticultural production. However, around 2.1% production is used by processing industries; the remaining produce is either consumed soon after harvest or stored for later use in fresh form. It is important for effective exploitation of the export capability of fruits and vegetables.

Postharvest Losses

Fruits and vegetables are the living tissue and very perishable in nature, are subject to respiration, water loss and cell softening throughout the postharvest system. The storage life of a product varies with species, variety and pre-harvest conditions- particularly quality and maturity. The magnitude of loss in fruits and vegetables are estimated at 35- 40% due to outrageous Post Harvest Management (PHM) (XI Planning Commission). The loss is not only in rupees invested in production cycle but also wastage of work, energy and inputs also. India wastes fruits and vegetables every year equivalent to the annual consumption of the United Kingdom.

The high moisture content of the horticultural commodities accelerates the reaction response making them highly perishable. Reducing the moisture content of the commodity to a recommended level through drying or dehydration, could improve the shelf life, in spite of the fact it disturbs the general texture and impairs the quality.



The impact of absence of sufficient storage facilities for fruits and vegetables after being harvested leads to the reduction in the quantity of fruits and vegetables that get to the market which also has an immediate impact on the distribution and consumption of the required amount for the sound living.

Storage consideration

There is scope to control storage life and quality of produce through postharvest management of the two most important determinants: respiration and transpiration. Both need to be limited but not stopped and proper control of temperature and relative humidity is the key to maximizing storage life and marketable quality. Produce quality loss after harvest happens as a result of physical, biochemical, physiological and biological procedures, the rates of which are influenced primarily by product temperature at harvesting and relative humidity surrounding the produce. Fresh produce needs low temperature and high relative humidity during storage.

Temperature

Each product handled has its own particular temperature requirements. The deterioration of fruits and vegetables with time depends on the temperature, rate of respiration and stress caused by harvesting and postharvest handling. Lowering the temperature of the product as quickly as possible after harvest will maintain a high level of quality remaining attractive for customers. The rate of spoilage increases by 2 or 3 folds with each increment in temperature of 10^{o}C. By lowering produce temperature as soon as possible after harvest generally within four hours the following effects are achieved:

- Respiration rate is decreased.
- Water loss is reduced.
- Ethylene production is suppressed.
- Sensitivity to ethylene is reduced.
- Slow or inhibit the growth of decay-producing microorganisms.

In addition to helping maintain quality, postharvest cooling also provides marketing flexibility by allowing the grower to sell produce at the most appropriate time.

Relative humidity

Maintaining high humidity around harvested produce reduces water loss, which would result in decreased returns through poor quality (for example, wilting, shrivelling) and loss of saleable weight.High humidity should be used with low temperature storage because humidity and warmth combined favour the growth of fungi and bacteria. Although the relative humidity of air increases when it is cooled, it is still necessary to check the relative humidity in a cool room is satisfactory.

Cold storage

Cold storage can be considered the main physical method for delaying or reducing biotic and abiotic diseases and accepted to be the best system for storing the fruits and vegetables in fresh form. Obviously, storage at low temperature is not an antifungal treatment, but its effects have consequences able to reduce produce weakening, influencing both the host and the pathogen simultaneously. Indeed, low temperature exerts its activity:

(a) Indirectly, by reducing the metabolism of the host, and thus delaying its senescence and contributing to the maintenance of fruit resistance to fungal infection,

(b) Directly, by inhibiting or delaying the growth and enzymatic activity of the pathogens.

Moreover, low temperature prevents moisture loss from the host tissues and consequent shriveling, which allows tissues to maintain a high level of resistance to pathogens as compared to fruit kept in low moisture environment.

Cold storage is the one widely practiced method for bulk handling of the perishables between production and marketing processing. It is one of the methods of reserving perishable commodities in fresh and whole some state for a longer period by controlling temperature and humidity within the storage system. Maintaining adequately low temperature is critical, as otherwise it will cause chilling injury to the produce. Also, relative humidity of the storeroom should be kept as high as 80-90% for most of the perishables, below (or) above which has detrimental effect on the keeping quality of the produce. Most fruits and vegetables have a very limited life after harvest if held at normal harvesting temperatures. Postharvest cooling rapidly removes field heat, allowing longer storage periods.

Having cooling and storage facilities makes it unnecessary to market the produce immediately after harvest. This can be an advantage to growers who supply restaurants and grocery stores or to small growers who want to assemble truckload lots for shipment. Postharvest cooling is essential to delivering produce of the highest possible quality to the consumer.

Controlled atmosphere storage

Quality and the freshness of fruit and vegetables are retained under Controlled Atmosphere (CA) conditions without the use of any chemicals. Under CA conditions, many products can be stored for 2 to 4 times longer than usual. CA storage is a system for holding produce in an atmosphere that differs substantially from normal air in respect to CO_2 and O_2 levels. Controlled atmosphere storage refers to the constant monitoring and adjustment of the CO_2 and O_2 levels within gas tight stores or containers.

The gas mixture will constantly change due to metabolic activity of the respiring fruits and vegetables in the store and leakage of gases through doors and walls. The gases are therefore measured periodically and adjusted to the predetermined level by the introduction of fresh air or nitrogen or passing the store atmosphere through a chemical to remove CO_2. There are different types of controlled atmosphere storage depending mainly on the method or degree of control of the gases:

Static controlled atmosphere storage: Product generates the atmosphere.

Flushed controlled atmosphere storage: Atmosphere is supplied from a flowing gas stream, which purges the store continuously.

Systems may be designed which utilize flushing initially to reduce the O_2 content then either injecting CO_2 or allowing it to build up through respiration, and then maintenance of this atmosphere by ventilation and scrubbing.

Evaporative cooled storage

Cold storage facilities is not suitable for rural or on-farm storage where the producer would like to store the commodities for only a few days to accumulate sufficient quantities before conveying them to the markets situated far off and in urban regions. Power availability and its cost are additionally major issues, due to which the refrigerated storages for on-farm short duration storage are not recommended. Hence, there is a shift in accentuation in cold storage to other alternative storage systems. An alternative to maintain lower temperature in an enclosed chamber has been a matter of prime significance under Indian condition. Evaporative cooled storage is one such alternative system that has been studied broadly.

The evaporative cooled storage structure has turned out to be useful for short term, on-farm storage of fruits and vegetables in hot and dry regions. Evaporative cooling is an efficient and economical means for reducing temperature by 10-15 ^{o}C and increasing the relative humidity of about 90- 95% of an enclosure, and has been extensively tried for improving the shelf life of horticultural produce which is essential for maintaining the freshness of the commodities. Based on the principles of direct evaporative cooling zero energy cool chambers (ZECC) have been developed. The main advantage of this on-farm low cost cooling technology are it does not require any electricity or power to operate and materials required to construct this like bricks, sand bamboo, etc. available easily and cheaply. It is a double brick-wall structure. The cavity is filled with sand and walls of the chamber are soaked in water. Even unskilled labour can build the chamber as it does not require any specialized skill. Small and marginal farmers can store a few days harvest to avoid middle men.

Physical treatments to control postharvest diseases

Physical treatments has gained great interest in recent years to control many postharvest diseases because the total absence of residues in the treated product and minimal environmental impact. However, they could have also some limitations, including low persistence, the risk of adverse effects on quality of produce or technological problems for commercial application.

The most well-known physical treatment is the heat. Traditionally it could be applied in the form of hot water dip, hot water rinsing and brushing, vapor, hot air and curing. More recently, the interest in the use of the radio frequency or microwave energy to heat fruits has increased. Other promising technologies are hypobaric and hyperbaric pressure and especially far ultraviolet radiation (UV-C light), due to the direct activity against the pathogens and the resistance induction in the host. Cold storage, controlled and modified atmospheres are complementary physical tools to reduce or delay the development postharvest pathogens, but they are used mainly to maintain fruit quality after harvest.

Pre-storage treatments

- Cleaning
- Washing
- Sorting
- Grading
- Waxing
- Packing
- Pre-cooling
- Curing
- Desapping
- Chemical treatments
- Irradiation
- Vapour heat treatment

1. Hot air treatments

The exposure of fruits for several hours or days to an air atmosphere heated to temperatures higher than 30°C at high relative humidity (RH > 90%) is known as hot air treatment or curing. The term curing was adopted after evidencing that a significant amount of rind wound of citrus fruit healed following exposure to this treatment.

2. Hot water treatments

Hot water treatment (HWT) is a non-conventional approach to control postharvest decay based on the use of water at temperature above 40°C. The technique is completely safe for human and environment (residue-free and environment-friendly) and of feasible use without registration rules. For these reasons, HWT appears to be especially recommended for organic crops or to comply with the stringent regulations of markets that require minimal or no chemical postharvest treatment on commodities. The system provides more efficient transfer of heat than air, so needs shorter times of treatment than hot air. In addition, it is cheap when compared to other heat treatments, such as vapor treatment or forced air. HWT may be suitable also for the control of pests of quarantine importance, such as fruit flies and codling moth.

3. Radio frequency and microwave

The need to achieve fast and effective heat treatments for sterilization or pasteurization in recent years has increased the use of radio frequency and microwave heating, also referred to as dielectric heating. On the contrary, little information is available about the use of these new technologies to control postharvest diseases on fruits and vegetables.

4. Hypobaric and hyperbaric pressure

Hypobaric treatment ranges from 0 to 100 kPa absolute and is applied for a short period of time. Indeed, its application differs from hypobaric storage at low pressure, which lasts for all or most of the storage period and is used to reduce fading of cut flowers, delay ripening of fruits and vegetables, and to kill quarantine insects in transhipped loads of imported and exported commodities. Similarly to hypobaric treatment, also short treatment with pressures slightly higher than atmospheric to control postharvest diseases of fresh fruits and vegetables.

5. Ultraviolet-C light

Among the physical means, the ultraviolet-C light (UV-C, 190–280 nm) showed interesting perspectives of applications due to the direct activity against pathogens and the resistance induction in the host. Induced resistance to diseases by the application of low or sub-lethal doses of UV-C light, is the result of the phenomenon termed “hormesis”, defined as the stimulation of a beneficial effect by low doses of a potentially harmful agent, which is in contrast to the germicidal effects of UV-C light at high doses, involving sterilization of the fruit surfaces. In the last decades, UV-C irradiation has been tested as a postharvest treatment to delay fungal growth and/or senescence in a variety of fresh fruits and vegetables.

6. Use of LED Lighting

The role of visible light in food production, as in agriculture and horticulture, is obvious, as light drives photosynthesis, which is crucial for plant growth and development. However, less recognition is given to its usefulness in other aspects of food processing. It is now understood that low quantities of light can maintain the postharvest quality of crops by mitigating senescence, and improving phytochemical and nutrient content in several species. The sterilizing capabilities of ultraviolet (UV) radiation are well known, yet visible light has been shown to have bactericidal effects under certain conditions, hence playing a role in food safety. High-intensity discharge (HID) lighting, including high-pressure sodium (HPS), metal halide and xenon lamps, as well as fluorescent and incandescent lamps, have been common lighting sources in food production and preservation. Such lighting systems are characterized by broad spectral power distribution, with limited control over the emissions of UV or infrared (IR) radiation. This presents several problems especially in terms of undesirable growth and development of plants, or in excessive heating due to IR radiation. Moreover, fluorescent lights and low-pressure mercury lamps contain mercury, and therefore need to be handled carefully to prevent damage and leakage of the toxic heavy metal.

Light-emitting diodes (LEDs) are solid-state lighting devices that emit light with emission wavelengths of narrow bandwidths, high photoelectric efficiency and photon flux or irradiance, low thermal output, compactness, portability, and which are easily integrated into electronic systems. The unique properties of LEDs allow for the convenient manipulation of the spectral characteristics, radiant or luminous intensity, and temporal settings of the light produced. When LEDs were in the early stages of development after the 1960s, they were of low power and were used mainly as indicator lamps. In the areas of horticulture and agriculture, LEDs are regarded as novel and easily controlled light sources for plant growth, and have been shown to enhance the production of crops while improving their nutritional content. The most recent literature sources on postharvest preservation of plants use LEDs because of their low radiant heat emissions and better efficiency at lower temperatures. This manuscript highlights the importance of LEDs light on quality and postharvest diseases management of fruits and vegetables.

An LED is a unique type of solid-state semiconductor diode that emits light when a current is applied through the device. Two elements of processed material, p-type semiconductors and n-type semiconductors, are placed in direct contact and form the LED chip which comprises the p–n junction (Fig. 2). A current flows only from the p-side (anode) to the n-side (cathode). Electrons and holes flow into the junction from electrodes with different voltages. When an electron meets a hole, it falls into a lower energy level and releases energy in the form of a photon. The light produced by a solid-state process is called electroluminescence. The energy gap of the semiconductor determines the color (wavelength) of the light and the materials used for an LED have energies corresponding to near-ultraviolet, visible, or near-infrared light. LEDs have a tendency for polarization unlike incandescent and fluorescent lamps. LED chips have a positive and negative pole and can glow only with a forward current.

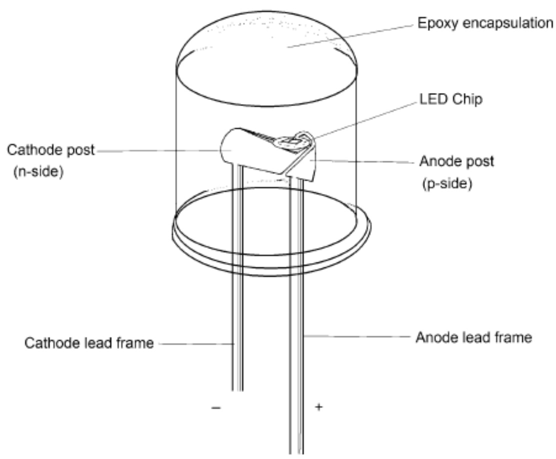


Fig. 2. The basic structure of an LED

Applications of LED in horticulture crops

1. Enhancing the nutritional quality
2. Postharvest Preservation
3. Accelerating or delaying fruit ripening
4. Delay the senescence
5. Prevention of microbial spoilage
6. LED's in food safety
7. Surface disinfection and Package decontamination
8. Reduction in anti-nutritional compounds (Nitrates in leafy vegetables & Indian mustard)

Advantages of LED light source:

Low power requirement - can be operated with battery power supplies,

Long life - 25,000 to 100,000 h, whereas fluorescent tubes typically rated to run for 10,000to 15,000 h,

High efficiency - Most of the power supplied to an LED is converted into light, *Color* - LED systems can be fine tuned to only produce the spectrums or colors that plants need for various morphogenic responses. Fluorescent light sources emit light inthe range of 400–700 nm wavelength, whereas monochromatic LEDs emit lightat specific wavelength,

Cool light - Heat generation in LEDs is relatively low compared to fluorescent lights,

Size – very small size.