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The Role of Evaporate Cooling Storage Technology to Reduce Post-Harvest Losses of Fruits and Vegetables: A Review

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Review Article

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Abstract

Fruits and vegetables are perishable crops, which have high moisture content and short shelf life. Most Postharvest losses of fruits and vegetables occur due to lack of proper cold storage. According to most of research and review show, approximates 40-50% fruits and vegetables loss in the supply chain at globally level. In many Africa countries, postharvest losses are not properly documented but experts have projected the losses to be up to 80%. In Ethiopia, postharvest loss of fruits and vegetables is 50% due to lack of appropriate postharvest handling practice and storage technologies. The loss up to 50% could be caused due to biological and environmental factors. In order to reduce postharvest loss of fruits and vegetables the roles of low cost evaporative cooling storage technology is great. Evaporate cooling is the process by which temperature of substance reduced due to cooling effect from evaporation of water. It work best at dry and hot climate area when results in reduction of temperature and increase in relative humidity. This storage technology reduces postharvest losses of fruits and vegetables by controlling temperature, concentration of gases and relative humidity of the storage area. Therefore, the aim of this review paper is to review studies made by several researchers and reviewers on the roles of evaporate storage technologies in postharvest loss reduction of fruits and vegetables. This storage technology of fruits and vegetables produce available for sale increased 42% to 62% and enhances 10-15 % food security. So to mitigate or alleviate high postharvest loss of perishable crops using evaporative storage technology is very important and determinant.

Keywords: Evaporate Cooling; Fruits and Vegetables; PostHarvest Losses

Introduction

Fruits and vegetables are perishables crops that have high moisture content, soft structure and result in limited shelf life. Fruits and vegetables (FV) production in the subtropical regions occur where the air is dry and warm and fresh produces have high moisture content [1]. Those perishable crops are vital agricultural products for human consumption all over the world. They are a highly good source of diet, minerals, and vitamins [2], rich in antioxidants and fibers [3]. They, also provide carbohydrates, protein, phytonutrients, which are needed for normal healthy. So, the consumption of fruits and vegetables is important for human health because they limit the risk of many diseases and maintain human health [4].

However, they are living parts of plant and contain 65 to 95% water [5]. After harvested, their moisture content decline, due to high temperature leads to respiration and transpiration as result they are spoiled and subjected to high PHL. Postharvest loss of fruits and vegetables associated with the degradation of quality and quantity between harvest and consumption. The highly perishable nature of fruits and vegetables needs proper postharvest storage which is used to reduce PHL in the tropical and subtropical Africa countries. Globally 10.6 million children under 5 years die every year and of this mortality malnutrition accounts about 53% of deaths to underfives children in developing countries [6].

However, fruits and vegetables play a vital role in increasing food availability, incomes, and the economy. Therefore, the reduction of postharvest loss of fruit and vegetables is a complementary means for increasing production [7]. According to Lipinski, et al. [8] reports, 45-55 % of all fruits and vegetables produced around the world are lost in the supply chain. From total horticultural production, 92.3% is responsible for fruits and vegetables in Indian country [9]. However, postharvest losses in African countries are difficult to estimate and they are not well documented, but most experts have estimated that losses could be as high as 80% [10]. The loss for fruits and vegetables are accounting for as high as 30 to 40% loss in Ethiopia [11]. Research done in the East Shewa Zone of Ethiopia indicates that the total postharvest loss of tomatoes fruits is 39.3% [12]. The loss up to 50% could be caused due to biological and environmental factors in developing countries like Ethiopia [13].

The lack of cold storage facilities is the main reason for postharvest losses in quality and quantity. However to control deterioration and loss of fruits and vegetables, low temperature and proper handling are the most important practices. Especially, low temperature refrigeration is the best method of reducing PHL and extending the shelf life. However, mechanical refrigeration is an expensive and has high energy demands and hence necessary to develop cooling technologies that have low energy and cost requirements [14].

Commonly in developing countries, evaporative cooling is an efficient and economical means for reducing temperature and increasing the relative humidity of an enclosure and has been extensively tried for enhancing the shelf life of horticultural produce and reducing PHL. Evaporative cooled storage is more energy efficient than a mechanical refrigeration system. This storage technology adds moisture to the cool air and is effective in hot and dry conditions [15]. The system provides cool air by forcing hot dry air over a wetted pad. From components of Evaporate cooling part, the cooling pad has a great role to solve the problems of postharvest loss by controlling temperature and RH, thus improving shelf life through the formation of the cooling effect and reducing temperature. The pad is a crossflow arrangement used for facilitates easy contact of air and water. Evaporative cooling storage technologies do not require any mechanical or electrical energy input to operate and are, therefore, appropriate for smallholder farmers in rural areas without electricity [13]. Therefore this review aims to review the roles of evaporate storage technologies in postharvest loss reduction of fruits and vegetables

Literature Review

Status of Fruits and Vegetable Production

The production of perishable crops is possible in African countries. In SSA countries also, there is an important potential for fruits and vegetables production, which has been increasing in cost and quantity over the last five to ten years. In India fruits and vegetables account for 209.72 million tons of production, with 73.53 million tons of fruits and 136.19 million tons of vegetables [16]. Those crops are important economic crops with a future for local consumption, export markets, and processing. Ethiopia has also high fruit and vegetable production potential , although, the annual yield is limited partly due to the reluctance of farmers to involve on these perishable produces. It has a comparative advantage in a number of fruits and vegetables productions because of its favourable weather, cheap labour, proximity to export market such as Europe and Middle East [17]. On average more than 2,399,566 tons of vegetables and fruits are produced by public and private commercial farms, this is estimated to be less than 2% of the total crop production [18]. Production of fruits and vegetables has its complexity due to their perishable nature characteristics and lack of knowledge as well as a shortage of capital, so horticulture industry in sub Saharan Africa in general and in Ethiopia particular stays at its infant stage [19].

Importance of Fruits and Vegetables

Agriculture of fruits and vegetables plays a central role in increasing food availability and incomes, supporting livelihoods and contributing to the overall economy and a key factor to improve food and nutrition security. Therefore, reducing PHL of FV, as an important component of food security, has potential to lower food prices to vulnerable communities in the region. Fruits and vegetables are also highly beneficial to our health because they are whole foods that were formed by nature and are high in nutrients. Fruits and vegetables naturally contain non-nutrient chemical compounds called phytochemicals, which are utilized to treat a variety of chronic conditions. Consumption fruits and vegetables which are source of phytochemical intake is consistently linked protection from chronic diseases due to presence of antioxidants [20] (Table 1).

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Fruits and Vegetables	Phytochemical and vitamin, mineral	Health benefits	Reference
Avocado and Cabbage	vitamin K, C, Potassium Lutein glucosinolates	maintain health bone and teeth	[21]
Watermelon and tomato	calcium, vitamin D and flavonoids	promote memory Function	[22]
Banana And potato	Allyl sulphide allicin and potassium	maintain cholesterol level	[23]

Table 1: Nutrients and health benefits of fruits and vegetable consumption.

Post-Harvest Losses of Fruits and Vegetables

Extent PHL of fruits and vegetables: The quantifiable decrease in a given produce during harvest or along the value chain of a postharvest storage is postharvest practices [24]. Inappropriate storage temperature and relative humidity are the main causes of PHL in fruits and vegetables [25]. Therefore, postharvest management of physiological processes such as respiration and transpiration is essential to control the storage life and quality of crops [26]. A large amount of food and products are not reaching the consumer particularly due to postharvest losses [27] during harvesting, handling, transporting, storage, processing, packaging and distribution (Table 2).

Sub Region	Country	Estimated of PHL (%)	Reference
Central Africa	Rwanda	30-80	[28]
West Africa	Ghana	30-80	[28]
Southern Africa	Swaziland	20-50	[29]
East Africa	Ethiopia	50	[30]

Table 2: Postharvest losses in fruits and vegetables for selected countries

Causes of PHL of fruits and vegetables: There are so many causes for losses in the perishable crops and they are classified into two group namely primary and secondary losses. Spoilage of fruits and vegetables occur due to factors like environmental factors temperature and relative humidity, physiological factors, biological and chemical [31].

- **Primary and secondary causes of fruits and vegetables loss:** Primary factors are those that are directly affect the fruits and vegetables shelf life and quality. It includes microorganism, physical factors, physiological factors and etc. The biological and chemical factors arise because fruits and vegetables are prone to microbial contamination during growth, harvest and postharvest operations [32]. Bacteria, yeast and mould are main microorganisms that affect quality of fresh produce during transportation and storage [33]. When fruits and vegetables stored at a very low temperature anaerobic respiration will occurred [34]. This sustained respiration in fresh produce make physiological weight loss [1]. Secondary causes of loss fruits and vegetables are load to conditions that encourage a primary cause of loss and encourage factors directly loss perishable crops. Those secondary factors are physiological deterioration which is the main core cause of PHL in the tropical and subtropical regions SSA [35].

- **Causes of losses during on farm storage and transportation:** Most of time storage and transport of fruits and vegetables for local markets are without controlling temperature, resulting deterioration of fresh produce. In conditions where on farm storage and transportation facilities are not stored at optimum environmental situations, the ripening of fruits and vegetables continues resulting in physiological deterioration as fruit rotted by organisms spread most rapidly at warm storage temperatures and low relative humidity [36].

Reducing Post-Harvest Losses of Fruits and Vegetables

Cold storage and transportation for fruits and vegetables: The shelf life of FV depends on temperature deviations during transport and storage. Therefore, maintenance of fresh produce quality requires precise application of optimum cold chain conditions from harvest, grading, packaging, storage and transportation to the consumer [36]. To keep the quality of fruits and vegetables proper storage is important and used for control the temperature and RH of the storage area [37]. Deterioration of fruits and vegetable during storage depends on temperature [38]. The maintenance of an optimum temperature and RH from the field to the store is crucial for maintaining fruit and vegetable quality. Transportation is often the most costly factor in the marketing channel. The method of transportation for fresh fruit and vegetables is determined by distance, perishability and the value of the product.

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Proper harvesting and postharvest management: Harvesting is an important unit operation, that decide upon the quality as well as storage life of produce and helps in preventing huge losses of fruits and vegetables. To ensure a proper harvest, it's important to set an optimal maturity date of the fruit and vegetable. Harvest maturity refers to the time when the fruit are ready for harvest [39]. Harvesting should be carried out at appropriate stage and during the cool part of the day, which is early morning and late evening. Since perishable crops are alive after harvest, that continues to respiration which results loss of nutritional value and loss of weight and processes cannot be stopped, but they can be slowed down significantly by precooling before storage or distribution [40]. The quality of fruit and vegetable also depends on the harvesting method. Several methods might be used for cooling of fresh produce after harvest such, evaporative cooling.

Packaging in reduction of postharvest losses of FV: Packaging plays a critical role in extending the shelf life of fresh produce and protecting fresh produce during postharvest stages. Therefore, appropriate packaging systems should be designed to reduce FV losses. Even though the contribution of advanced packaging systems on shelf life of fresh produce is tremendous, their industrial use is not very common [41].

Thus, the packaging requirements for fresh produce can be used as protection against microbial contamination and deterioration, protection against bruising and physical injury, protection against moisture or weight loss, providing ventilation for respiration and exchange of gases, slowing down respiration rate, delay ripening and increase storage life, controlling ethylene concentrations in the package [42].

Evaporative Cooling Pad and it's Principles

Evaporative cooling is the process by which temperature of substance reduced due to cooling effect from evaporation of water. Therefore, it is very important that the renewable energy dry air can be used to the greatest extent. This system expanded the areas where free cooling could be used to twice as many countries as pure free cooling systems. Such a system has not yet been demonstrated on operational scale. It works through the conversion of sensitive heat to latent heat, through decrease the ambient temperature as water evaporated provides cooling effect [43] and it is an adiabatic cooling process.

The sensible heat is a warm and dry air from the ambient that passes through the wetted pad and eventually changes to latent heat because of the occurrence of evaporation which results in the cooling of the system. Air is allowed to pass through the pad into the system with the help of suction fans. Water drips into the pad through a water distribution system. As the water drips into the pad the suction fan draws warm air from the system and passes it out. During this process the warm air which is the sensible heat passes through the wetted pad which is now changed to latent heat due to the evaporation that has occurred as a result of the water being evaporated which causes the cooling as a result of this, the shelf life of the fruits and vegetable is expected to increase. Evaporative coolers contain a cooling pad moistened with water. Air is pulled through the pad using a fan and then, cooled. Moist and cooled air moves through produce and carrying away the heat it contains. EC provide cool air with a temperature 12°C above wet bulb temperature of ambient air by forcing hot dry air over a wetted pad [44]. Below Figure 1 illustrates the process of EC where the ambient temperature reduces from t1 to t2. The evaporation and addition of moisture utilizes energy from the air thus increasing its water content from w1 to w2.

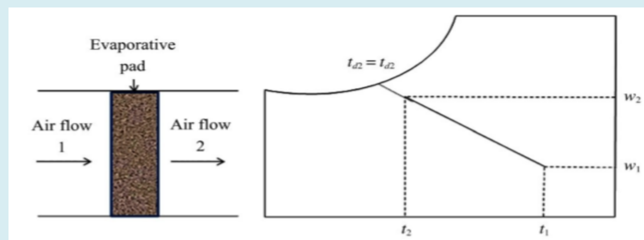

Figure 1: Illustration of evaporative cooling [16].

Design and characteristic of evaporative cooling pad: Evaporative cooling is the simplest and most cost effective technique of increasing the shelf life of fruits and vegetables, and it may additionally be used as ripening chamber for vegetable. Initial cost is less than 1/2 the cost of refrigerated air conditioning and the operating costs is less than 1/3 the cost of refrigerated air conditioning to run. Highly efficient evaporative cooling systems that can reduce energy use by 70% [45].

Evaporative cooling storage satisfies criteria of storage technology like reducing temperature and increased RH humidity with inside the area in comparison to the surrounding, thus useful to small farmers in developing countries. Drybulb temperature and wetbulb temperature are the two temperature measurements that are relevant to evaporative cooling performance. Higher air drybulb temperatures result in more sensible heat that can be converted to latent heat for evaporation by water inside evaporative cooling devices [46]. Wet bulb temperature is the lowest temperature to which air can be cooled by the evaporation of water into the air at a constant pressure. When the wetbulb temperature is lower than the dry bulb temperature and the difference between them represents the maximum decrease in temperature achievable using

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evaporative cooling devices storage technology. As EC removes sensible heat from produce and surface, it works best in hot and dry climate and it not suited for humid areas like coastal regions with moderate to high RH of 70-85% [47].

Pad materials of evaporate cooling structure: Many researchers have studied the effect of cooling pads on cooling efficiency. Although commercial pads gave good cooling efficiency, as they are specially made but they are expensive and not suitable to low income farmers and traders. Locally and easily available pads performed better with RH above 90% and maximum temperature drop of 25°C [48]. However, performance is dependent on outside weather, but cooling efficiency can further be increased by creating good porosity and airwater contact within pad.

Factors affecting the efficiency of cooling pads: Many parameters can decrease or increase the efficiency of pad evaporative cooling systems. Pad is an important component of ECS of fruits and vegetables storage rooms. The performance properties of evaporative cooling pads can be affected by a variety of factors such as, outside air temperature and relative humidity. It also affect by pad thickness, pad face air velocity, pad material, and water flow rate above the pad. Including surface area of the pad and, number of sheet of air also affect evaporative cooling pads. Pad evaporative cooling represents the direct evaporative cooling based on mechanical and thermal contact between air and water [49].

Therefore, areas with high temperatures have higher rates of evaporation and more cooling will occur. On the other hand, when the relative humidity is high, the rate of water evaporation is low, and therefore cooling is also low. The extent to which evaporation can lower the temperature of a container depends on the difference between the wet bulb and dry bulb temperatures. The cooling efficiency of the cooler is indicating the extent to which the dry bulb temperature of the cooled air approaches the wet bulb temperature of the ambient air [50].

Many scientists evaluated Evaporate cooling storage (ECS) by using various operating parameters such as pad thickness, pad density, pad face velocity, water flow rate, pad orientation, pad volume. Parameters like cooling efficiency, temperature and relative humidity inside the cool storage technology largely depends on operating parameters. Evaporative cooling or humidification of surrounding air in FV storage involves the use of principles of moist air properties or psychometrics [51]. Evaporative cooling has been reported for achieving a favorable environment in storage structures for FV where shelf life of some fresh produce has been increased by factors of 1.35 at the same time exhibiting good appearance [44].

- **Water flow rates:** As the water drips into the pad the suction fan draws warm air from the system and passes it out. During this process the warm air which is the sensible heat passes through the wetted pad which is now changed to latent heat due to the evaporation that has occurred as a result of the water being evaporated which causes the cooling, as a result of this, the shelf life of the vegetable and fruits are expected to increase [42]. The amount of water evaporated from the cooling pads increased as the difference in the inlet and the outlet air temperature increased. The amount of water that the evaporative pad cooling system used for heat reduction mainly dependent on outdoor temperature, relative humidity, and mass airflow rate through the pads. Therefore, low humidity facilitates evaporation and cooling [52].

- **Air velocity:** The air is usually moved naturally, by convection or by fans [53]. The most important feature to consider when designing and operating these systems is the velocity of the air flowing through the pad (pad evaporative cooling systems). A device called an anemometer is used to measure air velocity. With an increase in the air velocity, efficiency increases which happens due to the increased mass transfer between air and water [54]. Water consumption or evaporation rate increases with the increase in air velocity. It is due to the increase in the amount of surface evaporation and mass transfer [55].

- **Number of plate layers and fiber types:** The number of sheets refers to the total number of layers of a pad. The pad efficiency increases as the number of sheets increases. Although Ndukwu [10] observed that, increasing pad thickness increases cooling efficiency of evaporative cooling pad. The water flow rate through the pad evaporative cooling system is the most important parameters affecting the cooling efficiency of the system. The cooling pad made of plant fiber to provide a very porous structure able to hold water [56].

Parameters of Evaporate Cooling Pad Structure

Cooling efficiency, temperature drop and increase in humidity inside the evaporate cooling chamber largely depends on operating parameters. Optimum designed parameters for a given size gives better performance in terms of cooling efficiency. The evaporative cooler uses a fan to force warm air from outside through a porous pad onto which a continuous water spray is enabled to cool the air. When the temperature of the environment or the water rises, the water evaporates more quickly. Evaporation takes place on the liquid's surface [37].

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Cooling efficiency: Analysis of the moist air properties is important to look at the suitability of a given modified air condition for fruit and vegetables storage in hot climate. Cooling efficiency is an index used to assess the performance of a direct evaporative cooler. Cooling efficiency is also known as the saturation efficiency because it refers to the amount of moisture that the media can evaporate into the air. Evaporative media efficiency usually runs in between 80% to 90% and most efficient systems can lower the dry air temperature to 95% of the wetbulb temperature, the least efficient systems only achieve 50% [57]. The performance of the evaporate cooling system was evaluated using the cooling efficiency indicator.

$$\eta = \frac{T_{db-o} - T_{cond}}{T_{db-o} - T_{wb-o}} \times 100$$

Where: T_{dbo}= Outside drybulb air temperature (°C); T_{Cond}. = conditioned air temperature or cooler (°C); T_{wbo}= Outside wetbulb air temperature (°C).

The efficiency of the evaporative pad cooling system is designed to range between 70 and 80% and cooling efficiency is less than 100% to prevent the incoming relative humidity from becoming excessive [58]. A noload test of the evaporate cooler conduct to see the effect of the evaporation that is expected to take place whether the process is effective or not in order to determine its efficiency before being loaded with the vegetables that will be stored. This achieved by taken temperature difference and the relative humidity of the system relative to the ambient condition. The load test of the evaporative cooling system also subjected to temperature and Relative Humidity Measurement. Both the temperature and relative humidity of the evaporative cooling system and that of ambient determined. The temperature readings taken using the dry and wet bulb thermometer. The relative humidity then obtained using the psychometric chart.

- **Effect air velocity on cooling efficiency:** Air movement artificial fan is an important factor that influences the rate of evaporation and cooling efficiency. The cooling pad efficiency has a low value when the air velocity is low unless the water flow rate is high. When pad density of an evaporative cooling increased, the cooling efficiency increased. The work of Warke and Deshmukh [59] show that, efficiency increases as the thickness of the pad increases and it also may decrease due to it restricts the flow of air due to its high density.

Temperature and relative humidity: Temperature and relative humidity are the most important factors in the deterioration of fruits and vegetables during storage. Temperature increase Physiological, chemical and enzymatic changes that make faster produce deterioration during storage [60]. And storage of fruits and vegetables at low temperature is important to reduce PHL and extend shelf life RH also other significant factors to be considered while handling and storing fruits and vegetables. Evaporative cooling is generally more efficient where air temperature is high and relative humidity is low. Noted that 100% relative humidity was not achievable in evaporative cooling because of 100% saturation is impossible. This is because most of the pads are loosely packed, and the process air can easily escape between the pads without sufficient contact with the water. In addition, the contact time between air and water is not long enough which results that heat and mass transfer is insufficient [61].

Ndukwu and Manuwa [10] report that , the moisture loss in tomatoes fruits is 6.5 times as great in ambient conditions (28–33°C, 45%-65% RH) as in evaporative cooling conditions (20–25°C, 92% 95%RH).Also avocado fruits store at 5oc temperature and RH 85-90% could result in a shelf life 23 weeks [62]. EC reduce temperatures below ambient with a depression reaching 12°C and RH above 90% [63]. From Q10 concept for every 100c rise in the temperature there is rate of chemical reaction increases. A measure of the effect of a 10°C rise in temperature on the velocity of a chemical reaction. Therefore development of evaporate cooling pad storage technology is important to reduce PHL and extend the shelf life of fruits and vegetables by removing field heat which make faster deterioration of their quality. The recommended storage relative humidity for most horticultural crops is 70-90 % [64].

Effect of Evaporate Cooling System and Pad on Quality Attributes of Fruits and Vegetables

Today many researcher findings indicating that the improved storage conditions provided through evaporative cooling storage technology lead to improved fruit and vegetable physiochemical properties and resulting in prolonged shelf existence [13]. The change in quality of produce and thus decline in consumer acceptability of fruits and vegetables is may be due to change in physical (colour, weight loss) chemical (titratable acidity, pH vitamin C, beta carotene, total soluble solids,) qualities where each product has a unique set of attributes desired by the consumer [65].

Effects of Temperature and RH on Quality Attribute of Fruit and Vegetable

Physiological weight loss fruits and vegetables: Reduction of weight loss determines the saleable weight of produce. High temperatures and low RH increases weight loss of fresh produce [66]. Study on evaporative cooling storage to keep fruits and vegetables cool can reduce weight loss due to restriction of transpiration and respiration. By increasing the relative humidity, the vapour pressure deficit if reduced,

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result in less water loss [67]. The water loss and respiration rates however are influenced by the temperature and relative humidity of the surrounding environment.

Firmness of fruits and vegetables: Temperature that affects the firmness of fruits might be explained by differences in the rate of respiration that affect the firmness. Softening of fruits increase as the storage time increase due to there is the modification of texture through breakdown of polysaccharides that take place during storage of ripening [68].

PH and titratable acidity of fruits and vegetables: During storage, TAA of fruits and vegetables decreased due to susceptibility of acid to oxidative destruction as impacted by the ripening environment and utilization of acids as respiration substrates. Because of acidity in fruits is many organic acids which are consumed during respiration the acidity thus decreased with increasing storage duration [69] with a corresponding increase in fruit pH.

Total soluble solids (TSS) of fruits and vegetables: Total soluble solid is the refractometric index that indicates the percentage total soluble solids in a solution and it is one of fruits and vegetables quality. Increased TSS during evaporative cooling storage could be linked to changes in peptic compounds, polysaccharides in soluble sugar [70]. The increase in TSS during storage is attributed to the breakdown of starch into sugars or the hydrolysis of cell wall polysaccharides during ripening. The lower TSS with precooling could be due to slowing down of metabolic activities.

Colour of fruits and vegetable: Color is one of the physical quality assessment properties, and it is an external characteristic that represents a product's quality. The colour of commodities is not static and changes during maturation, ripening and senescence. Deng, et al. [71] report that, colour development in tomatoes is temperature sensitive, with lower temperatures slowing down degradation of chlorophyll. Duration and temperature of storage are two important factors responsible for the loss of pigments and colour, and special care must be taken to produce food that retains its bright attractive colour during subsequent marketing and consumption [72].

Nutrition Composition of Fruits and Vegetables

Vitamin C: Vitamin C is the most an organic acid bearing strong antioxidant properties [73]. Vitamin has high sensitivity, its retention in fruits and vegetables after storage is used to estimate the overall nutritional quality of the produce. At higher temperatures, vitamin C loss is accelerated. With longer storage, there is a decline of vitamin C in fruits and vegetable [74].

Beta carotene: Beta carotene is one of the most widely distributed carotenoid in foods [75]. It is a strongly coloured redorange pigment found in plants with provitamin A activity. Nutritionally, beta carotene is an antioxidant, important in binding active compounds in the body [76]. Beta carotene is a highly versatile compound affected by length and temperature of storage. Beta carotene is a compound of great nutritional importance due to its provitamin a activity [77].

Storage life fruits and vegetables: Shelf life of fruits is extended at lowtemperature storage because metabolism is delayed by a reduction in respiration rate, ethylene production, colour changes, physical disorder, microbial growth and softening [78]. Mature avocados fruits stored at 58oC could reach up to 12 week shelf life and a shelf life of 23 weeks at 5˚C [79].

Conclusion

Due to fruits and vegetables are perishable crops and contain high moisture content, they have short shelf life. To control deterioration and loss of fruits and vegetables, low temperature and proper handling are the most important practices. Especially, low cost evaporative cooling storage technology is the best method of reducing PHL and extending the shelf life because of part made may made of locally available materials. This storage technology adds moisture to the cool air and is effective in hot and dry conditions. From components of Evaporate cooling part, the cooling pad has a great role to solve the problems of postharvest loss by controlling temperature and RH, thus improving shelf life through the formation of the cooling effect and reducing temperature. Therefore to reduce postharvest losses of fruits and vegetables low cost and appropriate storage technology like evaporative cooling storage should be installed at different hot and dry climate condition area.

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