

Review on Pre and Post-Harvest Management on Quality Tomato (Lycopersicon esculentum Mill.) Production

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Abstract
Tomato (Lycopersicon esculentum Mill.) is one of the vegetables with the highest production in the world and its production is increasing all over the world. Tomatoes contribute to a healthy, well-balanced diet. Temperature affects plant growth balance, flower development and pollination, fruit growth and development, thus has substantial influence on fruit quality. Solar radiation and temperature have a large influence on fruit sugar accumulation. The best quality and long life storage for tomato product the research is required through incorporation of pre-harvesting as well as post-harvesting practices taking other factors under consideration in the specific locations. Day and night temperature and the variation between the two has pronounced effect on growth, flowering, fruiting and yield of fruits and seeds in Tomato, but the night temperature is a critical factor for fruit set in Tomato. There are many key points to be considered in assessing the quality of Tomatoes. Tomatoes for distant markets can be picked at the "mature-green" or "breaker" stages whereas tomatoes for near outlets can be picked at the "breaker", "turning", "pink "or "light-red" stages. The cluster or vine-ripe tomatoes are harvested at the "light-red" to the "table-red" stage. The quality of tomato cultural practices on post-harvest quality should incorporate all practices on integrated and manageable time and place.
Keywords: Pre and post-harvest management Quality, Tomato

1. Introduction

Tomato (*Lycopersicon esculentum Mill*.) is one of the vegetables with the highest production in the world and its production is increasing all over the world. Tomato is rich in minerals, vitamins, essential amino acids, sugars and dietary fibers (Ayandiji et al., 2011). World tomato production in 2001 was about 105 million tons of fresh fruit from an estimated 3.9 million ha. As it is a relatively short duration crop and gives a high yield, it is economically attractive and the area under cultivation is increasing daily. Tomato belongs to the Solanaceae family. This family also includes other well-known species, such as potato, tobacco, peppers and eggplant. Tomatoes contribute to a healthy, well-balanced diet. They are rich in minerals, vitamins, essential amino acids, sugars and dietary fibres. Tomato contains much vitamin B and C, iron and phosphorus. Tomato fruits are consumed fresh in salads or cooked in sauces, soup and meat or fish dishes. They can be processed into purées, juices and ketchup. Canned and dried tomatoes are economically important processed products. Tomato is an annual plant, which can reach a height of over two metres. In South America, however, the same plants can be harvested for several years in succession. The first harvest is possible 45-55 days after flowering, or 90-120 days after sowing. The shape of the fruit differs per cultivar. The colour ranges from yellow to red.

In Ethiopia, tomato is one the important and widely grown vegetable crops. Both in rainy and dry seasons for their fruits by smallholder farmers and commercial state and private farm in Ethiopia (Ambecha et al.,2012;MoA,2013;AVRDC,2014).It is also a source of basic raw material required for fresh consumption and local processing industry for the production of processed Tomato like Tomato paste, Tomato juice and etc.(EIA,2008). Lemma et al. (2003) indicated that the total production of Tomato in Ethiopia has shown market increase ,indicating that it has became the most profitable crop providing a higher income to small scale farmers compared to other vegetable crops.However,average yield of Tomato in Ethiopia is low,ranging from 6.5-24 metric ton/ha(Ambecha et al.,2012)as compared with average yields of 51,41,36 and 34 metric tonne/ha in America,Europe,Asia and the entire world, respectively (FAOSTAT,2010).The national average of Tomato seed yield under farmers 'conditions in Ethiopia is also very low, estimated at about 1.2 quintals /ha (Lemma,2002). Seeds are one of the least expensive but most important factors influencing yield potential. Crop seeds contain all the genetic information to determine yield potential, adaptation to environmental conditions, and resistance to insect pest and disease. Increasing agricultural production through the use of high quality seed, among other agricultural inputs, has become essential for providing enough food for rising number of people in the world (Barsa, 2006). Seed produced under controlled condition is likely to be higher yielding and is less likely to harbor pathogen than locally produced seeds (Rice et al., 1990; Barsa, 2006).

Seed quality is determined by many factors, principally seed purity and germination. However, many other factors, Such as the variety, presence or absence of seed-borne disease, vigor of the seed, and seed size are important when considering seed purchase. Seed lots that have low germination also are less vigorous due to seed deterioration .As seeds deterioriate,loss of vigor proceeds loss of viability ,so seeds with low germination usually will be less vigorous.Hence,in seed lots with poor germination, those seeds that do germinate often produce weaker seedlings with reduced yield potential (Barsa ,2006;Nemati et al.,2010). According to lemma (2002) ,the major production constraints of Tomato production in Ethiopia are shortage of varaties and recommended package of information ,unknown source and poor quality seeds, poor irrigation system, lack of information on soil fertility ,disease and insect pests ,high post-harvest loses, lack of awareness of existing improved technologies and poor marketing system. Supplying of high quality seeds is the basic requirement and it contributes greatly to the success of any crop. Various researchers (Gutterman, 1992; Uniyal et al., 2011) have reported variation in seed quality among population in some plant species to have been attributed to differences in environmental condition of mother-plant.

Many cultural practices such as types of nutrient, water supply, and harvesting methods are also believed to be factors influencing both pre- and postharvest quality of tomato (Melkamu, 2008). Many postharvest quality losses are as a result of many pre-harvest factors. Controlling the number of flowers, fruits, or fruit trusses in tomatoes is an effective way of reducing the competition between fruits. Water loss from harvested fruit produce is predominantly caused by the amount of moisture present in the ambient air expressed as relative humidity (Suslow, *et al* 2009). Respiration and metabolic activities within harvested climacteric fruits like tomatoes are directly related to the temperatures of the ambient environment. High temperatures can hasten the rate of respiration (CO2 production) in harvested or stored fruits products.

Seed yield and quality of Tomato is mainly dependent on the variety selected for seed production (George, 1999). A number of improved varieties and other agronomic packages have been recommended to the users to overcome the low productivity and quality of Tomato in the country. According to MoA (2013), Ethiopian National Agricultural System (NARS) has released about 25 Tomato varieties till 2013.Open pollinated Tomato varaties such as 'Melkashola','Mar globe','Melkasala','Heinz 1350,'Fetan','Bishola','Eshet' and 'Metadel'had been released nationally and recommended by the Melkessa Agricultural Research Center (MARC) for commercial production and small-scale farming systems in Ethiopia (Lemma,2002).However due to lack of seed multiplication or distribution system the varieties had not reached farmers. Previously Tomato production has been restricted to certain areas of the country for several reasons such as shortage of seeds of desirable varieties and the lack of a recommendation package regarding production (Lemma,2002).Smallholder farmer contribute most of the Tomato production produced in Ethiopia (Eyob et al.,2014).and small holder farmer are interested in Tomato production more than any other vegetables for its multiple harvests potential and for its high profit per unit area (AVRDC,2014).Attempts had been made to evaluate performances of different Tomato varities at Jimma condition (Menberu et al.,2012;Amana et al.,2012).According to these authors, the tested Tomato varieties have shown very good performace which resulted in high yield and quality fruit therefore the Objectives of this paper is to review cultural practices on pre-harvest and post-harvest on tomato quality.

2. Factors affect tomato quality

2.1 Effect of packing material on Tomato Quality

There are many key points to be considered in assessing the quality of Tomatoes. The minimum quality requirements for Tomatoes after preparation and packaging include: intact, fresh-looking, clean, free of excessive moisture, sound, and free of any foreign smell and/or taste (Sargent and Moretti 2002). Also, the development and condition of the Tomatoes must enable them to withstand transport and handling, as well as arrive in satisfactory condition in the place of destination. High quality fruit have a firm appearance, uniform and shiny color, without signs of injury, shriveling, or decay (Sargent and Moretti 2002). Tomatoes must also be packed in such a way that they are protected properly. The materials used inside the package must be new, clean, and of a quality such as to avoid causing external or internal damage to the produce. Physical attributes are used to assess quality in fresh, vine-ripened Tomatoes. Stem and blossom scars, shoulders, color, and skin are all quality indicators (Hodges 1997). The blossom scar should be small and tight, and the shoulders should be smooth and round and the stem scar should be small and smooth. The color of the Tomato should be uniform with no blotchiness or scarring and fruit locules should be filled with gel, not air spaces. Any deviation from the above physical descriptions can be a sign that the fruit has been exposed to stress such as improper temperature storage (Hodges 1997). Fruit quality is affected by ripeness stage, time of removal from plant, handling conditions and frequency, and storage temperature and time (Jones 1999).

2.2 Effect of different post- harvest treatment on tomato quality

Fruit sugar content is a complex, multi-genic trait that is highly affected by the environment (Hartl, 2011). Some cultivars have the genetic background to potentially realize high TSS, but pre- and postharvest factors severely influence the extent to which this is achieved. The pre-harvest environment, including solar radiation, temperature, day-length, water availability, soil mineral content, irrigation, fertilization regime and pruning techniques, can all influence fruit sugar levels (Dorais et al., 2008).

Postharvest practices such as timing of the harvest, handling techniques, and storage conditions, can also change fruit sugar profiles (Kader, 1986a). The effect of each will be dealt with individually. Proper harvesting determines the nutrient contents as well as storage durability of any fruit. Tomato is normally harvested at different maturity stages, such as green mature stage, half ripen stage and red ripen stage.

2.3. Effect of Pruning on quality of tomato

Culling the number of flowers, fruit or fruit trusses effectively reduces inter-fruit competition so that more assimilate is diverted to fewer sinks. This leads to increased fruit size (Luengwilai et al., 2010b and Prudent et al., 2009) and, in some cases, increased sugars and TSS (Gautier et al., 2001). However, the effects of pruning on TSS depends on a multitude of variables including the fruit-to-leaf ratio (or fruit load), before and after pruning, truss position, sink developmental stage, and genetic background (Bertin et al., 2001, Davis and Estes, 1993, Fanasca et al., 2007, Franco et al., 2009, Gautier et al., 2005, Heuvelink, 1997, Prudent et al., 2010 and Prudent et al., 2009). In most cultivars, pruning can result in increased fruit size under the right conditions and is therefore a viable strategy for improving the marketability of high TSS fruits which tend to be smaller; larger fruit (within a certain range) are usually perceived as being of better value.

2.4. Effect of Temperature on quality of tomato

Temperature affects plant growth balance, flower development and pollination, fruit growth and development, thus has substantial influence on fruit quality. Low temperature (<13ºC) reduces pollen viability while high temperature (>30ºC) favors an excessive growth of the style, both of which cause poor fertilization and uneven development of locules, and thus result in misshapen fruits such as 'cat facing' and roughness (Rylski,1979). High temperature increases photo assimilate distribution to the fruit at the expense of vegetative growth (De Koning, 1989); increasing air temperature increases fruit growth rate by approximately 5 µm h-1 C-1171. However, the final size of tomato grown under elevated temperature decreases because high temperature reduces the duration of fruit development (from fruit setto harvest); i.e. the reduction in duration is greater than the increase in fruit growth rate.

Table 1 effect of temperature on average ripening rate of mature green, breaker, turning, and pink tomatoes.

Quality character	Days to reach table- ripe at indicated temperature(c$^{o)}$				
Ripeness stages	12.5	15	17.5	20	22.5	25
Mature green	18	15	12	10	8	7
Breaker	16	13	10	8	6	5
Turing	13	10	8	6	4	3
pink	10	8	6	4	3	2

Source; (Kader, *et al* 1976)

Papadopoulos and Hao 166found that the reduction in tomato fruit size to average air temperature was mainly due to day air temperature, not night temperature. Therefore, they proposed a temperature management strategy, which uses high night temperature to achieve the desired 24-h temperature and to avoid the negative effect of high temperature on tomato fruit size. This strategy is more feasible in greenhouses equipped with thermal screens. Too high air temperature increases the number of hollow fruit in the winter and the miss-colored and soft fruit in the summer. As mentioned in the previous section high air temperature should be avoided by shading, whitewashing of the greenhouse or other temperature reduction measures such as roof-sprinkler cooling and evaporative cooling pads, depending on the greenhouse location and available equipment. Increasing air temperature in the range of 17 to 23ºC improves organoleptic quality (taste) of greenhouse tomato because it increases fruit dry matter content and reduces soft and mealy fruit (Janse and Gielesen1991). However, this fruit also has a less resistant cuticle, which makes it more vulnerable to physical injury. The combination of high temperature and high electrical conductivity (EC) of nutrient solution in the winter and early spring greatly improves tomato flavor without weakening fruit cuticle (Janse and Gielesen1991), because high EC can promote a resistant cuticle. Sudden temperature changes or high day/night temperature variation will favor the cracking of tomato fruit, (Peet, 1992). Low night temperature causes a negative pressure in fruit, whereas high day temperature increases both gas and hydrostatic pressure of fruit pulp on the epidermis, resulting in a wakening or cracking of the cuticle. Changes from night to day temperature setting need to be made before sunrise and ramping the temperature at no more than 1ºC per hour to avoid water vapor condensation on fruit, which increases incidence of fruit russeting (OMFRA, 2001).

2.5. Effect of Light on quality of tomato

Solar radiations have a large influence on fruit sugar accumulation. Under normal growth conditions, however, it is difficult to attribute the effect of each individually. Higher temperatures (ranging from 26 to 30 °C) led to increased TSS when applied during fruit cell division and ripening due to, respectively, changes in carbohydrate biosynthetic enzyme activity (Walker and Ho, 1977), and increased transpiration (Gautier et al., 2008). In both instances, fruit fresh weight and days to harvest were also sometimes reduced at the higher temperatures. Sink competition also comes into play. Increasing temperature in a cherry tomato promoted fruit evapotranspiration and higher sugar levels, but with increased sink competition sugar content decreased, presumably due to respiration at the higher temperature (Gautier et al., 2005). Seasonal changes in irradiance have a profound effect on fruit sugars. In one study fruit sugar content increased from 18 to 28 mg/L in glasshouse-grown tomatoes from April until September coinciding with irradiance increases from 50 to 170 J m−2 s−1 (Davies and Hobson, 1981). While other landmark studies also support this finding (Winsor, 1979) variations in temperature also accompany the seasonal changes in light and therefore must be taken into account. More controlled experiments have shown that poor light quality is a major contributor to the inferior taste of "out-of-season" tomatoes produced in greenhouses in Northern regions (Cockshull et al., 1992 and Riga et al., 2008). Even if genotypes can be selected that respond to sub-optimal conditions (Islam and Khan, 2000), it is unlikely that winter fruit sugar production in the glasshouse will equal that produced in the field in summer.

2.6. Effect of Fruit maturity stage at harvest on quality of tomato

Maturity at harvest and harvesting operation can influence the postharvest fruit quality (fruit taste, firmness and shelf-life), and the incidence and severity of physical injuries which, in turn, can adversely affect tomato quality. A 6-class classification of tomato fruit maturity has been widely adopted. For greenhouse tomato, the earliest stage for harvest is the mature-green stage. Tomatoes harvested at the mature-green stage will ripen adequately. Immature green fruit will ripen very poorly, and will have poor quality in postharvest. Mature green tomatoes are somewhat difficult to detect (difficult to distinguish from immature-green fruit). its identification can also be aided by the following characters: (1) some cultivars turn whitish-green while others show certain colored streaks at the blossom end, (2) waxy gloss surface, (3) skin not torn by scrapping, (4) appearance of brown corky tissue on the stem scar in some cultivars. Tomatoes harvested later than the mature green-stage will attain better flavor upon ripening than those picked at the immature or partially mature stages, and will be less susceptible to water loss because of their better developed cuticle (Kader,. 1984).

Tomato harvested at breaker stage was superior in flavour to fruit harvested in mature-green (Kavanagh, etal 1986). Vine-ripened tomatoes will accumulate more sugars, acids and ascorbic acid, and will develop better flavour than mature-green tomatoes ripened off the plant (Betancourt, etal 1977). Tomato harvested over-ripe was shown to have lower ascorbic acid content and higher ascorbate oxidase activity (Yahia, etal 2001a). Intensities of sweetness, saltiness and "fruity-floral" flavour were higher in tomatoes harvested at the table-ripe stage than at earlier stages (Watada, etal 1978). Early harvesting is a practice for obtaining firmer fruit suitable for transport and to attain a longer marketable period 22. However, trade journals recommended that fruit should be harvested at a late ripe stage to satisfy consumer's demand for better flavour (Watzl, etal, 1995). Therefore, tomatoes for distant markets can be picked at the "mature-green" or "breaker" stages whereas tomatoes for near outlets can be picked at the "breaker", "turning", "pink"or "light-red" stages. The cluster or vine-ripe tomatoes are harvested at the "light-red" to the "table-red" stage.

2.7. Effect of Method of Harvesting on quality

Tomatoes destined for fresh market are harvested by hand and usually in the morning to avoid the heat of the day. For beefsteak tomatoes, the fruit is picked from the vine by gentle twisting, without tearing or pulling. For cluster or vine-ripe tomato, the whole fruit cluster is cut off from the plants. Tomatoes should not be kept in the sun for an extended period of time. Greenhouse tomato fruit is usually harvested with the calyx and a short stalk for distinguishing from field tomato. The freshness of the calyx is used as an indication for freshness and quality of the fruit. Care must be taken to avoid the stalk puncturing other fruit, especially for tomatoes picked at a later stage, because they are much more susceptible to physical injury (Grierson and Kader 1986). Physical damage during the handling process increases the rate of respiration, ethylene production, and fruit water loss. The physical damage also serves as an excellent entry point for pathogens.

2.8. Effect of harvesting Time on quality of tomato

Harvest time is known to be a major factor responsible for physiological maturation level, size and vigor of seed during maturation (Delouche, 1980). The decision of when to harvest particularly under varying environmental conditions is therefore of importance to get maximum seed quality. Various studies examining the influence of seed development on seed quality in tomato have shown that seeds extracted from fruits harvested 70-75 days after an thesis (Berry and Bewley, 1991; Demir and Ellis, 1992; Liu et al., 1996) or when fruits are firm red (Valdes and Gray, 1998; Demir and Samit, 2001; Ramirez-Rosales et al., 2004) had the maximum viability and vigor. Although growing environment was not considered in these studies, environment and seed maturation may co-interact and time of occurrence of maximum quality may change. Moreover, changes in transplant quality, in relation to environment during seed development on the plant are valuable information for horticultural technology. Protected tomato cultivation by and large was done by using high value hybrid seeds. Therefore, high emergence percentage, uniform and developed transplant production has utmost importance (Cantliffe, 1994).

The physiological maturity of the fruit at harvest is a major determinant of quality and TSS. Sugar import in vine-ripened fruit increases in the latter stages of ripening (Carrari et al., 2006). Between Mature Green and Red Ripe, TSS increases from 2.4% to 5.2% (w/v), with doubling of reducing sugars in some varieties (Cantwell, 2000). Therefore, harvesting immature fruit curtails sugar import, and makes the postharvest degradation of starch the primary source of carbohydrates, which is both inadequate and undesirable (Balibrea et al., 2006). While picking the fruit at a later stage would permit greater sugar accumulation riper fruit is easily damaged and also has a short shelf-life (Kader et al., 1978b, Reid, 2002, Toivonen, 2007 and Watkins, 2006). An essential requirement of industrial postharvest handling is to pick the fruit from Mature Green to Breaker stage to mitigate against some of these losses (Kader and Morris, 1978, Kader et al., 1978b, Kader et al., 1978c and Reid, 2002). This produces an inferior tasting product, since this approach also leads to increased acids (Kader and Morris, 1978, Kader et al., 1978b and Kader et al., 1978c). However, while harvesting fruit at the Red stage is optimal for TSS, postharvest storage is limited to a few days before off-flavor, wilting and deterioration of the fruit occurs (Auerswald et al., 1999).

Determining the best time to harvest fruit from eating quality perspective, while reducing physical damage is not easy and varies by cultivar (Casierra-Posada and Aguilar-Avendaño, 2008). Other factors to consider include the mode of consumption, distance and time to market, and, the handling and production system (Cantwell et al., 2009, Joas and Léchaudel, 2008, Toivonen, 2007 and Watkins, 2006). The importance of developing accurate maturity indices for each cultivar cannot be overstated, but this, too, is challenging because of the high biological variability in ripening among similarly aged fruit (Hertog et al., 2004). The popularity of home-grown tomatoes is partly fueled by the ability of consumers to harvest fully-ripened fruit (Rodriguez-Burruezo et al., 2005). Seed fruits are allowed to ripen to maturity on the plant. Only completely colored and matured seed fruits are harvested. The mark of the two sepals (calyx) cut off should be checked carefully to ensure that only pollinated fruits are harvested. In hybrid seed production of Tomato and pepper, fruits are harvested manually. During this time, only fruits from hand pollinated flowers are picked .Any other fruits must be eliminated because they would be products of self-pollination and, if harvested, they would decrease genetic purity of the seed lot (Nassari et al., 2014).

2.9. Effect of handling on quality of tomato

Bruising and mechanical damage to fruit occurs before, during, and after harvesting and drastically reduce quality. Tomatoes in industrial production systems may be harvested mechanically at Mature Green, packed into crates, sorted, sized, washed, cooled, stored and transported over long-distances. At each stage there are significant opportunities for mechanical damage to fruit, including bruising, scarring, scuffing, cuts and punctures (Macleod et al., 1976a). The effects of physical injury are cumulative (Miller, 2003). Injury near or greater than the bio-yield point leads to cell lysis followed by unwanted chemical reactions, accelerated transpiration, respiration, ethylene production and pathogen infestation (Miller, 2003 and Sargent et al., 1992), the severity of which is determined by the extent of damage.

Table 2 effect of handling practices on phsico-chemical composition of tomato at harvesting, transportation and marketing

HP	g/100g														Brix
	ash	Cp	CF	CFB	CHO	RS	TA	Vit c	B ca	Lycp	Ca	Mg	K	TSS	
Harvest	7.40	15.01	1.1	0.71	70.27	3.0	0.63	28.4	0.02	3.43	44.	5.29	51.10	4.99	4.49
Transit	7.84	18.49	1.3	0.72	71.81	3.9	0.56	23.9	0.03	3.86	46	5.66	52.57	4.99	4.52
Market	8.39	19.18	1.3	0.77	75.53	4.5	0.54	16.8	11.8	4.80	50.	6.28	56.78	6.35	4.67
CV (%)	1.70	9.90	0.7	13.3	2.40	5.2	2.30	5.50	2.87	0.60	2.3	2.30	2.60	1.10	0.70
SE±	0.19	1.74	0.1	0.09	1.734	0.1	0.01	1.27		0.03	1.1	0.13	1.42	0.06	0.03

Fruit may experience internal or external injury, or both. Small, shallow cracks that develop during on-the-plant ripening can increase TSS by promoting evapotranspiration (Prudent et al., 2009), while fissures introduced postharvest are usually more injurious and cause severe problems. In a study in Nigeria, tomatoes were transported from the area of production to the city for sale; TSS and TA of fruit with external injury were lower than those that were intact (Aworh et al., 1983). Internal injury however may go undetected but still lead to massive fruit loss (Lee et al., 2007). In lab tests using Mature Green fruit dropped twice (Moretti et al., 1998 and Moretti et al., 1997) or eight times (MacLeod et al., 1976b) from a height of 40 cm, or where tomatoes were impacted with a swinging pendulum, the Investigators observed no changes in TSS (Lee et al., 2007). There were, however, negative effects on flavor of 'SolarSet' (Moretti et al., 1997) perhaps too due to changes in volatiles (Moretti et al., 2002). For commercial production the best defense against physical damage is to harvest the fruit green when it can withstand physical injury and to minimize handling after harvest to the point of transfer (Cantwell and Kasmire, 2002).

2.10. Effect of Relative Humidity on quality of tomato

Throughout the period between harvest and consumption, temperature control has been found to be the most important factor in maintaining product quality. Fruits, vegetables and cut flowers are living, respiring tissues separated from their parent plant. Keeping products at their lowest safe temperature (0 °C or 32 °F for temperate crops or 10-12 °C or 50-54 °F for chilling sensitive crops) will increase storage life by lowering respiration rate, decreasing sensitivity to ethylene gas and reducing water loss. Reducing the rate of water loss slows the rate of shriveling and wilting, causes of serious postharvest losses. Keeping products too cool can also be a serious problem. It is important to avoid chilling injury, since symptoms include failure to ripen (bananas and tomatoes), development of pits or sunken areas (oranges, melons and cucumbers), brown discoloration (avocados, cherimoyas, eggplant), increased susceptibility to decay (cucumbers and beans), and development of off-flavors (tomatoes) (Shewfelt, 1990). Cooling involves heat transfer from produce to a cooling medium such as a source of refrigeration. Heat transfer processes include conduction, convection, radiation and evaporation.

If a ready supply of electricity is available, mechanical refrigeration systems provide the most reliable source of cold. Methods include room cooling, forced-air cooling and evaporative cooling. A variety of portable forced-air coolers have been designed for use by small-scale growers and handlers (Talbot and Fletcher, 1993; Rij et al, 1979; Parsons and Kasmire, 1974). However, a variety of simple methods exist for cooling produce where electricity is unavailable or too expensive. Some examples of alternative systems (from Thompson in Kader, 1992) include night air ventilation, radiant cooling, evaporative cooling, the use of ice and underground (root cellars, field clamps, caves) or high altitude storage. Ice can be manufactured using simple solar cooling systems, where flat plate solar collectors are used to generate power to make ice, which is then used to cool produce (Umar, 1998). Ice can be used either directly as package ice, to cool water for use in a hydro-cooler, or as an ice bank for a small forced air or room cooling system. Several simple practices are useful for cooling and enhancing storage system efficiency wherever they are used, and especially in developing countries, where energy availability may be limited and any savings may be critical. Shade should be provided over harvested produce, packing areas, for buildings used for cooling and storage and for transport vehicles. Using shade wherever possible will help to reduce the temperatures of incoming produce and will reduce subsequent cooling costs. Trees are a fine source of shade and can reduce ambient temperatures around packinghouses and storage areas. Light colors on buildings will reflect light (and heat) and reduce heat load. Sometimes spending money will save money, as when purchasing lighting equipment. High pressure sodium lights produce less heat and use less energy than incandescent bulbs. Another aspect to consider when handling fruits and vegetables is the relative humidity of the storage environment. Loss of water from produce is often associated with a loss of quality, as visual changes such as wilting or shriveling and textural changes can take place. If using mechanical refrigeration for cooling, the larger the area of the refrigerator coils, the higher the relative humidity in the cold room will remain. It pays however, to remember that water loss may not always be undesirable, for example if produce is destined for dehydration or canning. For fresh market produce, any method of increasing the relative humidity of the storage environment (or decreasing the vapor pressure deficit (VPD) between the commodity and its environment) will slow the rate of water loss. The best method of increasing relative humidity is to reduce temperature. Another method is to add moisture to the air around the commodity as mists, sprays, or, at last resort, by wetting the store room floor. Another way is to use vapor barriers such as waxes, polyethylene liners in boxes, coated boxes or a variety of inexpensive and recyclable packaging materials. Any added packaging materials will increase the difficulty of efficient cooling, so vented liners (about 5 percent of the total area of the liner) are recommended. The liner vents must line up with the package vents to facilitate cooling of the produce inside. Vented liners will decrease VPD without seriously interfering with oxygen, carbon dioxide and ethylene movement.

2.11. Effect of Storage on Tomato quality

Tomato is an important vegetable crop that is available throughout the year in most of the tropical countries with seasonal peaks during June–October. It would be worthwhile to develop a simple method that is feasible on a small farm for extending the shelf life of this crop so that they can be stored and sold at a better price. Losses during post-harvest operations due to improper storage and handling are enormous and can range from 20-50 percent in developing countries (Kader, 1992).

3. Summary and Conclusion

Tomato is the most popular and widely grown vegetable in the world. In economic importance it is second only to Tomato. The quality of any fruit after harvest cannot be improved by the use of any postharvest treatment method or handling practices but can only be maintained. Understanding and managing the various roles that pre-harvest factors like fertilizer application, pruning, maturity stage, cultivar selection, and irrigation can play in the quality of fruits at harvest is very important in order to produce high quality fruits at harvest. Tomatoes are highly perishable and are subjected to rapid quality loss after harvest. Using best postharvest handling practices or factors such as optimum temperature, right relative humidity, and right gases in storage, the use of postharvest calcium chloride application and the best physical handling procedures to maintain the quality after harvest is also critical. It can be concluded by this study that the quality and storage life of tomatoes after harvest depends on not only the postharvest factors alone but also some pre-harvest factors during production and, until both factors are managed properly, quality loss will still be a major challenge for tomato producers and handlers.. Day and night temperature and the variation between the two has pronounced effect on growth, flowering, fruiting and yield of fruits and seeds in Tomato, but the night temperature is a critical factor for fruit set in Tomato. There are many key points to be considered in assessing the quality of Tomatoes. There are different cultural practices which can affect tomato quality in many ways. Temperature affects plant growth balance, flower development and pollination, fruit growth and development, thus has substantial influence on fruit quality. Maturity at harvest and harvesting operation can influence the postharvest fruit quality (fruit taste, firmness and shelf-life), and the incidence and severity of physical injuries which, in turn, can adversely affect tomato quality.

Therefore, the producer of tomato should give great attention to reduce the problem of loss of quality in due to cultural practices in pre-harvest and post-harvest handling through guiding by experts and researchers to aware of tackling such problems.

4. Future line of Prospects

Production and management of cultural practices for tomato post-harvest quality have been considered as a major problem area where research could have meaningful impact.

- Lack of management of pre and post-harvest practices in the production areas and handling which needs attention in research findings.
- The reduction of problems on tomato cultural practices on the quality aspect should be need further research for recommendation any production areas.
- For the best quality of tomato integrated management of pre-harvest and post-harvest handling with supporting the research and experts in areas of production as well as post-harvest handling.

Finally, for the best quality and long life storage for tomato product the research is required through incorporation of pre-harvesting as well as post-harvesting practices taking other factors under consideration in the specific locations.

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