International Scholars Journals

African Journal of Environmental Economics and Management ISSN 2375-0707 Vol. 11 (1), pp. 001-015, Feb, 2023. Available online at www.internationalscholarsjournals.org © International Scholars Journals



*Full Length Research Paper*

# Review on effects of pre and post-harvest factors affecting the quality and shelf life of tomato (*Lycopersicon esculentum* Mill.)

**Ashwini A**

Faculty, Dept of Horticulture,
Bharatiya Engineering Science & Technology Innovation University, Andhra Pradesh, India.

Accepted 20 February, 2023

**Abstract**

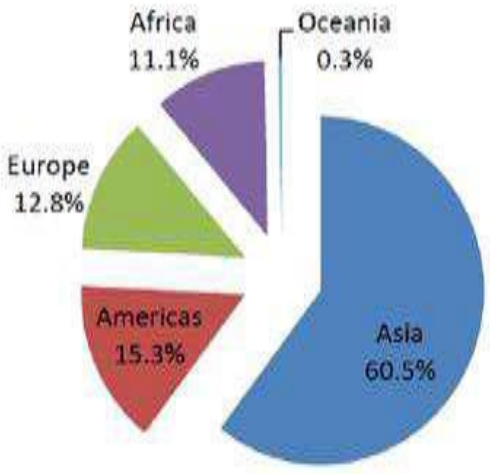
Tomato is one of the most popular produced and extensively consumed vegetable crops in the world and belongs to Solanaceae family. Tomato production can serve as a source of income for most rural and per urban producers in most developing countries of the world. However, postharvest losses make its production unprofitable in these parts of the world. Postharvest losses in tomatoes can be as high as 25- 42% globally. Postharvest losses in tomatoes can be either quantitative or qualitative. The postharvest quality status of tomatoes partly depended on some pre harvest practices carried out during production some of these factors are climate, fertilizer application, pruning, maturity stage, cultivar selection, and irrigation and also using best postharvest handling practices or factors such as temperature, relative humidity, gases in storage, postharvest calcium chloride application, and physical handling procedures to maintain the quality after harvest was also critical. The potential for solving some of the problems related to tomato quality and its postharvest maintenance through excellent genetic manipulations by plant breeders and work improving the nutritional

quality and technology of modified atmospheres application within consumer packages, pallets, and transport vehicles a high priority in future research. The main objective of this seminar paper is to review effect of pre harvest and postharvest factors affecting the quality and shelf life of harvested tomatoes.

**Keywords:** tomato, pre harvest, postharvest factors, quality and shelf life

## 1. Introduction

Tomato is one of the most popular produce and extensively consume vegetable crops in the world and belongs to Solanaceae family (Freeman *et al*, 2011) [6]. It is originating in the Andes Mountains of Peru, from where it spread as a weed to extensive areas in South and Central America (Colla *et al*., 2002). Tomatoes can be consuming in many ways. The fresh fruits are eating in salads and sandwiches and as salsa whilst the process ones are consuming dried or as pastes, preserves, sauces, soups, juices, and drinks (Alem and Tanweer, 2007) [1]. Tomato contains higher amounts of lycopene, a type of carotenoid with antioxidant properties which is beneficial in reducing the incidence of some chronic diseases like cancer and many other cardiovascular disorders (Arab *et al*, 2000). In regions where it is being cultivate and consume, it constitutes a very essential part of people's diet. Tomatoes production accounts for about 4.8 million hectares of harvesting land area globally with an estimate production of 162 million tones. China leads world tomato production with about 50 million tones following by India with 17.5 million tones (FAOSTAT, 2014) [5].




**Source:** (FAO STAT, 2014) [5]

**Fig 1:** Regional Production of Tomatoes

Tomato production can serve as a source of income for most rural and per urban producers in most developing countries of the world (Arah *et al.*, 2015) [2]. Despite the numerous benefits that can be derived from the crop, postharvest losses make its production in most parts of the world unprofitable. Postharvest losses in tomatoes can be as high as 25–42% globally (Rehman *et al.*, 2007) [18]. These losses bring low returns to growers, processors, and traders as well as the whole country which suffers in terms of foreign exchange earnings properly will reduce the postharvest quality losses in tomatoes.

Postharvest losses in tomatoes can be either quantitative or qualitative. Even though emphasis in crop research nowadays is increasing shifting from quantity to quality of produce. There is still little improvement in the quality of commercially produce tomato varieties, hence resulting in high amount of qualitative losses. However, qualitative loss in tomato production can have a negative impact on many parameters like consumer acceptability, nutrient status of fruits, and financial income to producers (Oko-Ibom and Asiegbu, 2007) [15].

The postharvest qualities of tomatoes are dependent not only on postharvest handling and treatment methods but also on many pre harvest factors such as genetic and environmental conditions (Hobson, 2008). Many cultural practices such as types of nutrient, water supply, and harvesting methods are also believing to be factors influencing both pre- and postharvest

quality of tomato (Melkamu *et al*., 2008) [12]. Tomato fruits that have disease and infecting by pest, inappropriately irrigating, and fertilizing or generally of poor quality before harvesting can never be improve in quality by any postharvest treatment methods. This indicates that the postharvest quality of the fruit cannot be improve after harvest but can only be maintained. It is therefore important to know the pre harvest factors that can produce superior qualities in fruits during harvest whilst using appropriate postharvest handling and treatment methods to maintain the quality after harvest (Booth, 2004).

It is warm season crop optimum temperature for growth is $21c^0$-$24c^o$ and also temperature for germination $26c^o$- $30c^o$.Tomato requires adequate amount of moisture. Highest production is usually achieved on a well-drained loamy soil (Heuvelink, 1989). Three major process products are tomato preserve (whole pealed tomato, dry tomatoes (powder, tomato flakes dry tomato) and tomato base foods (tomato soup, tomato souce, chili souces, kit chop) (Heuvelink, 1989).

In Ethiopia recently has expand to commercial production for home use, export and processing industries farmers are insert in tomato production more than any other vegetable for its multiple harvest, which result in high yield and profit per unit area. It is important cash generating to small scale farmers and provide employment in the production and processing industries (June Z.R, 1987). Which are mainly used for production of high value vegetable and tomato is one of the major crops widely cultivate and planting technique used in different part of the country and also where around the world (Lemma, 1998).

The climatic and soil condition of Ethiopia allow cultivation of wide range of fruit and vegetable crops including tomato. It is also grown in large part of eastern and central part mid to low land areas of the country. Large scale production is being carry out in the upper awash valley, under irrigate and rain fall condition where as small scale production for fresh market is a common practice. Tomato cultivation can be classifying by whether the plant is growing out dourer or under protection. Whether the plants are transplant or direct sowing (Villoreal, 1980). Since the transplanting first struck the western united states in the late 1990s. many crops in that country are grown exclusively with the use of transplant while others are slowly making the transplant while other to direct sowing as growers discovers potential advantage (Katz, 2002). Tomatoes are usually plant as seedling (also called transplant). Most of the world's tomatoes come from transplant, support plants grow out door (villareal, 1980).

### 1.1 Objective of the Review

To review the effects of pre harvest and postharvest factors affecting the quality and shelf life

of harvested tomatoes

## 2. Literature Review

### 2.1 Effects of Pre harvest Factors on Postharvest Quality of Tomatoes and its Shelf Life

#### 2.1.1 Climatic conditions

Climatic factors in particular temperature and light intensity, greatly impact on the nutritional quality of tomato fruits. Consequently, the location of production and the season in which plants are grow can determine their ascorbic acid, carotene, riboflavin, thiamine and flavonoid contents. In general, the lower the light intensity the lower the ascorbic acid content of plant tissues. Temperature influences the uptake and metabolism of mineral nutrients by plants, since transpiration rates increase with increasing temperature. Rainfall affects water supply to the plant, which may influence the composition of the harvesting plant part and its susceptibility to mechanical damage and decay during subsequent harvesting and handling operations this result small shelf life and poor quality (Ismail *et al*., 2007).

#### 2.1.2 Fertilizer Application

The quality traits required or purpose for which the crop is grow will help in selecting not only the type of fertilizer but the quantity used during production. For instance, an adequate supply of potassium fertilizer in tomato production improves fruit colour and reduces the incidence of yellow shoulder, whilst enhancing the titratable acidity of the fruit (Passam *et al*., 2007).

Yellow shoulder is a physiological disorder of tomatoes that is characterized by discolor regions that border the stem scar. Insufficient supply of potassium in soilless tomato production can also result in ripening disorders. Unlike potassium, an increase in nitrogen supply to greenhouse- grown tomatoes, beyond a certain threshold level, may reduce fruit quality by decreasing the sugar content of the fruits. High nitrogen supply of about 250 kg/ha can impair some important quality traits of fruits, such as total soluble solids, glucose, fructose, and pH (Passam *et al*., 2007).

A supply of reduce forms of nitrogen, such as ammonium, can result in improved fruit flavors. However, the variation of phosphorus supply in soils for growing tomato crops does not significantly influence quality traits such as the total soluble solids, pH, acidity of the tomato juice, or the fruit colour characteristics (Beckles, 2012) [4]. For trace elements use, the quality of tomato fruit is affect predominantly by the amount of boron used, although other micronutrients may affect fruit quality only when the plants show severe deficiency

symptoms. Lower amounts of boron supply reduce fruit firmness which is of major concern during storage.

Spraying tomato leaves with different combinations of calcium salts is effective in controlling powdery mildew on the crop (Wills and Tirmazi, 2009) [20]. The type of application is determined by the growth stage of the crop and type of disease prevalent. Postharvest calcium application can also have a positive storage effect in calcium deficient harvested fruits (Grandillo and Bertin, 2009) [8].

#### 2.1.3 Pruning

Controlling the number of flowers, fruits, or fruit trusses in tomatoes is an effective way of reducing the competition between fruits. Pruning therefore ensures nutrients are channel to fewer fruits sinks which can lead to increase fruit size whilst increasing sugar content of fruits in some cases (Hanna, 2009) [9]. Pruning clusters to three fruits increase total marketable yield and fruit weight and reduce cull yield of all cultivars under investigation.

Meanwhile, the effect of pruning on other quality traits of the fruit produce depends on many factors including the sink developmental stage, fruit to leaf ratio, truss position, and genetic background (Hanna, 2009) [9]. Pruning can result in increased fruit size in most cultivars, under the right growing conditions, and thus can be used to improve the marketability of high total soluble solids (TSS) fruits which in most cases tend to be smaller in size (Beckles, 2012) [11]. Larger fruits which are within a certain size range are usually considered to be of better value by most consumers.

#### 2.1.4 Maturity Stage

The maturity stage of tomato fruit at harvest is an important determinant of many quality traits (Beckles, 2012) [4]. Tomato, being a climacteric fruit, can be harvest at different stages during maturity, like mature green, half ripen, or red ripen stage depending on the market and production area. Each stage at harvest has its own postharvest attribute that the fruit will exhibit Moneruzzaman *et al*. (2006) [13] report that the shelf life of all tomato cultivars under investigation is longest when harvest at green mature stage and also Fruit nutritional values and appearance may be affect when harvest green.

For instance, sugar transport to fruits in a vine-ripe tomato appears to increase during the latter part of maturity and, therefore, when fruits are harvest immature or in a green state sugar import to fruits will be cut off making postharvest degradation of starch, the main source of carbohydrates, which is both undesirable and inadequate (Toivonen, 2007) [19].

Cultivars with high pH therefore may not be suitable for processing. A pH of 4.4 is suggest to be the maximum and the optimum of a target of 4.25 the acidity of tomatoes is highest at the pink stage of maturity with a rapid decrease as the fruit ripens (Getinet *et al*., 2011).
Moneruzzaman *et al*. (2006) [13] suggest tomato fruits can be harvest at mature green to give producers enough time for long distance marketing but for local marketing harvesting at the fully ripe stage is prefer to maximize nutritional value.

### 2.1.5 Method of harvesting in relation to physical damage and uniformity of maturity

The method of harvesting (hand vs mechanical) can significantly impact upon the composition and post-harvest quality of tomato fruit. Mechanical injuries (such as bruising, surface abrasions and cuts) can accelerate loss of water and vitamin C resulting in increased susceptibility to decay-causing pathogens (Singh *et al*., 2003).

### 2.1.6 Cultivar Type

The potential quality of fruit is dependent on the cultivar type. Different cultivars are characterizing by different quality parameters making some more desirable to the producers and consumers than others **(**Getinet *et al*., 2011). The choice of an adequate-yielding tomato cultivar with desired fruit qualities and longer shelf life is therefore a vital decision a producer must take. Failure to select an appropriate cultivar may lead to lower yield, low quality fruits, or less market acceptability. Fruits of different cultivars differ in size, colour, texture, and flavour as well as storage potential.
According to Getinet *et al*., (2011) establish that tomato cultivar Roma VF has higher sugar content whilst maintaining lower weight loss as compare to cultivar Mar globe. Cultivar selection is therefore critical to the postharvest storage life and eating qualities of tomatoes.

**Table 1:** Total soluble solid (°Brix) content of tomato varieties stored under ambient condition

| **Tomato varieties** | **Total soluble solid (°Brix)** | | | | | **Firmness (rating scale)** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| DAS | 0 | 4 | 8 | 12 | 16 | 0 | 4 | 8 | 12 | 16 |
| Roma VF | 4.2 | 4.32 | 4.4 | 4.8 | 5.2 | 6.0 | 5.9 | 5.8 | 5.6 | 5.5 |

| | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| Marglobe | 4.1 | 4.1 | 4.2 | 4.3 | 4.6 | 6.0 | 6.0 | 5.9 | 5.8 | 5.7 |
| Melkashola | 4.2 | 4.2 | 4.4 | 5.0 | 5.4 | 6.0 | 6.0 | 5.8 | 5.7 | 55 |

**Source:** Getinet *et al*., 2011

### 2.1.7 Irrigation

Tomato is not a drought resistant crop and therefore yields decrease considerably after short periods of water deficiency during production. Proper irrigation scheduling in tomato production is therefore crucial to the crop development. However, with water being a scarce resource in most production areas, growers in recent years have therefore has to develop a more efficient water management scheme that maintains crop yield but has a moderate and control level of moisture stress on their crops deficit irrigation reduce fruit water accumulation and fresh fruit yield but increase fruit total soluble solids levels and also irrigating with saline water has no significant effect on total fruit yield but moisture content of fruits is slightly reduce (Mitchell *et al*., 2007).

Tomato can be irrigating in early morning every three days result in higher yields than daily irrigation. The use of trace elements or the practice of soilless tomato production can be made possible during irrigation where the fertilizers (trace elements) are add to the irrigation water in a form of solution and administer. These trace elements are select depending on the specific postharvest quality traits need in the fruits (Ismail *et al*., 2008).

## 2.2 Effect of Postharvest Factors on Postharvest Quality of Tomatoes and its Shelf Life

After harvesting, the fruit still remains alive and performs all functions of a living tissue. The climacteric burst of ethylene which makes the fruit palatable also triggers senescence and subsequent ripening in the fruits. The goal of any postharvest handling practice or treatment is to manage the concentration and timing of ethylene synthesis so that the fruit reaches the consumer at optimal eating quality (Beckles, 2012) [11].

According to Peppelenbos (2007) Post harvest quality represents market quality, edible quality, transport quality, table quality, nutritional quality, internal quality and appearance quality. Quality means a combination of characteristics, attributes and properties that gives the values to human and enjoyments. Consumers consider good quality in relation to colour, flavor and nutrition. Quality of the produce is the final manifestation of inter-relation between the commodity and its environment.

### 2.2.1 Temperature

Proper temperature management between the period of harvesting and consumption is found to be the most effective way to maintain quality. Keeping harvest fruits cool at low temperatures of about 20°C will slow down many metabolic activities which lead to ripening, hence allowing more time for all the postharvest handling of the produce (Otma, 2003).

Respiration and metabolic activities within harvest 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 harvest or store fruits products.CO2 production in store climacteric products like tomatoes can trigger ethylene production although this depends on other factors like O2 or CO2 levels, exposure time, and ripening stage (Raison and Lyons, 2006).

Low temperature storage can protect nonappearance quality attributes like texture, nutrition, aroma, and flavor (Pranamornkith and Heyes, 2012) [16]. Meanwhile, tomato being a tropical fruit is also adversely affect by exposure to extremely low temperatures. Chilling injury can occur in tomato fruits store at temperatures below 10°C (Grossmann and Verh, 2009). The effect of chilling injury includes premature softening, irregular colour development, and surface pitting, browning of seeds, water-soak lesions, off- flavour development, and increase postharvest decay (Cantwell, 2009). It is therefore important to determine the optimum temperature needs when handling tomato fruits during storage.

### 2.2.2 Relative Humidity

Water loss from the harvest fruit produce is predominantly caused by the amount of moisture present in the ambient air expressed as relative humidity (Gómez and Artés Hernández, 2006) [3]. At very high relative humidity, harvest fruits maintain their nutritional quality, appearance, weight, and flavor, whilst reducing the rate at which wilting, softening, and juiciness occur. Tomato fruits are very high in water content and susceptible to shrinkage after harvest. Fruit shrivel may become evident with any small percentage of moisture loss. The optimal values of relative humidity for mature green tomatoes are within the range of 85–95% (v/v) but 90–95% (v/v) for firmer ripe fruits (Sandhya, 2010).

Below the optimal range, evapotranspiration increases resulting in shrivel fruits. Storage of tomato fruit at a lower relative humidity can result in shriveling. Addition of moisture (wetting fruits) in lower relative humidity storage can reduce weight loss and prevent fruit from shriveling. Meanwhile, completely saturate atmospheres of 100% relative humidity should be avoiding, as moisture condensation on the fruit surfaces may encourage

mould and fungal development.

### 2.2.3 Combination Gases

The combination of different gases in a storage environment is very important in extending the storage life of tomato fruits. with the optimal atmosphere needs to inhibit senescence in mature green and ripe fruit of tomatoes is 3– 5% (v/v) of oxygen but for carbon dioxide it is 1–3 % (v/v) and 1–5% (v/v) in mature green and ripe fruit, respechilst 94–96% (v/v) of nitrogen gas is required (Kader, 2003). A very low supply of oxygen can have a detrimental effect on fruits by causing anaerobic respiration Carbon monoxide (CO) is investigate as a gas for treating fruits and is found to speed up ripening. It is therefore necessary to balance the carbon monoxide with low oxygen to delay senescence in the fruits (Akhtar and Hussain, 2011).

Carbon monoxide slows down postharvest pathogenic infestations whilst improving some quality traits of tomatoes. For instance, tomatoes stored in 5–10% (v/v) carbon monoxide with 4% (v/v) oxygen were found to have superior total soluble solids (TSS) and titratable acid (TA) profiles as compare to control samples store in air (Akhtar *et al.,* 2011).

**2.3 Postharvest Calcium Chloride Application** Postharvest calcium application has a positive effect on many storage parameters of various fruits and vegetables. For instance, the use of calcium chloride in controlling rapid ageing in the harvest fruits (Prakash *et al.,* 2006). Postharvest calcium chlorideapplication reduces respiration, decreases ethylene production, and delays senescence in fresh produce such as tomatoes (Morvan and Thellier, 2004).

Exogenous application of calcium maintains cell-wall integrity and protects it from degrading enzymes, enhancing better linkages between pectin substances within the cell- wall whilst increasing the cohesion of cell-walls (Kwon *et al.,* 2009). This therefore gives an indication that the rate of senescence in fruits is closely related to the amount of calcium in the plant tissue and varying the calcium status affects the rate of senescence. Altering the levels of exogenous calcium application affects parameters for senescence such as protein and chlorophyll content, respiration rates, and cell membrane also note that addition of calcium rigidifies cell-wall and obstructs enzymes such as polygalacturonase from reaching active sites Fruits treating with CaCl2 has shown higher values for fresh firmness during storage whereas they have quicker development of red color, greater weight loss and higher soluble solids content rather than non- treating fruits during the shelf life (Garcia *et al*., 2006)

**Table 2:** Cumulative physiological weight loss (%) of tomato fruits at various days after storage (DAS) as affected by Cacl concentration at ambient condition (24 ± 30 C and 70± 5% RH)

| Cacl2 con | 2 DAS | 4 DAS | 6 DAS | 8 DAS | 10 DAS |
|---|---|---|---|---|---|
| 0.25 % | 3.21 | 6.13 | 8.56 | 12.06 | 17.02 |
| 0.50 % | 2.89 | 5.33 | 8.56 | 12.06 | 17.02 |
| 0.75% | 2.25 | 4.81 | 6.93 | 8.25 | 12.80 |
| 1.00% | 2.57 | 5.36 | 6.85 | 8.31 | 12.14 |

### 2.4 Physical Handling

Physical handling can have a drastic effect on the postharvest quality or life of the harvest fruits (Wills, 2009). Rough handling during harvesting and after harvesting can result in mechanical injuries which affect quality. Typical industrial production systems associate with tomatoes may include mechanical harvesting, packing into crates, sorting, grading, washing, and transporting over long distances. At each of these stages there may be significant occurrence of mechanical injury which may be bruising, scarring, scuffing, cutting, or puncturing the fruits. In small-scale tomato production, mechanical injuries may result from the use of inappropriate harvesting containers and packaging materials.

According to Miller (2002) the effects of mechanical injuries on fruit are cumulative. Injuries which are equivalent to or greater than the bio-yield point lead to a total breakdown of the structure of the affected cells which is accompany by un wanting metabolic activities which may include increase ethylene production, accelerate respiration rates, and ripening, which results in either reduce shelf life or poor quality. It is therefore important to handle tomato fruit with care during the harvest and postharvest activities to minimize mechanical injuries to avoid losses.

#### 2.4.1 Effects of Damage during Transport and Packing on post-harvest quality of tomato

Less suitable and not proper facility of tomato crop affect the post-harvest life and quality of the product. Temperature requirement or refrigeration facility is requiring. During transportation if the product is not well locating vibration of the product influence the post-harvest yield of the product. Tomatoes are package in open and close fruit crates (tomato crates), tubs, cartons, trays and jointed boxes. Carless packing also influences the product. The plastic container which is currently not in use in the system perform better in reducing mechanical damage resulting from vibration and impact than the traditional baskets currently being used to package fresh tomatoes and should therefore be exploit. Generally, all the above factors and contributes their own role in post-harvest loss of tomato (Sargent, 2003).

## 3. Summary and Conclusion

Tomato (*Lycopersicon esculentum* Mill.) is one of the most important supplementary sources of minerals and vitamins in human diet and belongs to the family Solanaceae. Postharvest quality management of tomatoes starts from the field and continues until it reaches the final consumer. The quality of any fruit after harvest cannot be improve 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 subjecting 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. 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.

## 4. Recommendation

The potential for solving some of the problems related to tomato quality and its postharvest maintenance through excellent genetic manipulations and should ·be given a high priority in future research.

Plant breeders in collaboration with postharvest physiologists should continue to select genotypes that have good flavor (high sugars and acids contents and good potential for development of volatiles associated with desirable tomato flavor) also; fruit firmness and softening pattern in relation to ripeness stage should be evaluate.

Research is also need to identify 'those organoleptic ally important volatiles and their mode of genetic control so that plant breeders can develop strategies for retaining the desirable volatiles and minimizing the undesirable ones from breeding lines.

Working on improving the nutritional quality of tomatoes via increase ascorbic acid and beta-carotene (pro-vitamin A) contents should be an integral part of tomato improvement programs.

All recommending handling procedures should be based on maintenance of flavor quality. Additional efforts are need to develop a dependable and practical method of eliminating immature fruits from those pick before the breaker stage.

Much effort is also need to develop the technology of modify atmospheres application within consumer packages, pallets, and transport vehicles.

## 5. References


1. Alam T, Tanweer G, Goyal GK. Packaging and storage of tomato puree and paste, Stewart Postharvest Review 2007;3(5):1-8.
2. Arah I *et al.*, An overview of post-harvest losses in tomato production in Africa: causes

and possible prevention strategies, Journal of Biology, Agriculture and Healthcare 2015;5(16):78-88.

3. Artés FA, Gómez P, Artés-Hernández F. Modified atmosphere packaging of fruits and vegetables, Stewart Postharvest Review 2006;2(5):1-13.
4. Beckles DM. Factors affecting the postharvest soluble solids and sugar content of tomato (*Solanum lycopersicum* L.) fruit, Postharvest Biology and Technology 2012;63(1):129-140.
5. FAOSTAT, Global Tomato Production in 2012, FAO, Rome, Italy 2014.
6. Freeman B *et al*., Tomato consumption and health: emerging benefits, American Journal of Lifestyle Medicine 2011;5(2):182-191.
7. Getinet H, Seyoum T, Woldetsadik K. The effect of cultivar, maturity stage and storage environment on quality of tomatoes, Journal of Food Engineering 2012;87(4):467-478.
8. Grandillo S, Zamir D, Tanksley SD. Genetic improvement of processing tomatoes: A 20 years' perspective, Euphytica 2009;110(2):85-97.
9. Hanna HY. Influence of cultivar, growing media, and cluster pruning on greenhouse tomato yield and fruit quality, Hort Technology 2009;19(2):395-399.
10. Hobson GE. Pre-and post-harvest strategies in the production of high quality tomato fruit, Applied Agricultural Research 2008;3(5):282-287.
11. Luengwilai K, Beckles DM, Saltveit ME. Chilling- injury of harvested tomato (*Solanum lycopersicum* L.) cv. Micro-Tom fruit is reduced by temperature pre- treatments, Postharvest Biology and Technology 2012;63(1):123-128.
12. Melkamu M, Seyoum T, Woldetsadik K. Effects of pre- and post-harvest treatments on changes in sugar content of tomato, African Journal of Biotechnology 2008;7(8):1139-1144.
13. Moneruzzaman KM, Hossain ABMS, Sani W, Saifuddin M, Alenazi M. Effect of harvesting and storage conditions on the post-harvest quality of tomato, Australian Journal of Crop Science 2009;3(2):113-121.
14. Oke M, Ahn T, Schofield A, Paliyath G. Effects of phosphorus fertilizer supplementation on processing quality and functional food ingredients in tomato, Journal of Agricultural and Food Chemistry 2005;53(5):1531-1538.
15. Oko-Ibom GO, Asiegbu JE. Aspects of tomato fruit quality as influenced by cultivar and scheme of fertilizer application, Journal of Agriculture, Food, Environment and Extension 2007;6(1):71-81.
16. Pranamornkith T, East A, Heyes J. Influence of exogenous ethylene during refrigerated

storage on storability and quality of Actinidiachinensis (cv. Hort16A), Postharvest Biology and Technology 2012;64(1):1-8.

17. Raison JK, Lyons JM. Chilling injury: A plea for uniform terminology, Plant, Cell & Environment 2006;9(9):685-686.
18. Rehman M, Khan N, Jan I. Post-harvest losses in tomato crop (a case study of Peshawar Valley), Sarhad Journal of Agriculture 2007;23(4):1279-1284.
19. Toivonen PM. A Fruit maturation and ripening and their relationship to quality, Stewart Postharvest Review 2007;3(2):1-5.
20. Wills RBH, Tirmazi SIH. Effect of calcium and other minerals on ripening of tomatoes, Functional Plant Biology 2009;6(2):221-227.