The Pharma Innovation Journal 2022; 11(6): 2222-2227

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(6): 2222-2227

www.thepharmajournal.com
Received: 01-04-2022
Accepted: 08-05-2022

Manmohan
Scholar, Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Deven Verma
Assistant Professor, Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

Corresponding Author:
Manmohan
Scholar, Department of Horticulture, School of Agriculture, Lovely Professional University, Phagwara, Punjab, India

A review on effect of pre and post-harvest treatments on tomato fruit shelf life

Manmohan and Deven Verma

Abstract
In most of the developing nations, tomato farming can provide a source of income for most of the rural and periurban producers. However, in these parts of the world, post harvest losses make production unprofitable. Tomatoes can lose up to 42% of their value after harvesting. There are two types of post harvest losses in tomatoes: quantitative and qualitative. Despite the fact that crop research is increasingly focusing on quality rather than quantity, there has been no progress in the quality of commercially produced tomato varieties, resulting in high quality losses. The various of the studies revealed that the post harvest quality of tomatoes was influenced by various pre harvest procedures used during production. Some of these characteristics include fertiliser application, cutting, maturity phase, cultivar choice, and watering. The life span of tomatoes can be enhanced by properly recognising pre and after harvesting elements affecting it, according to this review.

Keywords: Pre, post-harvest, tomato, fruit, shelf life

Introduction
Tomatoes (*Solanum lycopersicum*) are one of the most widely grown and consumed vegetable crops on the planet. It was first originated in South America and was domesticated in Central America. Tomatoes have 2n = 24 chromosomes.

Tomato ranked 3rd after potato and onion in India. India ranks 2nd in production and productivity of tomato in world. Area of production of tomato in India 796.87 Thousand Ha. (2017-18). Major tomatoes growing countries are China, India, USA, Turkey, Egypt, Italy, Iran, Spain, Brazil, Mexico. Leading state in production of tomato in India are following AP, Karnataka, Orrisa, Maharashtra, West Bengal, Bihar, Gujarat, Chhattisgarh, Tamil Nadu, Jharkhand. (NHB 2017-18).

(Grandillo *et al*., 1999) [1] Tomatoes can be eaten in a variety of ways. Fresh fruits are used in salads, sandwiches, and salsa, whereas processed fruits are used in pastes, preserves, sauces, soups, juices, and drinks. Tomatoes and tomato-based foods are high in nutrients and have a number of health benefits. Tomatoes contain more lycopene, an antioxidant carotenoid that aids in the prevention of cancer and other cardiovascular issues (T. Alam *et al*., 2007) [2]. In the areas where it is produced and consumed, it is a very important part of people's diets. Tomatoes are mostly made up of water, with only 5% of carbs and fibres. About 100 grammes of tomato has 18 calories, 95% water, 0.9 gramme protein, 3.9 gramme carbohydrates, 2.6 gramme sugar, 1.2 gramme fibre, and 0.2 gramme fat. Lycopene is a potent antioxidant and one of the most essential compounds in tomatoes. It is the red colour. Tomatoes contain beta carotene, an antioxidant that gives meals a yellow or orange colour. Chlorogenic acid is a potent antioxidant that aids in blood pressure reduction. Tomatoes are also a significant crop for industrial application, as they may be used to make a variety of goods such as tomato sauce, tomato chutney, tomato pulp, tomato concentrate, tomato juice, and so on. Tomatoes are also utilised in a variety of beauty products. Tomato exports totaled 47.45 thousand MT in 2017-18. APEDA has developed a number of Agri Export Zones for vegetables in Punjab, Uttar Pradesh, Gujarat, Bihar, Jharkhand, and West Bengal in order to promote vegetable exports and infrastructure is being built. In the 2017-18 fiscal year, India exported tomato to the United Arab Emirates (19960.65 MT), Nepal (18799.65 MT), Qatar (2670.57 MT), and the Maldives (1218.74 MT). 2017-2018 National Housing Budget.

There an attempt has been made to study the various factors affecting the shelf life of the tomato fruit
A. Pre -harvest factors affecting shelf life of tomato
B. Post - harvest factors affecting shelf life of tomato

Use of Fertilizer

In recent decades, consumers have become increasingly concerned about the quality of the food products they consume. As a result, researchers investigated the impact of plant nutrition on the quality of fruits produced. The needed qualitative features or the purpose for which the crop is cultivated will guide the choice of not only the kind but also the quantity of fertiliser used during cultivation. In tomato agriculture, for example, a sufficient supply of potassium fertiliser increases fruit colour and reduces the incidence of yellow shoulder FAOSTAT 2014, while simultaneously boosting the fruit's titratable acidity. 2015, I. K. *et al*. Yellow shoulder is a physiological problem with tomatoes that causes discoloured spots along the stem scar. Ripening illnesses are also a possibility.

A deficiency of potassium in soilless tomato growing can potentially cause ripening illnesses. M. Rehman *et al*., 2007 colour qualities 1992, A. A. *et al*., [9, 10]. When it comes to trace elements, the amount of boron used has the most impact on tomato fruit quality, with other micronutrients having an impact only when the plants are severely deficient. When boron levels are low, fruit firmness is reduced, which is a major concern during storage. G. O. Oko-Ibom and colleagues, 2007 [11]. Calcium supplementation in tomato production has recently been examined and found to aid in the prevention of certain illnesses as well as the reduction of fruit firmness loss during ripening. MA Salam *et al*. (2010) investigated the effect of boron and zinc on tomato quality under various NPK fertiliser levels, using twelve treatment combinations with four levels of boron and zinc. Commercial fruits at 30 days after storage (67.48 percent) and shelf life (16 days) were reported using a ratio of 2.5 kg B+ 6 kg Zn/ha and the recommended dose of NPK fertilisers (N= 253, P= 90, and K= 125 kg/ha).

Seed treatment

H. (Ruiz *et al*., 2022) investigated the impact of combining hydrothermal and atmospheric treatment on tomato quality and shelf life. The goal of this study was to determine how soaking at 10, 40, and 55 degrees Celsius before cutting, in combination with atmospheres of 5% O2 + 5% and 10% CO2 and air as a control, influenced sensory, microbiological, and functional parameters during a 12-day period at 5 degrees Celsius. Before being chopped, the fruit was soaked in water at various temperatures for 5 minutes. The fruit was then sliced into little pieces and stored in plastic trays in various locations. Color, firmness, soluble solids, titratable acidity, total phenols, antioxidant capacity, ethylene formation, respiratory activity, microbiological counts, colour, firmness, soluble solids, titratable acidity, total phenols, antioxidant capacity, ethylene production, respiratory activity, microbial counts. In both trials, the physical, psychological, and sensory aspects were all assessed. The researchers discovered that HT at 55 °C with storage in 5% O2 + 10% CO2 reduced respiratory activity, ethylene production, and firmness losses. During the first three days of storage, total phenols and antioxidant capacity, on the other hand, increased. The slices treated with HT at 10 °C and kept in an air environment had the worst visual appearance and texture, as well as the greatest translucency scores. Slices kept at 5 °C for 9 days in atmospheres of 5% O2 and 10% CO2 showed the lowest numbers of mesophilic bacteria, psychrophilic bacteria, enterobacteria, mould, and yeast. As a result, the tomato slices are kept at a high HT temperature of 55 °C combined with 5% O2 and 10% CO2. The effect of hot water treatment on ripening of tomato var. TA234 silenced with the TomLoxB gene was investigated by Wendy Marisol Mazón *et al*., (2022). The goal of this study was to see how hot water treatment affected tomato fruits that had been genetically engineered to mute the Tomlox B gene (Solanum lycopersicum cv. TA234). Unmodified and genetically modified tomato fruits were submerged in water at 40°C for 10, 20, and 30 seconds. The fruits were then maintained at 25°C for 18 days. As part of the physiological examination, electrolyte leakage, lipoxygenase, and polygalacturonase activities were all assessed. The genetically engineered tomatoes were treated at 40°C for 30 seconds, which resulted in slower ripening, lower metabolic activity, and longer preservation of the features. prolonging the tomato's postharvest life to 18 days Lipoxygenase and polygalacturonase activity were also lowered to some extent.

Pruning

Pruning tomatoes to reduce the amount of blossoms, fruits, or fruit trusses is an effective way to reduce fruit rivalry. Pruning ensures that nutrients are directed to fewer fruit sinks, resulting in larger fruits and, in some cases, higher sugar content of fruits [J. M. Harvey *et al*., 1978]. T. K. Hartz and colleagues, 2005. Reducing clusters to three fruits increased overall marketable production and fruit weight while decreased cull yield in all cultivars evaluated H. C. Passam *et al*., 2007. Meanwhile, a range of characteristics such as the sink developmental stage, fruit to leaf ratio, truss position, and genetic background influence the impact of pruning on key fruit quality indices. 1978, J. M. Harvey *et al*. When grown in the proper environment.

Irrigation

Because tomato is not a drought-resistant crop, yields are dramatically reduced during cultivation when there are brief periods of water scarcity. As a result, in tomato cultivation, precise irrigation timing is important to the crop's growth. However, because water is a limited resource in most producing areas, growers have had to develop more effective water management strategies in recent years in order to maintain agricultural productivity while lowering moisture stress on their crops to a manageable level. Fruit water accumulation and fresh fruit yield were reduced by deficient irrigation, although total soluble solids in the fruit were increased. M. Parisi and colleagues, 2006. They also discovered that, while saline water irrigation had no influence on total fruit output, it did reduce the moisture content of the fruits by a small amount.

Potassium Chloride: Potassium Chloride Improves Fertigated Greenhouse Tomato Quality and Enhances Fruit Appearance. KCl-treated plants demonstrated a slightly higher (but not significant) K absorption than KNO3-treated plants. The study also discovered that the cumulative absorption and leachate of NO3 in the KCl treatment was lower than in the KNO3 treatment. The treatment consisted of KNO3 (0 percent KCl). As a result of this discovery, KCl should be used instead. KNO3 could aid in the reduction of pollutants produced by NO3 leaching in the environment. Based on current fertiliser prices, it is clear that there will be potential. Yamazaki, H., and colleagues, 2005 [16].

Calcium Nitrate

Tomato foliar fertilisation uptake of calcium nitrate and potassium phosphate. Because it is environmentally friendly and allows for high productivity and high-quality crops, this type of fertiliser should be utilised in integrated plant production. The findings demonstrated various effects of nitrogen and potassium as foliar nutrition, as well as the combination of these elements, on tomato output and quality. These variations could be due to soil and meteorological circumstances during the cultivation period. Environmental factors have a considerable impact on the influence of fertiliser nitrogen and potassium on the given parameters. The alteration of the interplay between foliar nutrition and climatic circumstances has a significant impact. Tomato crops treated with 6 mmolL-1 nitrogen and 4 mmolL-1 potassium had higher quality, according to the results of the experiment. Despite several studies on mineral fertiliser foliar spray, many elements of nutrient uptake and transportation inside a plant remain unknown D. Martínez-Romero *et al*., 2007 [21].

The following section of this review study discusses the effects of several postharvest conditions.

After harvesting, the fruit remains alive and performs all of the tasks of living tissue. The climacteric surge of ethylene that makes the fruit appealing triggers senescence and subsequent ripening in the fruits. Any postharvest treatment or method seeks to limit the amount and timing of ethylene synthesis so that the fruit reaches the consumer in peak eating condition. The following elements can have an impact on tomato quality after harvest if they are not properly managed.

Temperature

Proper temperature regulation between harvest and consumption has been shown to be the most effective strategy for maintaining quality. Keeping harvested fruits cold, at 20°C, will slow down various metabolic processes that contribute to ripening, providing you more time to finish all postharvest procedures. A one-hour delay between harvesting and cooling a crop reduces the shelf life by one day. Cantwell, M. I., 1997. The temperature of the surrounding environment has a direct effect on the respiration and metabolic activities of climacteric fruits such as tomatoes that have been harvested. In fruits and vegetables that have been selected or stored, high temperatures can increase the rate of respiration (CO_2 production). CO_2 production in stored climacteric commodities like tomatoes can stimulate ethylene production. CO_2 generation in stored climacteric commodities like tomatoes can cause ethylene production, albeit this is dependent on other factors such as O_2 or CO_2 levels, exposure time, and ripening stage [H. P. J. De Wild *et al*., 2003 [39]. Ethylene can cause ripening in fruits even at low concentrations of tens of nanoliters per litre. T. Pranamornkith, T. Pranamornkith, T. Pranamornki Heat accumulated in field-harvested fruits is the primary source of high temperatures in fruits. To minimise excessive field heat, which could cause the harvested fruits to decay more quickly, harvesting should be done at a specified time of day. Texture, nutrition, aroma, and flavour are non-appearance quality aspects that can be kept by storage at low temperatures. R. E. Paull and colleagues, 1999 [38]. Meanwhile, because tomatoes are a tropical fruit, they are also damaged by extreme cold. Chilling damage can occur when tomatoes are stored at temperatures below 10 °C. 1986, J. K. Raison *et al*. Freezing injury causes premature softening, uneven colour development, surface pitting, seed browning, water-soaked lesions, off-flavor development, and increased postharvest degradation. K. Luengwilai and colleagues, 2012 [42]. As a result, determining what temperature is optimum for controlling tomato fruits during storage is crucial.

Relative Humidity

The amount of moisture in the ambient air, expressed as relative humidity, is the principal cause of water loss from harvested fruit products. M. N. Hong and colleagues, 1999 [43]. At high relative humidity, harvested fruits maintain their nutritional content, look, weight, and flavour while reducing the rate of withering, softening, and juiciness. Tomatoes contain a lot of water and are prone to shrinking after harvest. Even if only a small amount of moisture is lost, fruit might shrivel. The recommended relative humidity range for mature green tomatoes is 85–95 percent (v/v), but for harder ripe fruits, it's 90–95 percent (v/v). T. V. Suslow and colleagues, 2009 [44]. When evapotranspiration exceeds the required threshold, the fruits become shrivelled. Fungi can grow on tomato fruit that is stored at a lower relative humidity. Adding moisture (wetting fruits) to low-relative-humidity storage reduces weight loss and prevents shrivelling. Meanwhile, completely saturated environments with 100% relative humidity should be avoided, since moisture condensation on fruit surfaces may promote mould and fungal growth.

Combination of Gases

The combination of different gases in a storage environment is crucial for improving the storage life of tomato fruits. According to F. Artés *et al*., 2006 [45], the ideal atmosphere for inhibiting senescence in mature green and ripe tomato fruit is 3–5 percent (v/v) oxygen, but 1–3 percent (v/v) and 1–5 percent (v/v) carbon dioxide in mature green and ripe fruit, respectively, while 94–96 percent (v/v) nitrogen gas is required. Sandhya 2010 [46]. Fruits can be harmed by anaerobic respiration, which occurs when there is a lack of oxygen. A. A. Kader and colleagues, 2003 [47]. Carbon monoxide (CO) has been explored as a gas for treating fruits and has been found to speed up the ripening process. Carbon monoxide must be balanced with low levels of oxygen to avoid senescence. To avoid senescence, carbon monoxide must be balanced with low oxygen levels. Carbon monoxide prevents the spread of postharvest illness while simultaneously increasing the quality of tomatoes. Tomatoes stored in 5–10 percent (v/v) carbon monoxide with 4 percent (v/v) oxygen had superior total soluble solids (TSS) and titratable acid (TA) profiles as compared to control samples stored in air. A. A. Kader and colleagues, 2003 [47]. However, because of the health concerns that carbon monoxide poses to humans, it must be used with utmost caution in the food industry. Application of Calcium Chloride After harvest, higher plants contain considerable amounts of calcium, usually in the range of 1–50 mg Ca g1 dry matter. Kirkby, E. A., *et al*., 1984 [22]. Fertilisers containing calcium can assist. Calcium-based fertilisers can assist plants in avoiding calcium deficiency. After fertilisation, tomato plants with a calcium deficit become prone to a number of calcium-related illnesses, such as blossom end rot. M. C. Saure and colleagues, 2001 [49]. Calcium has been demonstrated to increase tomato yield when used as a fertiliser [A. Akhtar *et al*., 2010]. Many fruits and vegetables have been shown to benefit from postharvest calcium treatment in terms of storage qualities. Many researchers, for example, have looked at the use of calcium chloride to slow down the ageing of harvested fruits in general. R. L. Pilling, A. Prakash, P.-C. Chen, A. Prakash, A. Prakash, A. Prakash, A. Prakash, A. Prakash, A. Prakash, A. Pra Postharvest calcium chloride treatment decreases respiration, lowers ethylene production, and delays senescence in fresh produce such as tomatoes. P. R. is a fictional character. Exogenous calcium injection improves connections between pectic substances within the cell wall while also increasing cell-wall cohesiveness and protecting it from enzyme breakdown. M. Demarty and colleagues, 1984. This shows that the amount of calcium in plant tissue affects the rate of senescence in fruits, and that modifying the calcium status affects the rate of senescence. Protein and chlorophyll content, respiration rates, and cell membrane fluidity have all been demonstrated to be affected by exogenous calcium administration. Poovaiah, B. W., 1984 [56].

Physical Manipulation

Physical manipulation of grown fruits after harvest can have a substantial impact on their quality and shelf life. Rough handling while harvesting and later might cause mechanical damage, decreasing quality. Some of the most typical industrial tomato production processes include mechanical harvesting, crates packaging, sorting, grading, washing, and long-distance transportation. Each of these procedures can cause significant mechanical damage to the fruits, such as bruising, scarring, scuffing, cutting, or puncturing. Ineffective harvesting containers and packaging materials can cause mechanical injuries in small-scale tomato cultivation. According to Miller R. A. Mille 2003 [58], the effects of mechanical trauma on fruit are cumulative. Total disability is the result of injuries that are equivalent to or greater than the bioyield point. Injuries equal to or greater than the bio yield point result in a complete breakdown of the structure of the affected cells, as well as unwanted metabolic activities like increased ethylene production, accelerated respiration rates, and ripening R. A. Miller 2003, S. A. Sargent *et al*., 1992 [58, 59], resulting in either a shorter shelf life or poor quality. It's vital to treat tomato fruit with care during harvest and postharvest activities to avoid mechanical damage and losses.

Conclusion

Tomato quality control starts in the field and continues until the final consumer receives the product. Several preharvest practises utilised during production have an impact on the fruits' postharvest quality. No postharvest treatment or handling approach may improve the quality of any fruit after it has been harvested; it can only be preserved. It's vital to understand and manage the multiple roles that preharvest components such as fertiliser treatment, pruning, maturity stage, cultivar selection, and irrigation may play in producing high-quality fruits during harvest. Tomatoes are perishable, and their quality quickly diminishes once they are picked. Using the right postharvest management processes or conditions, such as the best storage temperature. Maintaining quality after harvest necessitates the use of the best postharvest handling procedures or parameters, such as the right temperature, relative humidity, and so on. The optimum physical handling practises, the proper gases in storage, and postharvest calcium chloride administration This study suggests that postharvest factors, as well as some preharvest factors during production, influence tomato quality and storage life after harvest, and that quality loss will continue to be a major concern for tomato growers and handlers until both aspects are well handled.

References

1. Grandillo S, Zamir D, Tanksley SD. Genetic improvement of processing tomatoes: a 20 years perspective, Euphytica. 1999;110(2):85-97.
2. Alam T, Tanweer G, Goyal GK. Packaging and storage of tomato puree and paste, Stewart Postharvest Review. 2007;3(5):1-8.
3. Beckles M. Factors affecting the postharvest soluble solids and sugar content of tomato (*Solanum lycopersicum* L.) fruit, Postharvest Biology and Technology. 2012;63(1):129-140.
4. Arab L, Steck S. Lycopene and cardiovascular disease, American Journal of Clinical Nutrition. 2000;71(6):1691S-1695S.
5. Basu, Imrhan V. Tomatoes versus lycopene in oxidative stress and carcinogenesis: conclusions from clinical trials, European Journal of Clinical Nutrition. 2007;61(3):295-303.
6. Freeman B, Reimers K. Tomato consumption and health: emerging benefits, American Journal of Lifestyle Medicine. 2011;5(2):182-191.
7. FAOSTAT. Global Tomato Production in 2012, FAO, Rome, Italy, 2014.
8. Arah K, Kumah EK, Anku EK, Amaglo H. 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.
9. ur 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.
10. Kader A. Post-Harvest Technology of Horticultural Crops, University of California, 1992
11. 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.
12. Gautier H, Guichard S, Tchamitchian M. Modulation of competition between fruits and leaves by flower pruning and water fogging, and consequences on tomato leaf and fruit growth, Annals of Botany. 2001;88(4):645-652.
13. Hanna HY. Influence of cultivar, growing media, and cluster pruning on greenhouse tomato yield and fruit quality, Hort Technology. 2009;19(2):395-399.
14. Senevirathna PAWANK, Daundasekera WAM. Effect of postharvest calcium chloride vacuum infiltration on the shelf life and quality of tomato (cv. ‘Thilina’), Ceylon Journal of Science. 2010;39,(1):35–44.
15. Mitchell JP, Shennan C, Grattan SR, May DM. Tomato fruit yields and quality under water deficit and salinity, Journal of the American Society of Horticultural Science. 1991;116(2):215-221.
16. Heeb B, Lundegårdh Ericsson T, Savage GP. Nitrogen form affects yield and taste of tomatoes, Journal of the Science of Food and Agriculture. 2005;85(8):1405-1414.
17. Bray CM. Biochemical processes during the osmopriming of seeds. In Seed Development and Germination; Jaime Kigel; CRC Press: Boca Raton, FL, USA, 2017.
18. Singh G, Gill SS, Sandhu KK. Improved performance of

muskmelon (*Cucumis melon*) seeds with osmoconditioning. Acta Agrobot. 2013;52:121-137.
19. By Muhammad Moaaz Ali Talha Javed, Rosario Paolo Mauro, Rubab Shabbir, Irfan Afzal Ahmed Fathy Yousef. College of Horticulture, Fujian Agriculture and Forestry University, Fuzhou, Fujian 350002, China, 2020.
20. Chapagain BP, Wiesman Z, Zaccai M, Imas P, Magen H. The Institutes for Applied Research, Ben-Gurion, University of the Negev, Beer-Sheva, Israel Dead Sea Works Ltd., Beer-Sheva, Israel, 1999.
21. Martínez-Romero, Bailén G, Serrano M, *et al*. Tools to maintain postharvest fruit and vegetable quality through the inhibition of ethylene action: a review, Critical Reviews in Food Science and Nutrition. 2007;47(6):543-560.
22. Kirkby A, Pilbeam DJ. Calcium as a plant nutrient, Plant, Cell & Environment. 1984;7(6):397-405.
23. Conway WS, Sams CE, Hickey KD. Pre-and postharvest calcium treatment of apple fruit and its effect on quality, in Proceedings of the International Symposium on Foliar Nutrition of Perennial Fruit Plants, Meran, Italy, 2001 September, 413-419.
24. Prudent M, Causse M, Génard M, Tripodi P, Grandillo S, Bertin N. Genetic and physiological analysis of tomato fruit weight and composition: influence of carbon availability on QTL detection, Journal of Experimental Botany. 2009;60(3):923-937.
25. Gautier H, Guichard S, Tchamitchian M. Modulation of competition between fruits and leaves by flower pruning and water fogging, and consequences on tomato leaf and fruit growth, Annals of Botany. 2001;88(4):645-652.
26. Hanna HY. Influence of cultivar, growing media, and cluster pruning on greenhouse tomato yield and fruit quality, Hort Technology. 2009;19(2):395-399.
27. 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.
28. Carrari, Baxter C, Usadel B, *et al*. Integrated analysis of metabolite and transcript levels reveals the metabolic shifts that underlie tomato fruit development and highlight regulatory aspects of metabolic network behavior, Plant Physiology. 2006;142(4):1380-1396.
29. Balibrea ME, Martínez-Andújar C, Cuartero J, Bolarín MC, Pérez-Alfocea F. The high fruit soluble sugar content in wild *Lycopersicon* species and their hybrids with cultivars depends on sucrose import during ripening rather than on sucrose metabolism, Functional Plant Biology. 2006;33(3):279-288.
30. Toivonen PMA. Fruit maturation and ripening and their relationship to quality, Stewart Postharvest Review. 2007;3(2):1-5.
31. Monti LM. The breeding of tomatoes for peeling, Acta Horticulturae. 1980;100:341-349.
32. Cliff M, Lok S, Lu C, Toivonen PMA. Effect of 1-methylcyclopropene on the sensory, visual, and analytical quality of greenhouse tomatoes, Postharvest Biology and Technology. 2009;53(1):11-15.
33. Getinet, Seyoum T, Woldetsadik K. The effect of cultivar, maturity stage and storage environment on quality of tomatoes, Journal of Food Engineering. 2008;87(4):467-478.
34. Getinet, Workneh TS, Woldetsadik K. Effect of maturity stages, variety and storage environment on sugar content of tomato stored in multiple pads evaporative cooler, African Journal of Biotechnology. 2011;10(80):18481-18492.
35. Mitchell P, Shennan C, Grattan SR, May DM. Tomato fruit yields and quality under water deficit and salinity, Journal of the American Society of Horticultural Science. 1991;116(2):215-221.
36. Ismail SM, Ozawa K, Khondaker NA. Effect of irrigation frequency and timing on tomato yield, soil water dynamics and water use efficiency under drip irrigation, in Proceedings of the 11th International Water Technology Conference, Sharm El-Sheikh, Egypt, 2007 March, 15-18.
37. Cantwell MI. Postharvest Handling of Specialty Vegetables, Department of Vegetable Crops, University of California, Davis, Calif, USA, 1997.
38. Paull RE. Effect of temperature and relative humidity on fresh commodity quality, Postharvest Biology and Technology. 1999;15(3):263-277.
39. De Wild HPJ, Otma EC, Peppelenbos HW. Carbon dioxide action on ethylene biosynthesis of preclimacteric and climacteric pear fruit, Journal of Experimental Botany. 2003;54(387):1537-1544.
40. Pranamornkith T, East A, Heyes J. Influence of exogenous ethylene during refrigerated storage on storability and qualit of *Actinidia chinensis* (cv. Hort16A), Postharvest Biology and Technology. 2012;64(1):1-8.
41. Raison JK, Lyons JM. Chilling injury: a plea for uniform terminology, Plant, Cell & Environment. 1986;9(9):685-686.
42. Luengwilai, 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.
43. Hong MN, Lee BC, Mendonca S, Grossmann MVE, Verhe R. Effect of infiltrated calcium on ripening of tomato fruits, LWT: Journal of Food Science. 1999;33:2-8.
44. Suslow TV, Cantwell M. Tomato-recommendations for maintaining postharvest quality, in Produce Facts, A. A. Kader, Ed., Postharvest Technology Research & Information Center, Davis, Calif, USA, 2009.
45. Artés F, Gómez PA, Artés-Hernández F. Modified atmosphere packaging of fruits and vegetables, Stewart Postharvest Review. 2006;2(5):1-13.
46. Sandhya. Modified atmosphere packaging of fresh produce: current status and future needs, LWT—Food Science and Technology. 2010;43(3):381-392.
47. Kader A, Saltveit ME Atmosphere Modification, Marcel Dekker, New York, NY, USA, 2003.
48. Kader A. Physiological and biochemical effects of carbon monoxide added to controlled atmospheres on fruits, Acta Horticulturae. 1983;138:221-226.
49. Saure MC. Blossom-end rot of tomato (*Lycopersicon esculentum* Mill.)-a calcium-or a stress-related disorder? Scientia Horticulturae. 2001A;90(3-4):193-208.
50. Wills RBH, Tirmazi SIH. Effect of calcium and other minerals on ripening of tomatoes, Functional Plant Biology. 1979;6(2):221-227.
51. Izumi H, Watada AE. Calcium treatments affect storage

quality of shredded carrots, Journal of Food Science. 1994;59(1):106-109.
52. Prakash P-C, Chen RL, Pilling Johnson N, Foley D. 1% calcium chloride treatment in combination with gamma irradiation improves microbial and physicochemical properties of diced tomatoes, Foodborne Pathogens and Disease. 2007;4(1):89-98.
53. Hussain R, Meena RS, Dar MA, Wani AM. Effect of post-harvest calcium chloride dip treatment and gamma irradiation on storage quality and shelf-life extension of red delicious apple, Journal of Food Science and Technology. 2012;49(4):415-426.
54. White PJ, Broadley MR. Calcium in plants, Annals of Botany. 2003;92(4):487-511.
55. Demarty M, Morvan C, Thellier M. Calcium and the cell wall, Plant, Cell & Environment. 1984;7(6):441-448.
56. Poovaiah W. Role of calcium in prolonging storage life of fruits and vegetables, Food Technology. 1986;40:86-89.
57. Kwon HR, Park KW, Kang HM. Effects of post-harvest heat treatment and calcium application on the storability of cucumber (*Cucumis sativus* L.), Journal of the Korean Society for Horticultural Science. 1999;40:182-187.
58. Miller RA. Harvest and handling injury: physiology biochemistry and detection, in Postharvest Physiology and Pathology of Vegetables, J. A. Bartz and J. K. Brecht, Eds., Marcel Dekker, New York, NY, USA, 2003, 177-208.
59. Sargent SA, Brecht JK, Zoellner JJ. Sensitivity of tomatoes at mature-green and breaker ripeness stages to internal bruising, Journal of the American Society of Horticultural Science. 1992;117:119-123.