POST HARVEST HANDLING PROCESS IN HORTICULTURAL CROP: A SYNTHESIS

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ABSTRACT: Tomato (*Solanum lycopersicum* L.) is one of the most cultivated and extensively consumed horticultural globally. Although the crop is believed to have originated from the wild in Peru, Ecuador, and other of tropical Americas, the nutritional and economic of the crop has led to its global production. Weight, tomatoes rank second only to potatoes in global of all horticultural produce. Tomato and tomato-based provide a wide variety of nutrients and many healthrelated benefits to the body. Tomato contains higher of lycopene, a type of carotenoid with antioxidant which is beneficial in reducing the incidence some chronic diseases like cancer and many other disorders. In regions where it is being and consumed, it constitutes a very essential part the people's diet. The numerous uses of tomatoes can be contributing factor to its widespread production. Tomato has increased in recent years to about 163 million by 2013 due to the economic and nutritional of the crop. This is made possible by the numerous research advances the entire value chain. The postharvest quality status and shelf life of the fruits in part will depend on some postharvest handling practices and treatments carried out after harvest. Even though the quality of any fruit after harvest cannot be improved by the use of any postharvest handling practices or treatment methods, it can however be maintained. Shelf life of the fruit can also be extended when appropriate postharvest handling practices and treatment methods are employed. Although most tomatoes handlers from developing countries may not have high-tech postharvest technologies in addressing postharvest losses in tomatoes, understanding simple and the best postharvest practices has been found to be beneficial. Postharvest handling practices like harvesting, pre-cooling, cleaning or disinfecting, sorting and grading, packaging, storage, and transporting played an important role in maintaining quality and extending shelf life of the tomato fruits after harvest.

Keywords: Post-harvest handling, cooling, pre-cooling, shelf life and tomatoes.

Tomato (*Solanum lycopersicum* L.) is one of the most cultivated and extensively consumed horticultural globallyGrandillo *et al.,* 1999. Although the crop is believed to have originated from the wild in Peru, Ecuador, and other of tropical Americas, the nutritional and economic of

the crop has led to its global production. Weight, tomatoes rank second only to potatoes in global of all horticultural produce. Tomato can be in various ways and in a countless number of dishes. It can be eaten raw in salads or as an extract or sauce in dishes and in drinks by Alam and Goyal, 2007. Tomato and tomato-based provide a wide variety of nutrients and many healthrelated benefits to the body. Tomato contains higher of lycopene, a type of carotenoid with antioxidant which is beneficial in reducing the incidence some chronic diseases (Basu and Imrhan, 2007) like cancer and many other disorders. In regions where it is being and consumed, it constitutes a very essential part the people's diet. The numerous uses of tomatoes can be contributing factor to its widespread production. Tomato has increased in recent years to about 163 million by 2013 due to the economic and nutritional of the crop. This is made possible by the numerous research advances the entire value chain. However, scientific research has on production mainly whilst neglecting postharvest. Kader, A.A. 2005 reported that less than 5% of resource in agricultural research in developing countries is postharvest. This means more than 95% of resource allocation is on production. Research in the production aspect of entire value chain in tomato production has resulted in cultivars or varieties which are high yielding and to both diseases and drought. This has made tomato enjoy good harvests in recent years; however, the good harvest of many producers in developing countries not translate into profit as most are lost after harvest. Loss is a major challenge hampering tomatoes in most developing countries Arah *et al.,* 2015. Tomato being perishable crop as a result of its high moisture content short shelf life of about 48 hours Muhammad *et al.,* 2011 under tropical. Specialised postharvest handling practices and methods are needed in order to extend the shelf life the crop after harvest. Failure to adhere to these specialised practices and treatment methods will result in high of loss. Losses of up to 50% can be recorded in between the harvesting and consumption stages of distribution chain in tropical countries which is line with estimates that between and 80% of all agricultural commodities end up with consumer whilst the remainder is lost. It is therefore to know the appropriate handling practices and methods needed for harvested tomatoes in order to postharvest losses thereby increasing profitability for in developing countries. The purpose of this paper is to look at some postharvest handling practices treatment methods that can be used by handlers of countries and how they can affect the postharvest and shelf life of harvested tomatoes.

POSTHARVEST HANDLING FOR TOMATOES

Physical handling can have a drastic effect on the postharvest and shelf life of most harvested fruits and vegetables. For instance, rough handling during harvesting and harvesting can cause mechanical injuries which can the postharvest quality and shelf life of harvested like tomatoes (Arah *et al.,* 2015). It is therefore important to know postharvest handling practices needed to maintain quality and extend the shelf life of harvested tomatoes producers in developing countries. Some of the handling which includes harvesting, precoolling, cleaning and, sorting and grading, packaging, transportation and storage. The physiological maturity of any fruit at has an important effect on postharvest quality (Beckles, D.M. 2012.). Therefore, care must be taken as to when to harvest fruit in order to attain the best quality. The shelf life of and a vegetable is described by postharvest physiologist's three stages: the maturation, ripening, and senescence. The maturation stage gives an indication of the fruit ready for harvest. Tomatoes can be harvested in matured green, partially ripe, or ripe state. Tomato a climacteric fruit can be harvested at the matured state allowing ripening and senescence to occur during postharvest period of the fruit. Producers targeting markets must harvest their tomatoes in a matured state. Harvesting tomatoes in matured green state not only give producers ample time to prepare the fruit the market but also prevent mechanical injuries during. Unfortunately, most producers from developing countries especially those in Africa harvest tomatoes when are partially or fully ripened. Fully ripened tomatoes susceptible to mechanical injuries during harvesting in shorter shelf life. Care must therefore take when harvesting tomatoes in ripe state to avoid injuries which will hasten deterioration. Also, the use of and packaging containers with sharp edges must discouraged to prevent bruising and puncturing of the. Harvesting of fruits should be done in either early or hours of the day to avoid excessive field heat generation. inability of producers to follow these simple but vital procedures coupled with some inefficiencies (like of ready market and processing facilities) in the entire chain may explain the reasons why there are lots losses in tomatoes harvested at fully ripened state in developing countries. Access to ready market is a big when dealing with highly perishable crops like in most developing countries. This challenge can be too many factors but the major factor is the pattern production resulting in high gluts. In most developing, a greater proportion of tomato production is rain. This causes high peaks in production during the raining which is always more than the local consumption the crop. The problem is further compounded by the processing facilities or equipment which can because to

process the crop into a more durable form for later use. Processing tomatoes into a more durable form will also serve as a means of value addition which will finally give a better market value for the crop. Producers from developed countries always have supply contracts with multinational supermarkets to supply tomatoes. In the case of producers in many developing countries, there is lack of communication between producers and consumers and also lack of market information. This could be the main as on for the mismatch between production and available markets. Producers therefore have to sell their harvest at very low cost to prevent total loss

Cleaning or Disinfecting: Proper hygiene is a major concern to all produce handlers, because of not only postharvest diseases, but also incidence of food-borne illnesses that can be transmitted to consumers. According to a report by the Government of India, Salmonella, Cryptosporidium, Cyclospora, and hepatitis A virus are some examples of disease causing organisms that have been transmitted to consumers through fresh fruits and vegetables. Unfortunately, cleaning or disinfecting tomatoes after harvest is not a common practice for most tomatoes handlers in developing countries especially those from Africa. This practice may be attributed to either the unavailability of portable water at the production sites or the sheer ignorance of the practice. However, in places where water is not a constraint, the use of disinfectants in water either for washing or for cooling can reduce both postharvest and food-borne diseases in fruits and vegetables. The use of various disinfectants during postharvest treatments of tomatoes is well documented. For instance, sodium hypochlorite solution has been used to sterilise tomato fruits in order to reduce the incidence of fungal infection before any postharvest treatment was applied. Dipping of tomato fruits in thiabendazole solution reduced the microbial load on the fruits. Fruits and vegetables are usually treated with chlorinated water after washing to reduce the microbial load prior to packaging. Disinfection can be used in conjunction with hydro-cooling to achieve the purpose of reducing excessive field heat and reducing microbial infection at the same time.

One of the most important processes in packaging and marketing of fruit and vegetables is sorting and grading. Sorting is the removal of rotten, damaged, or diseased fruits from the healthy and clean ones. The damaged or diseased fruits can produce ethylene in substantial amounts which can affect the adjacent fruits. Grading is also the process of categorising fruits and vegetables on the basis of colour, size, stage of maturity, or degree of ripening. The two processes are vital in maintaining postharvest shelf life and quality of harvested tomatoes. Sorting limits the spread of infectious microorganisms from bad fruits to other healthy fruits

during postharvest handling of tomatoes. Grading also helps handlers to categorise fruits and vegetables in a given common parameter which enables easy handling. For instance, grading on the basis of colour or maturity stage will help eliminate overripe fruits which will easily produce ethylene to hasten the ripening process in the whole batch. Commercial tomato producer's normally use sophisticated systems that require precise sorting and grading standards for their produce. Small-scale producers and retailers in developing countries in contrast may not use written down grading and sorting standards; however, the produce must still be sorted and sized to some degree before selling or processing.

Packaging: Packaging is also one of the important aspects to consider in addressing postharvest losses in fruits and vegetables. It is enclosing food produce or product to protect it from mechanical injuries, tampering, and contamination from physical, chemical, and biological sources. Packaging as a postharvest handling practice in tomato production is essential in putting the produce into sizeable portions for easy handling. However, using unsuitable packaging can cause fruit damage resulting in losses. Some common packaging materials used in most developing countries include wooden crates, cardboard boxes, woven palm baskets, plastic crates, nylon sacks, jute sacks, and polythene bags. Most of the abovementioned packaging materials do not give all the protection needed by the commodity. Whilst the majority of these packaging materials like the nylon sacks do not allow good aeration within the packaged commodity causing a build-up of heat due to respiration, others like the woven basket have rough surfaces and edges which cause mechanical injuries to the produce. The wooden crate and the woven palm basket are some of the common packaging materials used in many developing countries especially those in Africa for packaging tomatoes. The major shortcoming of the wooden crate is in its height which creates a lot of compressive forces on fruits located at the base of the crate. These undesirable compressive forces cause internal injuries which finally result in reduced postharvest quality of the tomatoes. There have been suggestions of modifying the wooden crate to make it more suitable for packaging tomatoes. The palm woven baskets used by tomato handlers have sharp edges lining the inside which puncture or bruise the fruit when they are used. **Storage:** Tomato has very high moisture content and therefore is very difficult to store at ambient temperatures for a long time. Meanwhile, storage in the value chain is usually required to ensure uninterrupted supply of raw materials for processors. Storage extends the length of the processing season and helps provide continuity of product supply throughout the

seasons. For short-term storage (up to a week), tomato fruits can be stored at ambient conditions if there is enough ventilation to reduce the accumulation of heat from respiration. For longer-term storage, ripe

Postharvest treatment: Techniques for Tomatoes After harvesting, the tomato fruit still remains living and performs all functions of a living tissue. However, the postharvest quality of the fruit at harvest cannot be enhanced by any postharvest technology but can only be maintained. In order to maintain this quality, there are some postharvest treatment methods that have to be adhered to in order to achieve this goal. Below are some of the treatments methods that can be used for harvested tomatoes.

Refrigeration storage: Refrigeration is one of the most effective methods of preserving the quality of many fruits and vegetables for several days. Low temperature storage can protect nonappearance quality attributes like texture, nutrition, aroma, and flavour in many harvested fruits. Tomato handlers have also used refrigeration storage for tomatoes in attempt to extend shelf life. However, some fruits and vegetables of tropical origin, like tomatoes, are sensitive to chilling injury when they are stored below their critical temperature of 10^0C. This gives an indication that refrigeration storage may not be the most effective method of storing tomatoes for a long period. Another challenge in using refrigeration storage in tomato handling in most developing countries is the huge initial cost which is beyond the reach of most of under resourced handlers. However, in situations where handlers can afford refrigeration storage and temperature regulation is possible, temperatures of about 10–15^{0}C should be maintained to avoid chilling injuries. In spite of the high cost of refrigeration, it is very important to control storage temperatures and relative humidity during storage, as these two parameters are the main causes of deterioration in fruits and vegetables. The required optimum temperatures of about 10–15^0 C and 85–95% relative humidity can be achieved by using less expensive methods of cooling such as evaporative cooling system. In such cooling system, air temperatures can be decreased to about 16^0C, whilst relative humidity can be increased to about 91%, which is appropriate for reducing deterioration of harvested tomatoes due to physiological weight loss. Evaporative coolers can be manufactured locally using low cost materials like jute sacks, wooden planks, and basins.

POSTHARVEST HEAT TREATMENT OF TOMATOES

Postharvest heat treatment of fruits and vegetables is receiving more attention as a way of reducing the incidence of chilling injuries in temperature sensitive fruits of tropical origin. It is one of the approaches that can be used to avoid or reduce chilling injuries in stored fruits. Postharvest heat treatments using hot air and heated water have been reported to reduce chilling injuries in fruits like mangoes, oranges, zucchini, and tomatoes. Heat treating of tomato fruit at temperatures of about 37–42^{0}C prior to cold storage can slow down ripening whilst increasing pathogenic resistance when in storage. Some studies have shown that heat treatment prior to storage enhanced or caused no change in some quality traits of stored tomatoes. For instance, TSS of heat treated tomatoes was unaffected when tomatoes ripened at ambient temperatures or when they ripened in a modified atmosphere storage system. However, uniform heat treatment before cold storage at 14^{0}C actually increased TSS and titratable acids (TA) when fruits ripened as compared to the untreated fruits. In situations where refrigeration storage is possible, postharvest heat treatment of tomatoes can be used in conjunction with refrigeration storage in extending shelf life of harvested tomatoes

Calcium chloride ($CaCl_2$) application: Postharvest calcium chloride ($CaCl_2$) application is receiving considerable attention in recent times due to its positive effects on shelf life whilst maintaining quality of many fruits and vegetables. It has been found that calcium chloride delays ripening and senescence, reduces respiration, extends shelf life, maintains firmness, and Induces physiological disorders of many fruits and vegetables. For instance, a 1% $CaCl_2$ treatment was found to have reduced fungal attack, slowed down fruit ripening, and maintained structural integrity of cell walls of strawberry whilst the same application also delayed softening and increased storage life by almost 3 months in Kiwi fruits stored at 0^{0}C. In loquat fruit, calcium chloride ($CaCl_2$) dip extended shelf life by 4-5 weeks. In tomatoes, calcium chloride treatment is vital for maintaining quality of fruits by reducing the physiological disorders, increasing the fruit firmness, delaying ripening process, and prolonging the shelf life. $CaCl_2$ has been found to have delayed fruit colour development in tomatoes and slowed down ethylene production thereby extending shelf life by 92%. Also, fruits treated with $CaCl_2$ have been shown to have reduced physiological weight loss and maintain higher firmness levels during storage. However, $CaCl_2$ is a very cheap and soluble salt which can be dissolved into any concentration for use by producers. The affordable cost of the $CaCl_2$ salt and the relatively easy preparation of the solution and its

application therefore make it a favourable choice for adoption by under resourced handlers of developing countries in reducing postharvest losses in tomatoes. A simple and cost-effective way of using $CaCl_2$ is by adding the required dosage of the salt in water used for pre-cooling or cleaning of the fruits after harvesting.

CONCLUSION

The postharvest quality status and shelf life of the fruits in part will depend on some postharvest handling practices and treatments carried out after harvest. Even though the quality of any fruit after harvest cannot be improved by the use of any postharvest handling practices or treatment methods, it can however be maintained. Shelf life of the fruit can also be extended when appropriate postharvest handling practices and treatment methods are employed. Failure to adhere to these best practices has resulted in high amount of loss especially in developing countries. Although most tomatoes handlers from developing countries may not have high-tech postharvest technologies in addressing postharvest losses in tomatoes, understanding simple and the best postharvest practices has been found to be beneficial. Postharvest handling practices like harvesting, pre-cooling, cleaning or disinfecting, sorting and grading, packaging, storage, and transporting played an important role in maintaining quality and extending shelf life of the tomato fruits after harvest. Also, the use of appropriate postharvest treatment methods like refrigeration, postharvest heat treatment, modified atmosphere packaging (MAP), and 1-methylcyclopropene (1-MCP) and calcium chloride ($CaCl_2$) application was also vital. It is concluded by this study that the quality of the harvested fruit can be maintained and shelf life extended by simply using appropriate postharvest handling practices and treatment methods. Until these simple postharvest practices are followed, postharvest losses in tomatoes will continue to be a major challenge for tomatoes handlers of developing countries.

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