NON-CHEMICAL AND INTEGRATED APPROCHES TO CONTROL POSTHRAVEST DISEASES AND EXTEND SHELF LIFE OF TOMATO FRUIT: A REVIEW

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Abstract
Due to consumers interest toward organic consumption, the effect of chemical fungicides on the environment and sustainable agriculture production, non-chemical postharvest treatments are getting more attention by researchers these days. The current review aimed to discuss the research work conducted in the last couple of years on different postharvest treatments as alternative to chemical fungicides to control postharvest diseases of tomatoes and extend the shelf life. The review specifically discusses the use of biological control agent as potential control agent to extend shelf life and control postharvest disease of tomatoes, the use of edible coatings, cold storage structure to extend shelf life of tomatoes, controlled and modified atmospheric packaging, other potential methods and finally discus the combination effect of different methods to extend the shelf life and control postharvest diseases of tomatoes. Finally the review conclude with challenges on using of non-chemical treatments and put the forward directions.

Key words: tomato, non-chemical, postharvest disease, shelf life, integrated approach.

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INTRODUCTION

Tomato (*Lycopersicum esculentum* Mill.) is one of the most important vegetable crops cultivated in many countries across the globe for its fleshy fruits (Upendra et al., 2003). It originated on elevated regions of Peru and was introduced by early explorers to Europe, where it became known as the "Apple of Love'' in France and Italy. Like Asia, tomato introduced to various parts of Africa by conquering European nations that established colonies and protectorates throughout the continent (Naika et al., 1993). Fresh-market tomatoes are a popular and versatile fruit vegetable, making significant contributions to human nutrition throughout the world for their content of sugars, acids, vitamins, minerals, lycopene and other carotenoids, among other constituents (Simonne et al., 2006; Toor and Savage, 2006). The tomato fruit contains about 94.5% water per 100 g of fresh weight, 16% protein, 71.27% carbohydrate, 21.82 % of total dietary fiber, 15145.45 IU of Vitamin A and 230.91 mg of ascorbic acid per 100 g of dry weight (OECD, 2008).

Tomato like most fruits and vegetables are classified as perishables, because of its tendency to rapidly deteriorate soon after harvesting (Frazier and Westholf, 1986). It is susceptible to tremendous chemical changes, like high respiration when separated from its parent plant until spoilage finally sets in as a result of attack from bacteria, yeast, mould and viruses. Tomato is a climacteric fruit, having respiratory peak during their ripening process. Being a climacteric and perishable vegetable, tomatoes have a very short life span, usually 2-3 weeks (Padmini, 2006). Thus, an increase in the storage life and improvement of tomato fruit quality is really desirable (Kader, 1994). Major losses in tomato quality and quantity occur between harvest and consumption (Brooks et al., 2008). So different alternative strategies to chemical fungicides have been studied by different researchers to control postharvest disease of tomato fruit and retain the quality. Some of them includes applications of application of physical agents (Stevens et al., 2004, Bailen et al., 2006), biological control agents (Lee et al., 2006, Wang et al., 2010), and chemical treatments that induce host resistance (Liu et al., 2007, Lai et al., 2011, Zhu and Tian, 2012). In addition Low temperature (Cheng and Shewfelt, 1988), edible coatings (Ali et al., 2010), 1-methylcyclopropene (1-MCP) (Wills and Ku, 2002) and controlled atmospheres (Artés et al., 2006) proved to be good tools for extending tomato postharvest life.

Postharvest recommendations indicate that tomatoes, including cherry and grape tomatoes, should be stored at 10 °C or higher to avoid chilling injury (Jimenez et al., 1996, Roberts et al., 2002) and even 10 °C may be detrimental to tomato flavor quality (Maul et al., 2000). Due to improper storage, there is a loss in fresh weight of about 10-15%. This causes them to appear shriveled and stale, thus considerably lowering their market value and consumer acceptability. Thus, during handling of highly perishable products like tomatoes all stake holders involved in the value chain should consider temperature and relative humidity of the storage conditions. Temperature and relative humidity are the two most important environmental factors play vital role in the postharvest shelf life and quality of horticultural produces (Chinenye, 2011, Vala et al., 2014). These two environmental factor can affect the fruit respiration, weight loss, and growth of pathogens (Jobling, 2000). So management of these factors is a crucial task maintain the produce quality and extend shelf life. Maintaining the optimum temperature and relative humidity can be achieved through proper storage facilities such as mechanical refrigeration, hydro-cooling and vacuum cooling. Proper storage facilities are important in stabilizing the supplies by carrying over the produce from periods of high production to periods of low production. Proper storage conditions at retail level are also very important to reduce the post harvest loss of fresh tomato.

The maintenance of postharvest quality and post harvest life of fresh fruits and vegetables is becoming increasing important. This has been partly as a response to free market situation where the supply of good quality fruits and vegetables constantly exceeds demand. Therefore to increase or to maintain the market share there is increase emphasis on quality (Keith Thompson, 2010). Consumer's increasing desire for high quality and nutritional foods has created a need for longer market season for both domestic as well as export markets. In the last decades, quality concerns have become increasingly important worldwide and, therefore, many investigations have addressed the impact of postharvest treatment on the quality of tomato fruit (Toor and Savage, 2006). This is especially true for tomatoes, which ranks number one among vegetables contributing vitamins and minerals (Rick, 2008). The perishable nature of tomatoes requires the development of technologies that reduce their postharvest deterioration and extend their shelf life (Gonzalez- Aguilar et al., 2009).

So the current review aimed to discuss the research work conducted in the last couple of years on different postharvest treatments as alternative to chemical fungicides to control posthravest diseases of tomatoes and extend the shelf life. The review specifically discusses the use of biological control agent as potential control agent to extend shelf life and control posthravest disease of tomatoes, the use of edible coatings, cold storage structure to extend shelf life of tomatoes, controlled and modified atmospheric packaging, other potential methods and finally discus the combination effect of different methods to extend the shelf life and control postharvest diseases of tomatoes.

BIOLOGICAL CONTROL AGENTS (BCAs)

In the past few decades the use of biological control agents is getting more attention by researchers as an alternative to chemical controls to manage postharvest disease of fruits and vegetables. Use of microbial antagonistic like yeasts, fungi and non-harmful bacteria are widely studied. They are getting more attention due to the following factors 1) the high interest of consumers toward organic food consumption and fear consuming chemically treated foods 2) the issues of chemicals on the environment and global warming 3) the fear of some fungi developing resistance to chemical fungicides.

Zhao et al., (2020) reported that *Saccharomyces cerevisiae* EBY100 via yeast surface display system can significantly induce disease resistance against *Botrytis cinerea* in tomato wounds. *Bacillus amyloliquefaciens strain 5PVB* was particularly effective in controlling the grey mold disease of tomatoes causes by *B. cineria*. This strain apparently did not produce extracellular antibiotic substances, yet was highly active against the pathogen on both mature-green and red tomatoes. Treatment with 5PVB before storage at 10 °C showed only fungistatic activity against grey mould (Mari et al., 1996).

EDIBLE COATINGS

A coating is defined as a thin layer of material which can be eaten by the consumer, be applied on or within the food by wrapping, dipping, brushing or spraying and act as barriers against transmission of gases, vapors and solutes and provide mechanical protection (Wu et al., 2002). Edible coatings are composed of hydrocolloids (polysaccharides or proteins), hydrophobic compounds (lipids or waxes) or a combination of both (composite coatings) that may enhance the coating properties for optimal handling (Espino-Diaz *et al*., 2010). Today, many edible coatings are available, mainly to preserve the quality of fruits and vegetables (Olivas *et al*., 2008). The mechanism by which edible coatings preserve fruits and vegetables is the establishment of a modified atmosphere around the product, which serves as a partial barrier to O_2 and CO_2, water vapor and aroma compounds, decreasing the respiration rate of the fruit and water loss and preserving texture and flavor (Olivas and Barbosa-Canovas, 2008).

Application of coatings to fresh produce has been one method of extending its shelf life by slowing down its metabolic processes. With the advent of new materials for use as coatings and consumer demand for more naturalness in food, environment friendly coatings have become popular and a very wide list of applications has been found. Edible packaging materials include both edible films and edible coatings along with primary and secondary packaging materials originating from agricultural and marine sources (Cha and Chinnan, 2004).

Using two edible coatings Stafresh2505™ (SF 2505) and Stafresh 151™ (SF 151) are tried to extend the shelf life of tomatoes at two different ripening stages at Mexico by González-Aguilar, (2011). The result shows significant differences in the respiration rate of CO2 and C2H4 production of tomato fruits were observed between treatments and storage days of tomatoes at both maturity stages. Control and coated fruits showed an initial CO2 production rate of 33.4, 20.7 and 28.5mL Kg h^{-1} for the breaker stage and 31.5, 17.0 and 25.6mL Kg h^{-1} for the pink stage, respectively. For both maturity stages, the respiration rate remained relatively constant during the storage period. From the experiment it was concluded that coatings are effective in preserving the overall quality of tomato fruit. The use of a mineral oil treatment preserved the quality of tomato fruit to the greatest extent. In conclusion, mineral oil wax could be a good alternative for preserving the quality & extending the shelf life of fresh tomato fruit (González-Aguilar, 2011).

On experiment did by Silvia et al., (2008) mature green tomato fruits waxed with carnauba wax

DECCO® and no waxed were stored at 12 °Cand 5 °C for 5, 10, 15 and 20 days, and then transferred to 22 °Cfor 3, 6, 9 and 12 days to allow ripening. Waxed fruits showed a delay in weight loss, color development and ripening after both 5 °C and 12 °C temperature storage.

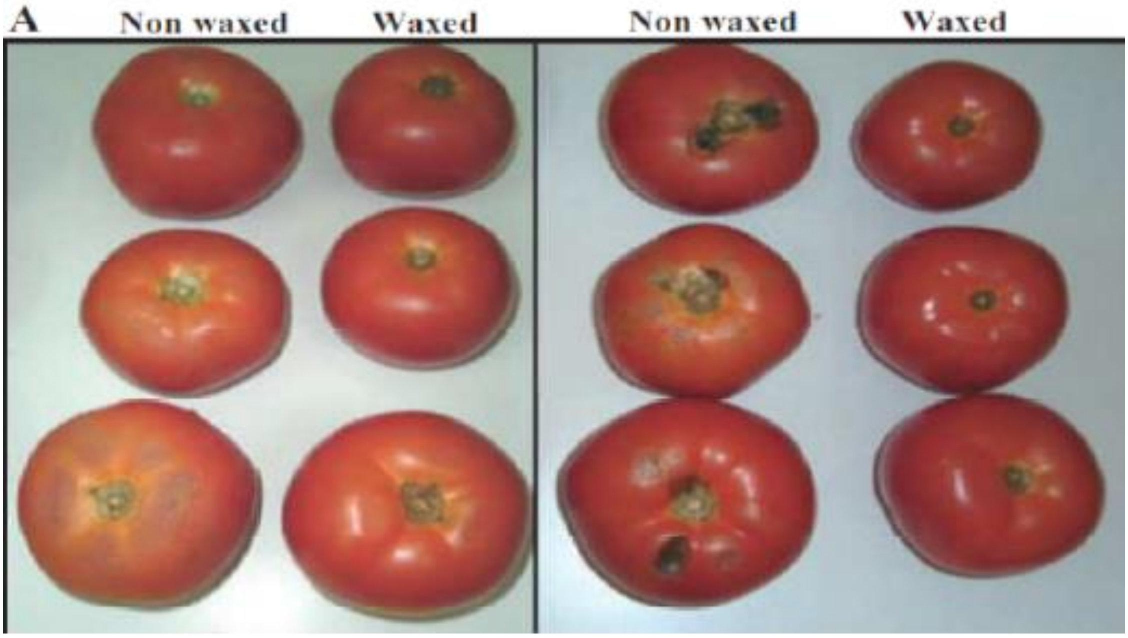

Figure 1: Tomato fruits cv. charleston after storage for 5 days (left) and 20 days (right) at low temperatures (Silvia et al., 2008).

Okolie and Sanni, (2012) did an experiment to see the effect of different coatings on the extension of shelf life of whole tomatoes. Calcium chloride, lemon juice, citric acid, sodium metabisulphite, pure Shea butter, and hot water were used as the post harvest treatments. Among post-harvest treatments, physiological loss in weight (PLW) was lowest in Sodium metabisulphite dip (SMB 0.73) which was significantly lower over all other treatments. The next best treatment in terms of low PLW was citric acid (CTA). The PLW progressively increased with an increase in the storage period, irrespective of the post harvest treatments. No significant differences in titratable acidity were observed among the post-harvest treatments at 7 and 14 days of storage. However, the control fruits recorded significantly lower titratable acidity at both days of observation.

Use of the edible coating Aloe Vera as coating can increase the shelf life of tomatoes up to one month and retain better fruit quality as compared to control. Combination of Aloe Vera with lemon juice, and combination of Aloe Vera with citric acid reduced the fruit weight loss and increased the shelf as compared to the control group as well (Goyal et al., 2017). Tomatoes at breaker and pink maturity stage coated with comzein film showed a better Color, weight and firmness changes and sensory quality as compared with non-coated tomatoes during storage at 21°C. Corn-zein fdm delayed color change and loss of firmness and weight during storage. Shelf life was extended by 6 days with film coatings as determined by sensory evaluation (Park et al., 1994).

COLD STORAGE STRUCTURES

Cooling of horticultural crops in different cold storage structures is the most widely used way to keep quality and increase the shelf. However cooling to keep quality and extend the shelf life of produces is the most traditional way though it is widely used in small holder farmers. Different storage structures are available currently from simple structure which uses zero energy like zero energy cooling chambers (ZECC) to the modern advanced mechanical cooling structures like refrigeration, hydro-cooling, vacuum cooling, and room cooling (Xuan et al., 2012, Vala et al., 2014). The main purpose of postharvest cooling of produces is to reduce the rate of respiration and

transpiration (Falah et al., 2015). Other benefits of cooling includes maintaining quality, decreasing susceptibility to ethylene damage, increasing shelf life and decreasing normal metabolism rate which is associated with consuming sugars, acids, vitamins and other constituents of the tomato fruit (Thompson et al., 2001).
Tropical fruits and vegetables are harvested under ambient temperatures from 25-35 °C. Under this temperature, the respiration rate is higher and the storage life is short. Throughout the period between harvest and consumption, temperature and relative humidity play a key role in the metabolism of fruits and vegetables (Perez et al., 2003). Respiration and metabolic rates are directly related to room/air temperatures within a given range. The higher the rate of respiration, the faster the produce deteriorates (Ashby, 2000). One way to slow down this change and to increase the length of time of storage for fruits and vegetables can be achieved by lowering the temperature to an appropriate level.
Reduced the rate of water loss slows the rate of shrivelling and wilting, causing of serious postharvest losses specially in leafy vegetables. Therefore, areas with high temperatures will have higher rates of evaporation and more cooling will occur. With lower air temperature, less water vapour can be held and slow respiration rates and the ripening and senescence processes, and cooling will take place, which prolongs the storage life of fruits and vegetables. Though temperature affects the physical and physiological properties it can also affect the biochemical and nutritional properties of the fruit. Vitamin C content, total phenolic content, lycopene content, and different antioxidant activities widely affected by the storage temperature and relative humidity conditions (Duma et al., 2017). Generally, by lowering produce temperature as soon as possible after harvest it (1) decrease the rate of respiration, (2) reduce water loss, (3) lower ethylene production, (4) reduce sensitivity to ethylene and (5) slow the rate of microbial development (Basediya et al., 2013).
Cool chambers can reduce temperature by 10-15℃and maintain high relative humidity of about 95% that can increase shelf life and retain quality of horticultural produce like tomato. Small and marginal farmers can store a few days harvest to avoid middlemen and retailers can use this storage technique to increase the post harvest shelf life of their product (Workneh and Woldetsadik, 2004). Fresh product needs low temperature and high relative humidity during the storage and transportation. Reduced temperature decreases physiological, biochemical and microbiological activities, which are the causes of quality deterioration such as flavor and colour (Kader et al., 1989; Workneh et al., 2011).
Nkolisa et al., (2018) reported that tomato fruits stored inside evaporative cooling structure retained better color, firmness. The rate of respiration and physiological weight loss were lower as compared to fruits stored at room temperature. Storage of tomatoes at lower temprature improves the fruit chemical properties like lycopene content, antioxidants, total phenolic content and ascorbic acid (Nikolas et al., 2019). According to Mondal et al., (2003), lipoxygenase activity and the malondialdehyde and H_2O_2 content of tomatoes, harvested at the turning stage and stored for 14-15 days at 10, 25 or35°C, increased with temperature. Moreover, the increase in these components was higher in a cultivar with a short storage life (5-7 days) than in that with a longer storage life (14-15 days). A temperature-related increase in reactive oxygen species (ROS) scavenging enzymes was also observed, indicating that fruit stored at high temperatures are susceptible to increased oxidative activity, leading to membrane damage and a loss of fruit integrity. Cultivar related differences in the activity of lypoxygenase, hydroperoxide lyase and alcohol dehydrogenase were also reported by Yilmaz et al., (2002).
Even though fully ripe tomatoes may be stored for a short time at low temperatures,

nevertheless adverse effects on fruit quality may occur. For example, ripe fruit that had been stored at 5°C for 4 days were deemed by sensory analysis to be significantly less aromatic, less sweet and more acidic than corresponding fruit stored for the same length of time at 20°C. The poorer aroma of fruit stored at 5°C was attributed to a loss of the principal volatile components, detected by gas chromatography (Maul et al., 2000). Although fully ripe tomatoes may be held at 2-5°C for a few days prior to consumption (not longer, since colour loss and softening may occur), fruit that are mature green or at the turning or breaking stage should not be subjected to temperatures lower than 12°C as chilling injury may occur, with adverse consequence for subsequent ripening and quality (Passam et al., 2007).

USE OF CONTROLLED AND MODIFIED ATMOSPHERIC PACKAGING

A modified atmosphere can be defined as one that is created by altering the normal composition of air (78% nitrogen, 21% oxygen, 0.03% carbon dioxide and traces of noble gases) to provide an optimum atmosphere for increasing the storage length and quality of food produce than the food produce store at room temperature (Moleyar and Narasimham, 1994, Phillips, 1996). Modified atmosphere packaging (MAP) and controlled atmosphere (CA) storage techniques to reduce the oxygen around the food are largely used for the preservation of fresh produce. However, when using these technologies, careful attention must be paid to the effect on the survival and growth of pathogenic organisms (U.S. FDA, Center for Food Safety and Applied Nutrition, 2001).

On the study conducted by Srinivasa et al., (2006) stored green, physiologically mature tomatoes in cartons covered with chitosan (biodegradable membrane) for 30 days at 27±1°C showed better color retention and firmness not only in relation to the control (fruit stored in air) but also in comparison with those enclosed in low density polyethylene film. Mondal et al., (2006) also reported that when tomatoes are enclosed in polyethylene and stored at 25°C they are more resistant to oxidative stress than unenclosed fruit stored at the same temperature.

Low oxygen levels in modified or controlled atmospheres also inhibit polygalacturonase activity, thus reduce the rate of fruit softening (Kapotis et al., 2004). High concentrations of CO_2, on the other hand, are known to inhibit ethylene synthesis, apparently acting at a site prior to that of the conversion of 1-aminocyclopropane-1-carboxylate ACC to ethylene (de Wild et al., 2005). Low oxygen (3-5%) atmospheres retard tomato ripening while high levels of carbon dioxide (>5%) are considered damaging for tomatoes. Low O_2 injury is characterized by uneven ripening and off-flavors due to increases in ethanol and acetaldehyde. Carbon dioxide concentrations higher than 5% may cause surface discoloration, softening, and uneven coloration (Moretti et al 2004).

Exposure of mature green fruit to atmospheres containing ethanol (from 2.5 to 25 ml per 2.5 kg) fruit held in a total volume of 50 ml delayed ripening due to a reduction in ethylene synthesis and respiration, and a delay in the onset of the climacteric. A parallel delay in fruit softening was attributed to an inhibition of polygalacturonase and pectin methyl esterase, and the most effective treatment was that of 20 ml ethanol per 2.5 kg fruit (Thakur et al., 2000).

Batu (2003) observed that after 60 days storage of mature green or rose tomatoes at 13 or 15°C, those stored under controlled atmospheres of 5.5% O_2 + CO_2 (3.2, 6.4 or 9.1%) were less acceptable in terms of sweetness and aroma than those stored in air.

A study conducted at Nagarjuna University, India (2009), at different storage conditions (room temperature, modified atmosphere packaging at room temperature, refrigerated, and modified atmosphere packaging in refrigerator) show that there is a significance difference between the storage conditions and

from the study it is recommended that storage of tomato fruit at modified atmosphere packaging in refrigerator is the best storage condition which extends the shelf life of the fruit (Babitha and Kiranmayi, 2010).
Moneruzzaman et al., (2009) see the effect of different storage conditions (Control: Uncovered condition, Covering with polythene, Placing CaC_2^+ below tomato and then covered with polytheneon) at different ripening stages (Matured green tomato, half ripe tomatoes, and Full ripen tomato), the highest rotting percentage shown on the control (4.92%) at the third day, and the least percentage of decay observed on treatment covered with polyethylene (4.88), while the maximum weight loss (5.96) was seen on control and the minimum weight loss (5.89) was on treatment dipping in $CaC_2\ ^+$ and then covered with polyethylene. On day 15 of storage however the maximum percentage of decay (57.36) was observed on treatment dipped in $CaC_2\ ^+$ and then covered with poly ethylene and the minimum percentage of decay (51.48) was observed on control. However the weight loss percentage was maximum with control and minimum with treatment dipped in CaC_2^+ and the covered with polyethylene.

OTHER METHODS

Different approches as an alternative to chemical have been studied by numerous researchers. Among them organic salts, micro nutrients, and physical methods are few of them. The well know selenium for example used as a treatment showed a promising result for managing postharvest decay caused by gray mold and retained fruit quality during postharvest storage. Foliar treatment of 1 mg L^{-1} sodium selenate at the time of fruit onset and development effectively controlled gray mold rot caused by *Botrytis cinerea* on both inoculated and naturally infected tomato fruit. Se treatment reduced lipid peroxidation, enhanced antioxidant enzyme activity of glutathione peroxidase and superoxide dismutase, and increased the concentration of non-enzymatic antioxidants, such as reduced ascorbate and reduced glutathione in the tomato fruits (Zhu et al., 2016). Applications of selenium have also been found to prolong the shelf life of peach and pear (Pezzarossa et al., 2012), and alter the level of antioxidant compounds in tomato fruits (Schiavon et al., 2013).
Suzuki and Nagata, (2019) reported that postharvest ethanol vapor treatment suppresses tomato fruit ripening. The treatment stimulated ethylene production and increased gene expression of LeACS2 and LeACS4, which are related to ethylene-related ripening. In the ethylene-independent ripening process, expression of RIN-dependent and ethylene-independent ripening related genes was inhibited by ethanol, suggesting that ethanol could inhibit some processes downstream of RIN. Inhibition of each process by ethanol could be a mechanism by which ethanol inhibits ripening, although it stimulates ethylene production and factors upstream of the ripening process which extend the fruit shelf life. It also reported that ethanol accelerates fruit ripening of kiwifruit and tomato (Mencarelli et al., 1991, Beaulieu and Saltveit, 1997).
Application of colorless gas like nitric oxide can also enhance tomato fruits resistance against diseases. For example, externally applied nitric oxide exert effffects in enhancing fungal infection resistance, retarding the pericarp redding, delaying the ethylene production and influencing positively in the firmness (Lai et al., 2011), but it can decrease the total soluble solids (TSS) content and enhance the total titratable acidy (TTA) (Lai et al., 2011). In tomato the 1-MCP treatments produces a rise in the TTA resulting in an increment of the sugar to acid ratio of tomato and a decrease of the respiration rate (at 5 d after harvest); however experimental evidences over the effect on the ethylene production are still not conclusive (Wills and Ku, 2002).
UV-C irradiation was effective in increasing the total phenolics content and individual phenolic acids and flavonoids of tomato fruit

including cafferic acid, p-coumaric acid, trans-ferulic acid, chlorogenic acid, gallic acid, protocatechuic acid, rutin and quercetin. UV-C treatment also induced expression of genes coding for key enzymes in the phenylpropanoid pathway, including PAL, C4H, 4CL, CHS, CHI, F3H and FLS, and enhanced the activities of PAL, C4H, 4CL, CHS and CHI during storage, which in agreement with a corresponding increase in phenolic compounds content (Liu et al., 2017). numerouse studies also reported that postharvest UV-C irradiation induced phenolic compounds in tomatoes (Jagadeesh et al., 2011, Bravo et al., 2012, Liu et al., 2012, Severo et al., 2015). Afanddi et al., (2020) reported that Far-red light during cultivation induces postharvest cold tolerance in tomato fruit. Nájera et al., (2018) reported LED-enhanced dietary and organoleptic qualities in postharvest tomato fruit.

INTEGRATED APPROCHES

Use of the above stated single approaches are less effective as compared to the integrated approach. To manage the fruit postharvest disease and reduce the massive postharvest loss management of the fruit should start from the time of pre-harvest. However using integrated approaches which is the combination of multiple effective treatments, it is possible to extend the shelf life of the fruit and control the fruit postharvest diseases. For example, the combined effect of 1-MCP and the nitric oxide delayed fruit softening at days 5 and 10, reduced the ethylene synthesis significantly at day 5 and elevated the respiration rate at 10 d, compared to the individual treatments of 1-MCP and nitric oxide alone (Steelheart et al., 2019).

The combination of 0.1% chitosan and 500 µl/l methyl jasmonate showed a higher efficacy to reduce the disease incidence and lesion diameter of postharvest decay of cherry tomato than the application of methyl jasmonate or chitosan alone. The combined treatments resulted in higher activities of PPO (polyphenol oxidase), POD (peroxidase) and PAL (phenylalanine ammonialyase) than the control (Chen et al., 2014).

CONCLUSION

Due to its perishable nature tomatoes have high postharvest loss and a shorter shelf life. Among the massive fruit postharvest loss, postharvest diseases take the largest share. Other factors also include: poor pre-harvest treatments, harvesting at inappropriate stages, poor postharvest infrastructures, poor postharvest handling such as non-removal of field heat, and improper transportation and handling contributes to the high postharvest loss of tomato fruits. Though chemical fungicides were used as firsthand in the previous days due to consumers interest toward organic consumption and the effect chemical on the environment non-chemical treatments are getting more attention. Biological control are widely studied and are determined as potential postharvest treatment to extend shelf life and control postharvest diseases of tomato fruits. Edible coatings, use of controlled and modified atmospheric packaging, cold storage structures, and combination of these methods can also be a potential alternative to chemical fungicides to control postharvest disease and extend shelf life of the fruit.

However the major challenges in the use of biological control agents for example in regard to certification time makes very less contribution to use at commercial level. The need of high investment to build controlled and modified atmosphere ware houses is the biggest challenge for small holder farmers in developing countries. So government, policy makers and researchers should closely work together to scale up the research work and use of these non-chemical treatments at the commercial level. Finally attention by the researchers should also be given to the sensory quality of the produce in addition to the nutritional and quality attributes as some treatment alter the sensory quality of the fruit.

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