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Effect of Hot Water Treatments on Shelf Life of Tomato (Lycopersicon esculentum Mill)

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Abstract
The experiment was conducted in 2015 academic year at Wolaita Sodo University College of Agriculture Department of Horticulture laboratory room to study the effects of different postharvest treatments to extend shelf life and to reduce postharvest loss and maintain quality of tomato. The study was consist of four levels of temperature treatments as T1= 50^{0}C, T2= 40^{0}C, T3=30^{0}C, and T4= control using tomato *(Lycopersicon esculentum* Mill*),* cv. Roma VF. The experiment was laid out using completely randomized design, (CRD) with three replications. The post-harvest losses in horticultural products are the major problems in most developing countries that have tomatoes been reported from 20 to 50%. In this work, the effect of tap water, 30ºc, 40ºc and 50ºc hot water dipping for 20 minutes on quality and reducing decay of cheap tomatoes were studied. Fruits were harvested at mature green stage and after treatments were done, they were stored at ambient lower temperature and pH for 11 days. Quality parameters including weight loss, color development and shelf life were analyzed after 3 days of storage. The recorded data were analyzed using analysis of variance and the means of different parameters were compared by LSD. Significant variations were observed in relation to most of the parameters studied. The result showed that there is significant difference between treatments ($P \leq 0.05$), the hot water treatment using 50^{0}C is more suitable than other treatment temperatures, for 11 days storage life of tomato fruits i.e, 50ºc hot water dipping for 20 minutes delayed the ripening rate by reducing the fruit softening, weight loss, and chlorophyll degradation, in contrast fruit ripening was accelerated in untreated (control) one. The post-harvest decay that was the main quality factor in this experiment, significantly reduced in treated fruits with hot water treatment.
Keywords: Tomato, temperature, hot water, shelf life, weight loss and color change.

1. INTRODUCTION

Tomato (*Lycopersicon esculentum* Mill) belongs to the botanical family *Solanaceae*, genus *Lycopersicon* sub family *Solanoideae* (Taylor, 1986) is a perennial, monocarpic and herbaceous plant believed to be originated from Andean region of South America (Sams, 1999). It is second most important in the world next to potato both in terms of area and volume of production. Tomato plants are generally many branched, spreading 24-72 inches and recumbent when fruiting but a few forms are compact and up right leaves are more or less hairy, strong odorous, pinnate compound, up to 18 inches long. The flowers are yellow two cm across pendant and clustered. Fruits vary in diameter from half to three inches or more, there are usually red, scarlet or yellow that vary in shape from almost spherical through over and elongated to pear shaped **(**Harvey and Chan 1983**)**. The fruit is soft, succulent, berry red or yellow in color contain too many cells of small seeds surrounded by jelly like pulp. It is used raw in salads served as a cooked vegetables used as an ingredients of various prepared dishes and pickles (Wills et al., 1998).

The chemical composition of tomato includes total sugars 2.50-4.50%, Vitamin C 15-20 mg/10 g, calcium 0.25-0.50 g/100 g, magnesium 0.10-0.50 g/100 g, phosphorus 0.20-0.80 g/100 g, iron 40-500 ppm, zinc 10-50ppm, lycopene 20-50g/100 g (dry fruit weight basis). The food value is greatly dependent on its chemical composition such as dry matter, titratable acidity, total sugar, total soluble solid and ascorbic acid and antioxidants like lycopene. These compounds contribute to postharvest quality, namely flavor taste, transportability, shelf life and processing. Studies have demonstrated that flavor and taste of tomato are related to free sugars, organic acids and sugar acid ratio (Kader *et al*., 1978b). Tomato is highly perishable vegetable crop because of its climacteric pattern of respiration (Wills *et al*., 1998). Tomatoes are the richest of all foods in vitamins. They are very rich in all three important vitamins like A, B and C while most vegetables are deficient in one or more (Weston and Barth 1997) it is the most wonderful and effective blood cleaner known to man. It is rejuvenate, stomachic, digestive and tonic. Unripe or half ripe fruits are very effective in stomach disorders, liver disorders, liver troubles and spleen disorders. But excessive consummation may retard sexual desire (Harve 1978).

Tomato is one of the vegetables with the highest production both in the world and in our country level. Asia is by far the continent the greatest production. China is the main producer of tomato with the area coverage of 90,803 ha and production of 45,365,543 tons with the productivity of 49.22t/ha followed by the USA, Turkey, India and Italy (FAO, 1989).

However, the total production and productivity in Ethiopia is far below than the average of the major producers in Africa. According to FAO (1989), in 2009 cropping season, the country area coverage by this crop was 4,593 ha and production was 40,426 tons with the productivity of 8.8t/ha which is very low when compared to other tomato producer countries.

Estimation of the magnitude of losses and waste are still lacking, particularly in developing countries. FAO (2012) roughly estimated that yearly global quantitative food losses and waste reached at 40–50% for fruits, vegetables and root crops. Olayemi *et al.* (2012) also estimated that as much as 25% and 40% fruits and vegetables, respectively, are lost after harvest and farmers affected seriously due to poor postharvest handling measures. Based on the data of CSA (2013), postharvest losses of some fresh fruits and vegetables were estimated by Hailu and Derebew (2015). Accordingly, out of 863,347.8, 85,547.8, 55,514.3 and 23,224.7 tons of yearly production of Ethiopian cabbage (kale), green pepper, tomato and head cabbage, respectively, postharvest loss reached 166,947.8, 38,496.5, 24,981.4 and 10,451.1 tons in that order. Post-harvest losses of fruit and vegetables are a matter of concern for all these countries whose economy is based on agriculture. As this happens in most event developing countries those fruits and vegetables are extremely perishable product which require to be dealt with which care to reduce losses. Because of its high moisture content, horticultural crops are inherently more susceptible to deterioration especially under high temperature conditions. The biologically active and carryout transpiration, respiration, ripening and other biological activities which result in quality deterioration, tomato is one of perishable fruits. It changes continuously after harvest. The post-harvest loss of fresh fruits and vegetables including tomatoes is estimated to be 5 to 25% in developed and 20-50% in developing countries (Neeta et al, 2010; Kadar, et al, 1978b).

Extending the shelf life of tomato is very important for domestic and export marketing. Generally, shelf life of tomatoes is extended by low temperature storage. Many fruits and vegetables can be kept for several weeks at low temperature. Storage at 13°c was more favorable as compared to 24°c for prolonging the shelf life and increasing vitamin content of fruits (Mustafa and Al-Mughabi, 1984).

Decay is the most harvest loss in most horticultural products; especially in products that hot post-harvest treatment with synthetic fungicides, heat treatment, hot water treatment and $CaCl_2$ treatment is allowed (Aquino et al, 2011). Until now, pesticides have been largely used to control decays on the production. Nevertheless, the increased demand for pesticide free products and resolutions on the use of chemical treatments has reviewed interest in the use of non-chemical treatment (procedures) such as heat treatment (Lurie, 1998; Karahasim et al, 2005). Post-harvest treatment could be a pesticide free method to reduce pathogens, control insect infestation and maintain storage quality (Shao et al, 2007; Jingi et al, 2010). Over the last few years, there has been increasing tendency on the use of post-harvest heat treatments (Fallik, 2004). Indeed, the quality of fresh produce treated with optimal hot water temperature is significantly better than untreated produces, as determined sharp reduction in decay incident and maintenance of several quality traits (Varit and Songsin, 2011).

In spite of the importance of tomato in diet and economic subsistent for farmers and country level, less attention has been given to the management of its post-harvest loss in Ethiopia. Therefore, there is the need to develop favorable post-harvest treatments which minimize the post-harvest loss of the commodity. Thus, the present experiment was undertaken with following objective:

- To evaluate the effects of different hot water treatment on the extension of shelf life of tomato

2. LITERATURE REVIEW

2.1. The plant Tomato

Tomato is one of the most important cash crops in many countries. More than 2000 varieties are grown all over the world. In terms of per capita consumption, tomato is the leading processed vegetable. The main producers and exporters are China, USA, Turkey, Egypt and India (FAO, 1989). It is good source of vitamin A and C. it is used as fresh vegetable as well as raw material in food industry for products ketchup, tomato juice, pulp and puree and tomato paste. Thus, the quality of tomato should be controlled before consumption.

2.2. Post-harvest handling of tomato

The post-harvest losses in terms of quality and quantity of food are the major problems all over the world. Therefore, post-harvest technology has been given more attention by all developed and developing countries. They have identifies the most of these losses are due to the poor post-harvest handling, rough handling in the field, improper packaging, careless loading and unloading during transportation and poor storage facilities are the major factors responsible for quality and quantity losses. Losses cannot be eliminated but can be reduces to a certain extent by employing better handling method or post-harvest treatment. Post-harvest losses for tomato are rarely reported in developing countries. This means that studies have not been conducted frequently to estimate losses. However, frequent systematic studies are necessary for estimating post-harvest loss in order to identify the weakness of the handling system and provide necessary improvements for the losses of tomatoes that ranges 20 to 50% in developing countries (APO, 1989).

A coating is defines as a thin layer of material which can be eaten by the consumer, be applied on or within the food by warping, dipping, brushing or spraying and act as barrier against transmission of gases, vapors and solutes and provide mechanical protection (APO, 1989). Post-harvest rots are more prevalent in fruits and vegetables that are bruised or otherwise damaged. Mechanical damaged also increases moisture loss. The rate of moisture loss may be increased by as much as 400 present by single and bruise on a tomato and likewise skinned potatoes may be loose three or four as much weight as non-skinned potatoes. Damage can be prevented by training harvest laborer to handle the crop gently; harvesting at proper maturity; harvesting dry whenever possible, handling each fruit and vegetable no more than necessary (field pack kept at 5% for longer than 6-8 days (Thompson, 1996). The fruit ripening was significantly delayed when the fruit was exposed to hot water, $CaCl_2$ solution and in combination with plastic film package (Mathooko 2003.).

2.2.1. Effect of post-harvest handling on shelf life of tomato

Proper post-harvest handling and storage conditions are essential to maintain an acceptable quality and longer shelf life of tomatoes. Post-harvest losses in quality and quantity are related to immaturity at harvest, inadequate initial quality control, incidence and severity of physical damage, Exposure to improper temperature, and delays between harvest and consumption. Shorting the time between harvest and consumption can minimize loss of the characteristic tomato and aroma and development of off flavor. Tomato subjected to bruising usually has less "tomato- like" flavor and more off-flavor than those without physical damage. Exposure of chilling temperature adversely affects tomato flavor before other symptoms of chilling become apparent. Temperature also influences color uniformly and softening rate of tomatoes (Buescher et al., 1999).

The effect of modified atmosphere's on post-harvest behavior of tomato fruits picked at the mature green or partially ripe stage. Using a low oxygen atmosphere to related tomato ripening has less of an effect on flavors than ripeness stage at harvest. If oxygen concentration is reduced to 2% or lower increased off flavor and uneven color development will result (Arpaia, 1994). Controlled atmospheres reduce the loss of chlorophyll and the synthesis of lycopene, carotenoids and xanthophylls carbon monoxide at 5 to 10% in combination with 4% 0_2 reduces post harvest decay incidence and severity with influencing of flavor of tomatoes (Mattheis et al., 1999). Mature green tomatoes can be stored at 12.8^{0}C for up to two weeks under 4% 0_2, 2% CO_2 and 5% CO and still retain and adequate marketing life at acceptable quality for one to two week at 20^{0}C. However the flavor of these tomatoes is likely to be inferior to that of mature green tomatoes ripened soon after harvest (Buesher et al., 1999). Fresh tomatoes can be stored after they have been harvested and stored or they can first be packaged before storing, cooling before and during storage is important. Tomatoes are sensitive to chilling. Tomatoes that suffer chilling injury fail to ripen, and to develop full color and flavour. Their color development is irregular, and they are likely to suffer premature softening, browning of seeds and increased decay (Buescher et al., 1999).

2.3. Effect of hot water treatment on shelf life of tomato

Hot water treatment by decreasing activity of cell wall, degrading enzymes, and disorder of the ethylene synthesis enzymes and loss of ripening synthesis can inhibit such biochemical path ways involved in ripening. (Paul and chen, 2000; Safdar Khan, 2009).

Firmness is an index to determine post-harvest storage quality which decreases with fruit maturation (Hartman et al 1981). Safdar Khan (2009) reported that treated tomato with hot water had higher firmness at 42°c than untreated controls. This may be because of inhibition or inactivation of cell wall hydrolytic enzymes such as polygalacturonase, pectinesterase or supperession of MPWA synthesis coding for wall softening enzymes in tomatoes (Paul and Chen, 2000; Safdar Khan, 2009).

According to some study, hot air softened slower than control fruit (Klein and Zurie, 1992; Lurie, 1998). Weight loss is one of the symptoms of deterioration, degrading the quality and losing the quality (Ullah, 2009). In the present study, hot water treated fruit had lower weight loss at 45°c hot water than untreated (Karasahim et al, 2005). In addition, Safdar Khan indicated that treat reduces fresh weight loss of tomato fruits over control at the end of 25 days storage. Transpiration and respiration mechanisms are main cause of water loss of tomato fruit (Bhowmilk and Pan, 1992) but in general, in most agricultural products including tomatoes, 5-10% loss is acceptable (Mathooko, 2003; Safdar Khan, 2009).

The color of the tomato is one of the quality factors of tomatoes for consumer preference (Ullah, 2009). The delay in color development occurred in treated cherry tomatoes with hot water (Lurie and Nussinovich. 1996). The delay the color development is due to inhibition of lycopene biosynthesis or its precursors such as pristoene and phyto-fluene (Yakir et al, 1984). How water dips (39°c for 90 min) of mature green cherry tomatoes fruit delayed the color development (Ali et al, 2004). How water treatment reduces disease incidence (Aquino et al, 2011). According to Fallik et al., (1993), the protective mechanism against disease may be due to action of heat in delaying ripening.

The study showed that heated tomatoes were less susceptible to botrytis, which usually attacks ripe fruits, however, how water treatment may benefit as non-chemical fungicidal treatment (Fallik et al, 1993). Hot water dipping is the quickest way to increase fruit temperature (Lurie, 1998). In the study by Hakim et al (1998), tomato as 'vibelo' at the mature green stage tolerate immersion in 42 or 46°c water for 90 minutes, with 46°c being more effective in reducing chilling injury during 6 weeks storage at 20°c.

A short pre storage hot water rinsing and brushing method as shown to be effective for reducing infection by *Botrytis cinerea* in tomatoes. Fruit of the pink tomato (V.189 were placed at so 12°c for 13 days, plus 3 days at 22°c for 1 minute hot water dip, significantly reduced decay after development, slow development of color, slow down weight loss, low respiration rate and ethylene production (Fallik et al 1993).

The efficiency of different heat treatment methods such was hot water treatment 53°c for 10 min and hot water brief 60°c for 20 t0 35 seconds and brief exposure to hot water disc (60°c for 20 t0 35 seconds) for the control of post-harvest disease of tomatoes was assessed. Fruits were exposed to vapor heat treatment and ripened at 25°c hot water treatment followed by vapor heat induced faster feel color change compared with other treatment (Ferguson and Woolf. 1999). Fallik et al (1993) found that dipping pink tomato fruit in 52°c water for 1 minute significantly reduces decay development and completely inhibited chilling injury symptoms after storage. McDonald et al (1999) also stated that short term hot water treatment extended storage life equally as well as longer term hot air treatment.

2.4. Factors affecting the shelf life of tomato

2.4.1. Pre harvest factors

Primary factors responsible for post-harvest produce losses include poor pre harvest measures, adoption of poor production techniques (varieties with low shelf life, imbalance use of nutrients, insect pests and disease infestation and abiotic stress and low application of pre harvest recommended treatments (practices and harvesting at improper stage and improper care at harvest (Kader et al. 1985).

2.4.2. Post-harvest factors

Post-harvest problems such as non-removal of field heat, damping produce, moisture condensation causing pathogen infestation, packaging in bulk without sorting and grading of produce, improper transportation and storage and distant and time consuming market distribution. These losses bring low return to growers, processors and traders and country also suffers in terms of foreign exchange earnings (Kader et al. 1985).

2.4.3. Respiration and Transpiration

During post-harvest handling and storage, fresh fruits and vegetables lose their moisture through their skins via transpiration process. Commodity deterioration such as shriveling or impaired flavor may result if moisture is high. In order to minimize losses due to transpiration and thereby increase both market quality and shelf life, commodities must be stored in low temperature, him humidity equipment. In addition to proper storage conditions, various skin coatings and moisture proof firms can be used during commodity packaging to significantly reduce transpiration and extend shelf life (Ben Yehoshua, 1996).

Metabolic activity in fresh fruits and vegetables continues for short period of time after harvest. The energy required to sustain this activity comes from respiration process (Ferguson and Woolf 1999). The respiration involves the oxidation of sugar to produce carbohydrate, water and heat. The storage life of a commodity is influenced by its respiration activity. By storing a commodity at low temperature, respiration is reduced and senescence is delayed, thus extend storage life (Neeta et al. 2010). Proper control of the oxygen and carbon-dioxide concentrations surrounding a commodity is reducing the rate of respiration. Properly designed and operated refrigerated storage facilities will extend the storage life of commodities by providing a low temperature, high humidity environment which reduces moisture loss and allows both designer and operator of cold storage facilities to achieve optimum storage condition. The quality of good shelf life of vegetable is related some biochemical process that takes place after harvest. Physiological action such as respiration involves heat emission resulting in temperature increase and this accelerates metabolic process and decay phenomena (Rolle 2006).

Green vegetables have high respiration rate which limits their shelf life after harvest to 1-4 weeks maximum. This is partly attributed to the high metabolic activity of the leaves and in some cases the fruits' seed inside the fruit (Wills et al, 2004). The later stage of ripening, the degradation process increases with the hydrolysis starch and the consumption of soluble sugars on respiration (Ben Yehoshua, 1996).

The tomatoes are subjected to post-harvest cooling to remove field heat to maintain the quality to the desired level and to increase the shelf life appreciably. Furthermore, it is possible to reduce the effects of dehydration and minimize decay by applying suitable cooling system. Room cooling system may be adopted after the containers are loosely stacked allowing spacing between the containers for sufficient air circulation (Rolle 2006). Proper temperature condition is a critical requirement for maintaining the quality and extending shelf life of tomatoes. The optimum temperature for ripening mature green tomatoes is from 18 to 24°c. Mature green tomatoes stored at below 10°c were found to be susceptible to decay by *Alternata*. Ripe tomatoes (light red) can be stored at lower temperature (about 4°c) than mature green tomatoes. However, longer storage at lower temperature may lead to loss of color, firmness, shelf life and more importantly, taste (Rolle 2006).

3. MATERIALS AND METHOD

3.1. Description of the study area

The experiment was conducted under applied in horticulture laboratory room at Wolaita Sodo University (WSU), SNNPRS, during 2015 cropping season. Wolaita Sodo University is located at 390km south of Addis Ababa, 6°49'N latitude and 37°45'East longitude and has an elevation of 1800m above sea level (masl). The annual rainfall of the area was 1450 mm. the average annual minimum and maximum temperatures and 18°c and 28°c, respectively.

3.2. Experimental material

The experiment was carried out using ordinary well matured (firm) tomato purchased from a nearby small scale vegetable producers farm surrounding the Sodo Town in April, 2015. They were non defect, uniform medium-sized and shape, matured tomatoes, cv. Roma VF. They were randomized and assigned to three replicates of 60 fruits. To minimize the diseases, whole fruit washed with distilled water for 1 min, drained and kept overnight at l0 ^{0}C before being heat-treated.

3.3. Experimental design and treatments

The experiment was laid out in completely randomized design (CRD) with four treatments (50°c, 40°c, 30°c and control as a treatment one (T_1), T_2, T_3 and T_4), respectively. Each replication was consisted of three (3) treatments 20 minutes soaked in hot water, except one control was washed at normal distilled water. In each treatment there was five uniform sized of tomato fruits with a total number of 60 fruits per experiment. In accordance with specification of design, each treatment was assigned randomly to the experiment unit within a replication. The temperature was adjusted by a thermometer and treated tomato fruits were kept in laboratory at room temperature.

3.4. Experimental procedure

The fruits used for the experiment were fresh and fully matured but not ripen. The experimental room was well prepared manually cleaned and the jogs were sanitized with potable water. Samples were sorted at the same maturity level and the pathogen-infected and/or mechanical damaged tomatoes were discarded. Uniform sized but not cured and waxed were put into primarily prepared jogs after the fruits were washed and trimmed with clean tap water to remove any dirty and then dipped in hot water according to the treatment. Data were taken carefully and regularly every day for color and shelf live, and every two days interval for weight loss.

3.5. Method of data collection

The different levels of hot water treatment WSU horticultural laboratory was assessed by examining data on the response of tomato to apply shelf life related traits of the crop.

Parameters of investigation

Weight loss of tomato fruit: weight loss, the tomatoes were weighted during the storage period using a tap balance after applications of treatment. It was determined by periodically weighing of fruits at interval of two days for a period of 15 days of storage time.

Weight loss % was determined as follows

Weight loss (%) $= \frac{(A-B)}{A(g)} X100$

Where, A indicates the tomatoes' original (initial) fresh weight after harvest and B indicates the tomatoes' weight after storage (final) in gram.

Decay: the tomatoes were treated with various hot water treatment was started at room temperature and monitored daily for signs of decay which included fungal mycelia growth, necrotic spots and rotors. The number of deal tomatoes was expressed as percentage of the total number of tomatoes the treatment at storage (start of storage).

Shelf life: the shelf life of each tomato per treatment at included when decay commented, excessive weight loss, loss of firmness and bronzing were observed, such tomatoes were recorded daily and the day the preceded the quality loss was taken as the shelf life of the tomato fruit (vegetable).

Shelf life is one of the important quality parameters of tomato. Shelf life of tomato fruit would be a period of time which started from the harvest and extends to the start of rotting of fruits (Goldman et al, 1992). This would be calculated by counting day at optimum marketing and eating qualities.

3.6. Data analysis

For the experiment, the data obtained on physico-chemical characteristics of' tomato were statistically analyzed to find out the significance of difference among the treatments. The collected data on various parameters were statistically analyzed using SAS Statistical Package. The means for all the treatments were calculated and analysis of variances (ANOVA) for all the parameters was performed by F-test. The significance of difference between the pair of means was compared by least significant difference (LSD) test at the 5% levels of probability (Gomez and Gomez, 1984).

4. RESULT AND DISCUSSION

4.1. The influence of hot water treatment on the Shelf life (day) of tomato

Hot water treatment had a significant (P ≤ 0.05) effect on mean days of shelf life of tomato was fresh fruits at different levels of treatment (Appendix 1). From the treatments, hot water at 50ºc temperature for 20 minutes showed the maximum shelf life (10 days after treating) to provide safe shelf life of the produce (Table 1), Whereas the control (tap water) treatment showed the lowest shelf life 6 days (Table 1). This shows that when perishable fruits are treated with hot water, the shelf life of fruits to become higher. In this case, the shelf life of tomatoes was extended to two weeks. This study showed that hot water treatment delayed ripening rate by delaying softening, weight loss and degradation of chlorophyll and carotenoid. Hot water treated by decreasing activity of cell wall degrading enzyme, disorder of the ethylene synthesis enzyme and loss of ripening related RNA synthesis can inhabit path ways involved in ripening (Safdar, 2009). The fruits treated with 50ºc for 20 minutes displayed the shelf life of 10 days, but the control was started to die after 6 days.

Table 1. Main effect of means for shelf life of tomato fresh produces as affected by different level of hot water treatments at Wolaita Sodo University, 2015.

Treatments	Shelf life (mean days)
50ºc for 20 minutes	10.00[a]
40ºc	8.96[b]
30ºc	7.64[b]
Tap water (control)	6.16[c]
LSD	0.84
CV (%)	7.3

Note: Values followed by the same letter (s) with in a column are not significantly different at P≤ 0.05

4.2. Peel color change

Peel color change was significantly (P<0.05) affected by treatments. Tomatoes which were treated with hot water at 50ºc for 20 minutes remained on the way break green color up to 3 days. At the end of 9 days, except tomatoes which were treated at 50ºc for 20 minutes, all other groups had shown a bright yellow color (Table 2). Influence of post-harvest treatments on the color development had indicated significant differences (P<0.05) between 3, 6 and 9 days.

Among the treatments, hot water treatment at 50 ºc had significantly delayed the color development. Our finding in accordance with previous researches, the delay in the color development occurred in treated Cherry tomatoes with hot water (Lurie et al, 1996). Hot water dips (39 ºc for 90 minutes) of green cherry tomato fruits delayed the color development (Ali et al, 2004). The delay in color development with hot water is due to inhibition of lycopene by synthesis or its precursors such as phytoene and phytoflune (Yakir et al, 1984; Safdar Khan, 2009). However, among groups of this treatment there was fast rate of color development observed after 6 days. Finally, at the end of 11 days, almost all fruits were changed to complete yellow color (Safdar Khan, 2009).

Table 2: Main effect of means for peel color change of tomato fresh produces as affected by different level of hot water treatment at Wolaita Sodo University, 2015

Treatments	Color (scales) on day
Hot water at 50ºc for 20 minutes	3.2a
Hot water at 40ºc for 20 minutes	2.32ab
Hot water at 30ºc for 20 minutes	2.08b
Tap water (control)	1.58c
LSD	0.08
CV%	4.95

Means with columns not sharing the same letter are significantly different.
* indicates significant difference at (P<0.05), and LSD = Least Significant Difference

4.3. Weight Loss (gm)

Significance at (P<0.05) in weight loss of tomato fruits was observed between up 9 days only: after that, there was no significant difference among treatments (table 3). This is the perishability of the produce due to high water content leads to water loss (transpiration) according to (Bhowmik and Pan, 1992) who stated that transpiration and respiration mechanism is the main cause of water loss of fresh fruits. The present study hot water treated fruit had lower weight loss at 50ºc than untreated (control). These results are agree with Karasahim et al (2006), that reported combined 50ºc hot water and VU-C treatment reduces weight loss of tomato fruits. In addition, Safdar khan (2009) indicated that hot water treatment reduces fresh weight loss of tomato over control at the end of 25 days storage. On day 12, nearly all tomatoes were unmarketable while those groups treated at 50ºc for 20 minutes had left.

Table 3: Main effect of means for weight loss of tomato fresh produces as affected by different level of hot water treatment at Wolaita Sodo University, 2015

Treatments	**Weight loss (WL) (g) on days**
Hot water at 50ºc for 20 minutes	2.303a
Hot water at 40ºc for 20 minutes	1.4913b
Hot water at 30ºc for 20 minutes	1.347c
Tap water (control)	1.288^{d}
LSD	0.031623
CV%	2.41

Means within columns not sharing the same letter are significantly different

* indicates significant difference at ($P<0.05$) by LSD, and LSD = Least Significant Difference, WL= Weight Loss and g- gram

5. SUMMARY AND CONCLUSIONS

Tomato *(Lycopersicon esculentum* Mill) is one of the perishable products of horticultural products because of its high moisture content. The post-harvest handling system starts with harvest but Pre harvest factors can influence the final quality. It is not possible to improve the quality of the produce after harvest, but it is possible to slow down the rate of undesirable change. Different environmental conditions including temperature, humidity and atmospheric composition can influence harvested fruits depending on the fruits their highly specific requirements and tolerances to storage conditions.

The experiment is laid out in completely randomized design of four treatments i.e. tap water, hot water treatment at 30ºc, 40ºc, and 50ºc for 20 minutes with three replications. It was periodically analyzed for weight loss, shelf life and peel color change. The shelf life of tomato fruits was kept for 11 days under ambient temperature. During storage period disinfected treatments shown significant difference in their effects on quality parameters of tomatoes. From the result, we observed significant difference in peel color intensity when tomato is treated at different level of hot water. It should be noted that tomatoes treated at 50 ºc for 20 minutes remained the break green color during the 3 days of storage, the longest shelf life extended up to 11 days, and Weight loss of tomatoes during a period of 11 days, had shown that significant difference while the control one showed the maximum weight loss.

In general, we recommended that the hot water at 50 ºc for 20 minutes is better to extend the shelf life, to delay the peel color change and to reduce the weight loss of tomato (Roma VF) fruits, but it is not the end result; therefore, further investigations with more promising postharvest treatments are suggested to carry out to confirm the results of the present study with different tomato varieties and dipping duration is required.

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