Effect of Using Plant Extracts with Coating Materials on Physicochemical Quality of Tomato Fruit (Solanum Lycopersicum L.) Stored at Ambient Temperature

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Abstract

Tomato (Lycopersicon esculentum Mill.) is one of the most widely consumed fresh vegetables in the world. Tomato, being a very nutritious and health protective food, is highly perishable in nature. Its sensitivity to postharvest diseases and physical injury limits its successful marketing. Therefore, postharvest losses in tomato are a serious problem because of rapid deterioration during handling, transport and storage. Due to this problem, simple technology is required to reduce the postharvest loss of this commodity. The use of edible coatings with plant extracts appears to be a good alternative preservation technique to extend the shelf-life of mature tomato fruit. This study was, therefore, initiated to investigate the effect of using plant extracts (garlic bulb (G) and capsicum (Cp)) and incorporation with coating materials (maize starch (MS) and beeswax (BW)) on physicochemical quality of tomato fruit stored at ambient conditions (temperature 15.5 to 20.2°C and relative humidity of 55.5 to 67.3%).

The experiment was conducted using complete randomized design (CRD) of two varieties (Fetane and Melkashola) and six treatments. The tomato fruits were coated by dipping into solution for 3 minutes. The treatments prepared were on coating solution of (MS+G): 9.5% maize starch mixed with 0.5% garlic extract, (MS + Cp): 9.5% maize starch mixed with 0.5% capsicum extract, (Bw + Cp): 9.5% beeswax mixed with 0.5% capsicum extract, (Bw+G): 9.5% beeswax mixed with 0.5% garlic extract, 10% maize starch without plant extract, 10% beeswax without plant extract.

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extract and control. The treatment means were tested at significance level of P≤0.05 using the statistical package used was SAS 9.1.3 software. The effectiveness of plant extracts with coating materials on physicochemical quality of tomato fruits were evaluated at three (3) days intervals for 30 days. The tomato quality parameters such as decay loss, weight loss, marketability, total sugar content, pH, and beta-carotene content were assessed. As storage period increased the decay loss, and weight loss were increased whereas marketability, acidity, ascorbic acid, and total sugar were decreased gradually during storage. There was a significance difference (P<0.05) between coated and uncoated fruits. All coatings delayed tomato ripening and improved the keeping quality parameters, but best results were exhibited by 9.5% beeswax mixed with 0.5% capsicum extract followed by 9.5% maize starch mixed with 0.5% garlic bulb extract by maintaining the mature tomato fruit for 30 days. The study showed that the Fetane variety has maintained more quality attribute than Melkashola variety during storage.

Keywords: Ambient temperature; Edible coating; Physicochemical Quality; Plant extracts; Storage and Tomato

Introduction

Tomato (Solanum Lycopersicon L) is considered as one of the most important and known vegetables in the world. In terms of world area cultivated and production among vegetable ranks next to potato because of high yielding, better adaptability and multipurpose uses (Sajid et al., 2017). Globally, tomato production accounts 162 million tons from about 4.8 million hectares of land area (FAOSTAT, 2014). According to CSA (2015), tomato production in the Ethiopia was estimated to be 8,550,210 tons from 10319 hectares that corresponds to approximately 5% of the total world production.

Even with numerous nutritious and health benefits of tomatoes, storage life has being limited by several factors including physiological losses and senescence, biological factor, physical or mechanical injuries, and environmental condition. Indecorous handling of tomatoes can also result in the damage of the fruit cell wall result to softening, and increased respiration that results in faster fruit ripening and deterioration of fruit quality and reduced marketability of the product (Mutari and Debbie, 2011).

Natalia et al., (2013) reported that plant extract could be incorporated into edible coatings formulation as antimicrobial agents, which will lead to improved food safety. Plant extract is alternative as creating the possibility to reduce application of the chemical preservative. Curtis, et al (2004) suggested that among the different plant extracts screened, those from garlic and capsicum extract showed high levels of antimicrobial activity towards plant pathogens.

In Ethiopia, growing and marketing of fresh produce is complicated by high postharvest losses in quantity and quality between harvest and consumption, which is estimated to be in the range of 20-45% (Seyoum, 2002). According to Mohammed and Aferwork (2015), the average annual postharvest of tomato is estimated to be 45%. This high loss is due to improper use of packaging

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As wholly, being a climacteric fruit has a relatively short postharvest life and may undergo physical, biological and chemical changes that can lead to quality and quantity losses after harvest. Between producers to consumer losses, happen due to under developed infrastructure for postharvest management throughout the country Ethiopia. Therefore, to solve these problem simple and effective technologies could be valuable. Use of edible coatings have beneficial impact on the produce to preserve the organoleptic properties of foods, retard moisture loss and create a barrier for gas exchange between the fresh fruit and the surrounding atmosphere.

As result, there is a huge gap between production and consumption of fresh produce in the country Ethiopia due to significant postharvest loss. This is typically of tomato fruits and requires the use of different methods to reduce the losses. One of the methods is the use of coating materials on fruits and applying anti-microbial substances use of wax materials and starches for coating fruits have been practice quite for same time, but their use in combination with plant extracts have not been tried for preservation of local produce.

Generally, the purpose of this study was to use natural extracts of garlic and capsicum by incorporation with coatings materials to extend the shelf life of the mature tomato fruits at ambient condition. To evaluate the effect of using garlic bulb and capsicum extract with coating materials (beeswax and maize starch) on quality and shelf life of tomato fruit. The output these study was used for producer, wholesaler, and food processor as wholly.

**MATERIALS AND METHODS**

**Preparation of Materials**

A fully mature green to breaker stage of tomato fruits were harvested and collected in plastic crate. While harvesting, proper manual harvesting procedure and technique as described by Mazumdar and Majumder (2003) were followed. The tomato fruits were sorted, and graded by size. Then, tomato fruits were washed under running water and sub-divided into seven piles 48 fruits in each pile and 672 of total fruit were used during storage period. All tomato fruits were disinfected by dipped in surface- sanitizer sodium hypochlorite (NaOCl, 1 %) solution for 5 min and rinsed in water (Gustavo et al., 2003).

Then, the surface water was dried at ambient temperature before subsequent treatments. The tomato fruits were dipped into prepared coating solution for 3 min. The treated tomato fruit was stored at ambient temperature. Then from each treatment, three fruits were taken randomly at three days intervals within 30 days of storage time for determination of quality (Eric et al., 2015).
Preparation of Emulsion

Emulsion was prepared as described in Muhammad et al., (2008). 3.50 g of beeswax was taken in 250 mL conical flask and melted at 70°C, heated continuously to attain the temperature of 85°C of melted wax. 4.40 g of stearic acid was added to melted beeswax followed by addition of 1.50 g triethanolamine (TEA) by using magnetic stir.

![Flow chart of beeswax emulsion in water, Source: Shahid (2007).](image)

Preparation of Garlic (Allium sativum) Bulb Extract

Garlic bulb extract was prepared according to (Jeum et al., 2015). The supernatant was filtered by Whatman No.1 filter paper. The extract was collected in bottle and stored in a refrigerator at 4°C until subsequent use.

![Flow chart of garlic bulb extract](image)

Preparation of Green Hot Pepper (Capsicum Annum L.) Extract

Fresh green hot pepper, attribute of uniform size, color and freedom disease was purchased from local market at Harar city and transported into laboratory. A 3 kg of fresh, unblemished and healthy green hot pepper was removed the stack and cleaned by running water and surface-sterilized with sodium hypochlorite (NaOCl, 1%) for 5 min. Then, green hot pepper was reduced by a clean laboratory knife and extracted by miller (Model: SL-1304, STARLUX, and China). The extracted pepper was wrapped, squeezed by double layer cheesecloth. Then, the crude extract was filtered by Whatman No.2 paper and centrifuged at 1000 rpm for 10 min.

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Preparation of coatings

Maize (or corn) starch was purchased from supermarket. A 9.5% (w/v) maize starch was prepared by mixing in distilled water. The starch slurry was heated at 70°C for 20 min, using magnetic stirrer (Model: heat-stir SB162, UK). The solution of coatings were maintained at pH of 5.6 using 1N NaOH (Ali et al., 2010). The undissolved suspension was filtered by cheesecloth and then the temperature was maintained at room temperature. The prepared coatings were stored in a refrigerator at 4°C until used.

Determination of Physical Attributes

Weight Loss (%)

The weight loss (WL) was determined by using the methods of Gharezi, et al. (2012). The percentage weight loss (% WL) was calculated for each sampling interval using the formula given below.

\[ WL(\%) = \frac{W_i - W_f}{W_i} \times 100 \]  

Where, \( W_i \) = initial weight (g), \( W_f \) = weight the time of evaluation (g)

Decay loss was calculated from numbers fruits infected on each day of observation in relation to the numbers of fruits initially taken. Then, percent of decay loss was worked out by the formula given below (Nirupama et al., 2010).

\[ \text{Decay Loss}(\%) = \frac{\text{Total No. of infected fruits}}{\text{Total No. of fruit initial taken}} \times 100 \]

Percentage of Marketability

The overall condition of marketability of tomato fruits were determined according to the procedure of Mohammed et al. (1999). Then, percentage of marketable fruits was calculated by the following formula:

\[ \text{Marketability} = \frac{\text{Number of marketable fruit of fruit}}{\text{Total fruit taken}} \times 100 \]

Chemical Analysis

PH Value

The pH of the tomato juice was determined using the method described by Rangana, (1995). The fruits were chopped into small pieces and extracted by juice extractor (Model: SL-1304 STARLUX, made in China).

Total Acidity (Citric Acid %)

Titratable acidity of freshly extracted tomato juice from each treatment was determined by AOAC (2006). The titratable acidity expressed as percentage citric acid was obtained by titrating 5 mL filtrate of juice against standard 0.1 N NaOH solution using phenolphthalein indicator until the end-point was reached to pink (persisting for 15 sec.).

\[ \text{Acidity}(\%) = \frac{\text{Titre} \times \text{Normality of NaOH} \times \text{meqwt}}{\text{Volume of juice taken} \times \text{Volume of filtrate} \times 100} \]  

Where: 0.1N NaOH is equivalent to 0.06404 g citric acid of milliequivalent weight (meqwt)
Ascorbic Acid (Vitamin C)

Vitamin C (ascorbic acid) content was determined by using titrimetric method with the titration of filtrate against 2, 6- dichlorophenol indophenol reagent as described in AOAC, (2006) Method no. 967.21.

\[
\text{Ascorbic Acid (mgAA100g}^{-1}) = \frac{\text{Titre} \times \text{dye factor} \times \text{Volume made up}}{\text{Volume of juice} \times \text{volume of filtrate}} \times 100
\]

Where:

\[
\text{Dye factor(D.F) was prepared from standard dye solution } = \frac{0.5}{\text{Titre}}
\]

Beta-Carotene

The beta-carotene content was determined as described in AACC (2000) Method 14-50. Using the following formula

\[
\beta-\text{Carotene} (\mu g100 g^{-1}) = \frac{0.0 D \times \text{volume made up}}{\text{volume of juice} \times 250} \times 100 - \text{---} \text{---} \text{---} \text{---} \text{---} (7)
\]

Total Sugar

Total sugar of freshly extracted tomato juice from each treatment was measured as described in Lane and Eyenon method AOAC, (2006) Method No 923.09 by titration with Soxhlet modification of Fehling reagent. The volume at which permanent brick red color observed were recorded and total sugar content was estimated as described below.

\[
\text{Total sugar(%) } = \frac{\text{Titre} \times FF \times \text{Volume made up}}{\text{Volume of aliquot} \times \text{Volume of juice}} \times 100
\]

\[FF = \frac{TV \times 2.5}{100}\]

Where: FF (Fehling factor solution was prepared from 0.2% glucose standard)

Data Collection

The average ambient air temperature and relative humidity of the storage laboratory room were measured throughout the storage period. Over the entire period of the study, the readings were taken in daytime with 4-hour intervals. Temperature was recorded using digital psychrometer (Model: ALNOR® 8612 S, Germany).

Statistical Analyses

The data was analyzed by the Statistical Analysis System (SAS) version 9.3.1 for windows (SAS Corporation, Cary, NC, USA version 9.3.1, TS020) software (SAS, 1996).

Significance tests were made by two-way factorial Analysis of Variance (ANOVA) model using for Completely Randomized Design (CRD).

The results were reported as an average value of triplicate analysis (mean ± SD). Differences between treatments was determined by Fisher’s Least Significance Difference (LSD) method and statistical significance was accepted at (P ≤ 0.05)
RESULTS AND DISCUSSIONS

In this Thesis work the effects of using plant extracts (garlic bulb and capsicum) with coating materials (maize starches and beeswax) on physiochemical quality of tomato fruits stored at ambient temperature are presented here under reported. Two varieties of tomato (Fetane and Melkashola) grown in the same geographic region and same season have been used studied for evaluating the parameters at 3 days-interval for 30 days.

Temperature and Relative Humidity of Ambient Storage

The average ambient air temperature and relative humidity of the storage room varied from 15.5 to 20.2°C, and 55.5 to 67.3%, respectively, during storage period.

Hardenburg et al. (1986) mentioned that storage under relatively low temperature is the most efficient method to maintain quality of most fruit and vegetables due to its effects on reducing respiration rate, transpiration, ethylene production, physiological change and microbial activities. It was reported that the matured green tomato can be stored for relatively longer period at storage conditions of between 85 and 95% relative humidity (RH) and from 12 to 18°C temperatures, which should be maintained continuously (Javid.,2012).

In this study, the temperature of the storage room also offered similar conditions except that the relative humidity was low. Hence, the ambient storage conditions did not have extremes of temperature and relative humidity that could affect the stored tomato fruits.

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Figure 1. Ambient storage condition of tomato fruit

Figure 1. Tomato fruit stored for 30 days at ambient temperature

Maize starch plus garlic extract

Beeswax plus capsicum extract

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Effects of Coating Materials and Plant Extracts on Physical Quality of Stored Tomato Fruits

Decay Loss

![Uncoated tomato (Control)](image1)

![Beeswax plus garlic extract](image2)

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Figure 2 presents data of decay loss of tomato fruit as affected by use of coating materials without plant extracts. It shows that there was no visible sign of decay loss in both coated and uncoated tomato fruit by the 9th day storage. Furthermore, both coated and uncoated fruits exhibited equal decay loss rates of 8.34 and 13.34% at 12th and 15th days of storage period, respectively.

However, after the 15th day decay loss increased at different rates which were significantly (P<0.05) different from each other. From the 18th day storage the decay losses were significantly (P<0.05) high in the control sample than the coated tomato fruit samples. The loss on day 18th was 35.5 % for control sample whereas it is very low in coated samples with 26.56 and 30.00%, for those fruits coated with maize starch and beeswax, respectively. The losses for 21st, 24th, 27th and 30th days exhibited similar trend of increment among the tomato fruit samples. A significant (P<0.05) highest percentage decay losses of 51.42, 67.78, 81.12, and 96.67 % was observed in the control samples for the same days (21st, 24th, 27th and 30th days) of storages.

Whereas, for tomato fruits coated with maize starches and beeswax for the same days described above, the losses were 41.67, 50.00, 66.67 and 85.05 %; and 50.00, 60.00, 78.34, 93.34 %, respectively.

Similarly, fruits coated with materials having capiscum extracts exhibited losses of 25.01, 38.89, 48.62 and 65.84% less as compared to the control sample for storage days indicated above, respectively. All these could be attributed to the combined effect reduce respiration and microbial attack because of coating materials.

The study showed that there were significant difference between coated and uncoated tomato fruit. Application of maize zein 5% and gelatin 10% coatings were reported (Neeta et al., 2014) to delay ripening and to extend the shelf-life of mango fruit by maintaining quality attributes during storage at room temperature. Similarly, Ali et al. (2011) found that tomato fruit treated with 5 and 10% gum arabic coating and stored at 20°C showed reduce decay as compared to control tomato fruit.

**Weight Loss**

![Figure 3. Weight Loss (%) of tomato fruits](image)

The impact of coating materials on weight loss is presented in figure 3. Weight losses started soon after storage and the first record after 3 days showed of storage (1.91, 1.77 and 1.85% for the control, samples coated with maize starch and those coated with beeswax, respectively). There was no significant difference (P>0.05) among those values.

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The tomato fruits weight losses on days 21\textsuperscript{st}, 24\textsuperscript{th}, 27\textsuperscript{th} and 30\textsuperscript{th} were 4.29\%, 4.59\%, 6.09\%, and 6.24 \% for garlic containing beeswax and maize starch coating; and 4.68\%, 5.43\%, 6.13\%, and 6.69\% for capsicum containing beeswax and maize starch coating, respectively. There was significant difference between extracts on weight loss of tomato stored under ambient temperature on days 21, 24 and 30. The weight loss was less for garlic extract containing coating as compared to the capsicum extract containing coating, showing garlic extract containing coating performed better as barriers and probably in terms of its bioactive compounds activities.

**Percentage of Marketability**

The effect of coating materials with plant extracts on marketability of tomato fruits. No difference has been noted until 6 days when 100\% marketability was recorded for samples. On day 9 samples coated with beeswax mixed with capsicum extract still had 100\% marketability where as other sample exhibited reduced values with significant (P<0.05) differences among each other. Starting from day 12 all samples showed further reduction in marketability with significance differences among them until day 30. At all storage days statistically, the highest marketability were recorded for samples coated with beeswax mixed with capsicum extracts showing as high as 46.67\% marketability on day 30.

The next better performance was recorded for sample coated with beeswax and starch mixed with capsicum extract most of the time with significant (P<0.05) difference between them. Samples treated with a mixture of starch and capsicum exhibited the lowest marketability of the four treated samples at all storage day. Mechanical damage, delay harvest, temperature effect and improper handling of fruits are the major causes of quality deterioration in flavor and texture (Genanew, 2013).

**Effect of Coating Materials and Plant Extracts on Chemical Quality of Tomato**

**Titratable Acidity**

![Figure 4. Titrability Acid (citric acid %)](image-url)

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Figure 5. Ascorbic Acid

Generally, TA values were ranged from 1.09 (day 0) to 0.24% (on day 30) for both the control sample and coated sample with beeswax while TA values for those coated by starch at same time was ranged from 1.09 to 0.36%.

Ascorbic Acid

The interaction of coating materials and plant extract did not show consistent trend about having significance difference between combinations (Figure 4). Generally, the ascorbic acid contents of the coated samples were significantly (P<0.05) higher than those control sample. The ascorbic acid of the fruits increased with storage time until day 18 and kept falling after that for all the samples. This finding was in harmony with the ascorbic acid contents (8.27 to 22.02 mg/100g) reported by Ali et al. (2011) on tomato coated by gum Arabic stored at ambient temperature.

Conclusion

Adding extracts in the coating materials further reduced the decay loss by more than 15% in case of garlic and more than 12% in case of capsicum. The different combinations of coating materials and plant extracts have shown significantly reduce in decay loss. For instance, starch mixed with garlic and beeswax mixed with capsicum have reduced the decay loss on day 30 by more than 18% each while combination of beeswax with garlic close to 13% and starch with capsicum more than 7%.

The interaction of coating materials and extracts showed further reduction the weight loss like close to 9% in case of beeswax plus capsicum, more than 8% for starch plus garlic, close to 8% for beeswax plus garlic and more than 6% starch plus capsicum. The use of coating materials on the surface of the tomato fruits had helped to maintain the quality of the fruits for longer storage time. The decay loss has reduced to 85.05 and 93.34% when using maize starch and beeswax coating materials, respectively as compared to 96.67 loss of the fruits stored with no coating. Similarly, the use of coating materials has reduced the weight loss of the fruits from 14.71% in 30 days for uncoated samples to 9.06 and 10.51% of those with maize starch and beeswax. The use of plant extracts capsicum and garlic had significantly improved the performance of the coating materials by further reducing the decay losses to 84.17 and 81.39%, respectively, and weight losses to
6.69 and 6.64% after 30 days of storage under ambient conditions.

The performance of the coating materials has been shown by storing down the changes such as TA, vitamin C, pH, beta-carotene, and total sugar. Thus, the tomato fruits are preserved more when coated than uncoated and beeswax appeared to perform better than maize starch. The tomato quality parameters under ambient conditions was largely dependent on variety and postharvest treatments. Fetane tomato fruits had slightly maintained better quality parameters than Melkashola in terms of percentage marketability, weight loss, total sugar, pH, and titratable acidity. Whereas, Melkashola tomato fruits exhibited slightly better result in maintaining beta carotene and ascorbic acid content when as compared to Fetane tomato fruits. In generally, there was significance difference in physicochemical quality of tomato variety during storage period due to genotypic factor and respiration rate variability.

In developing country like Ethiopia, which is still under struggle to ensure food security, losing a substantial amount food due to spoilage during postharvest handling of the produce is an adversity. Applying the result of this study can contribute a lot in saving a significant amount of fresh perishable tomato that perhaps lost in every household every producer and small-scale industry. Moreover, prolonging the shelf life of fresh tomato fruit can keep under control the problem faced to export fruit to other parts of the world. Based on this finding, therefore, the following points are.

Different concentration of edible coating materials with plant extract on fresh tomato fruit should be investigated. Need to further study should be done on different dipping time with same coatings. As the study was conducted at Haramaya University with specific climatic condition, further investigation on the variety of tomato fruit and kinds of decay loss that spoil fresh tomato fruit on the warmer parts of Ethiopia should be evaluated. Stakeholders of the area need to be trained on the postharvest treatment and techniques to extending postharvest managements of tomato flower and other fruits. Consumer acceptance for edible-coated tomato should be investigated. Consumers are also required to be educated on the beneficial effects of edible coating application on fruits.

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