

The Quality of Tomato (Solanum Lycopersicum L.) After Pre Storage $CaCl_2$ and Edible Coating Treatment

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Abstract
Tomatoes are a high-value crop all over the world, including Ethiopia. Tomato ripening is highly dependent on ethylene action as a climacteric fruit, making this fruit highly perishable in a short period of time. Pre-storage treatments such as $CaCl_2$ and edible coatings are essential for preserving fruit quality after harvest and extending shelf life. The purpose of this study was to determine the effect of $CaCl_2$ and edible coatings on tomato postharvest quality and shelf life. The experiment was set up in the form of a Complete Randomized Design with three replications. The results revealed that both $CaCl_2$ and edible coatings had a highly significant ($p<0.01$) effect on tomato shelf life and quality. Fruits treated with 6% $CaCl_2$ and coated with aloe Vera gel and beeswax significantly reduced physiological weight loss (PLW), percentage decay, TSS, pH of tomato juice, and ascorbic acid loss during storage, and increased the shelf life of the fruits by 15 days when compared to the control. The combination of treatments (6 percent $CaCl_2$ with AG and BW coating) resulted in the highest fruit marketability, firmness, and ascorbic acid levels over the storage period. According to the findings of the study, the combination of treatments 6 percent $CaCl_2$ with aloe Vera gel or bees wax can be recommended for Shanty tomato in terms of shelf life and quality.
Keywords: fruit marketability, pre storage, shelf life, tomato, quality
DOI: 10.7176/ALST/89-02
Publication date: August 31st 2021

Introduction

In tropical agriculture, including Ethiopia, postharvest losses of fresh fruits and vegetables such as tomatoes are incredible (Emana *et al*., 2017). According to Gazai (2013), approximately 39% of harvested tomato fruits were lost in the country's central rift valley, with producers suffering the greatest loss (20.45%), followed by wholesalers (8.63%), retailers (2.93%), and hotels and cafeterias (7.3%). Although quantitative evidence is limited at the national level, postharvest tomato loss in Ethiopia is significant, reaching staggering proportions (Tessema, 2013). This significant loss of tomato fruits has huge economic and nutritional implications unless and otherwise appropriate control measures are implemented to extend storage life and improve quality retention (Zekrehiwot *et al*., 2017). Lack of postharvest and marketing infrastructures such as packaging, cold storage, prepackaging and distribution, postharvest treatment and washing facilities, as well as production constraints, are reported problems that contribute to tomato postharvest loss in Ethiopia (Tessema, 2013). Due to poor postharvest handling and a limited shelf life, a significant amount of tomato is wasted before it reaches the target market or consumers. It is estimated that between 20 and 50 percent of tomatoes are lost before reach to the customer (Emana *et al*., 2017). Low temperature, coating, low oxygen and high carbon dioxide storage, and ethylene inhibitors such as $CaCl_2$ treatment have been reported to have the potential to extend the storage life of fresh produce such as tomatoes (Tessema, 2013). Edible coatings have been shown to extend the shelf life of fresh produce by forming a semi-permeable barrier to water vapor and gas exchange, resulting in weight loss reduction, respiration rate modification, and senescence delay of coated produce (Prasad *et al*., 2018). These are also non-polluting alternatives for extending the post-harvest shelf life of produce (Mezemir *et al*., 2017). Calcium applied postharvest may delay senescence in fruits while having no negative effects on consumer acceptance. Ca^{+2} levels have been shown to reduce respiration and ethylene production rates in a variety of fruit crops, including tomatoes (Shahkoomahally and Ramezanian, 2014). Some researchers advocate the use of multiple postharvest treatments in combination that have additive or even synergistic effects (Hajilou and Fakhimrezaei, 2013). The combination of an effective and indigenous surface coating material with proper postharvest treatments would increase marketability by preserving market weight and appearance while also conserving fruit quality by reducing water loss, respiration, and microbial load (by reducing infection) in fruits (Mezemir *et al*., 2017). Several authors have investigated the effect of different coatings and $CaCl_2$ on the quality parameters of tomato fruit (Tessema, 2013; Richard, 2014; Eric *et al*., 2015; Mezemir *et al*., 2017; Prasad *et al*., 2018;Sucharitha *et al*., 2018 and Kator *et al*., 2018). However, the combined effect of these treatments on tomato fruit has not been investigated. As a result, the purpose of this study was to determine the effect of edible coatings and calcium chloride application on the postharvest quality and shelf life of tomato fruits.

Material and method

Description of the Study Area

The experiment was carried out at Haramaya University in Plant Science Laboratory at ambient (20 - 25°C and relative humidity of 70 - 90%). It is located at latitude of 9°24' N latitude and 42°01' E longitude with an elevation of 2007 masl. The area is located at Haramaya with a distance of about 510 km East of Addis Ababa and 40 km from Dire Dawa and 17 km from Harar towns (Abera, 2017).

Treatments and Experimental Design

The treatments consisted of 4x4 factorial combinations of $CaCl_2$ concentrations (0%, 2%, 4% and 6%) and four edible coatings (without coating, aloe Vera gel, cactus mucilage and bees wax). Completely randomized design (CRD) with factorial arrangement with three replications was used. The experiment was conducted between December 2017 and January 2018 at Haramaya University in Plant Science Laboratory.

Coating Material and Dipping Solution Preparation

Aloe Vera gel preparation

Preparation of aloe gel was followed the procedure described by Sofia *et al*. (2015).

Cactus mucilage preparation

The procedure used by Oluwaseun *et al*. (2014b) was used in preparing the cactus mucilage.

Bees wax preparation

The wax emulsion was prepared by dissolving 100 g bees wax into 100 ml distilled water (Hassan *et al*., 2014).

$CaCl_2$ solution preparation

Calcium chloride solution was prepared by dissolving 20g, 40g and 60g solid CaCl2 salt in 980ml, 960ml and 940 ml distilled water for each respective concentrations. Then tomato fruits were immersed in the prepared solution for 10 minutes (Eric *et a*l., 2015).

Data Collection

Samples of two tomato fruits per experimental unit were taken as a sample for the analysis of chemical quality attributes at every five days interval and three fruits per treatment were taken for sensory analysis. Thirteen fruits were kept for non-destructive evaluation per experimental unit.

Data Analysis

Analysis of variance (ANOVA) for the parameters was done using SAS statistical software and comparison of treatment means was made by Least Significance difference Test at 5% probability level.

Results and Discussions

Physiological Loss in Weight

Interaction effect of edible coatings and $CaCl_2$ treatments on the percentage of physiological loss in weight (PWL) of tomato fruits during storage was highly significant ($P < 0.001$) as shown in Table 1.The highest weight loss was recorded in control throughout the storage time. Similarly, CM, 2% $CaCl_2$ and 2% $CaCl_2$ + CM also resulted in high percentage of weight loss as compared to other treatments. On the other hand, the lowest PLW was recorded in 6% $CaCl_2$ + AG followed by T16 (6% $CaCl_2$ + BW) as compared to other treatments throughout the storage time, however the results were not significant on day 25 and 30 after storage. On day 5 and day 10 after storage, fruits coated with 6% $CaCl_2$ + AG and 6% $CaCl_2$ + BW had reduced the PWL by 9.13, 9.04, and 31.47, 30.99 %, respectively as compared to the control treatment. The control fruits became deteriorate and finished its shelf life on the 14th day after storage. On day 25 and 30 there was no statistically difference on the value of PLW was observed among the combination of treatments and on the 30th day among edible coatings too. The PLW is mainly attributed to the loss of water during metabolic processes like respiration and transpiration. The above result implies that $CaCl_2$ concentration of 6% + both AG and BW applied to tomato fruits are capable of preventing the fruit from weight loss by slowing down transpiration and respiration rate that reducing water loss. This result is in agreement with the finding by Shweta *et al*. (2014) that $CaCl_2$ was notably more effective in retarding physiological process when applied in combination with chitosan on mango. Kuwar *et al*. (2015) and Kator *et al*. (2018).

When combined effects are compared, fruits treated with AG and BW + 6% $CaCl_2$ showed lowest weight loss. But with an increase in storage time, weight loss progressively increased in different rate with those treatments and on the other. Moisture loss and gaseous exchange from fruits is usually controlled by the epidermal layers provided with guard cells and stomata. The film formed on the surface of 6% $CaCl_2$ + both AG and BW treated fruits act as a physical barrier to reduce moisture migration from the fruits. This barrier property also reduces the oxygen availability and uptake by the fruit for respiration process and hence slows down rate of respiration and associated weight. This indicated the significant role of edible coatings as a semi permeable barrier against oxygen, carbon dioxide, moisture and solute movements (Kuwar *et al*., 2015). Shafiee *et al*. (2010) reported that combinations of postharvest treatments were more effective than each treatment alone. The combination of effective and indigenous surface coating material with proper postharvest treatments would increase marketability by maintaining marketable weight (Mezemir *et al*., 2017). Postharvest treatments used in this study exhibited a pronounced effect on weight maintenance of tomato fruits during storage. However, it exhibited more effectiveness on tomato fruits coated with edible coatings (AG and BW) with chemical treatment (6% $CaCl_2$).

Table 1 effect of $CaCl_2$ and edible coating on weight loss (%) of tomato fruit storage

Treatments		**Storage period (days)**					
$CaCl_2$	Coatings	5	10	15	20	25	30
0	No coating	9.64a±0.26	32.88a±0.40	-	-	-	-
	Cactus mucilage	5.64b±0.27	10.50b±0.44	22.47a±0.24	-	-	-
	Aloe Vera gel	4.37c±0.35	4.73d±0.44	6.67d±0.30	8.48c±0.48	13.58b±1.06	19.32a±0.90
	Bees wax	4.37c±0.37	4.74d±0.43	6.35d±0.46	8.82c±0.11	13.65b±0.91	19.30a±0.9
2	No coating	5.61b±0.31	10.40b±1.01	22.24a±0.27	-	-	-
	Cactus mucilage	5.81b±0.21	10.33b±0.83	22.45a±0.28	-	-	-
	Aloe Vera gel	1.51e±0.50	3.52e±0.20	4.12e±0.19	5.77e±0.21	11.97c±0.50	17.63bc±0.51
	Bees wax	1.45e±0.41	3.63e±0.26	4.30e±0.21	5.80e±0.41	11.56c±0.78	18.44ab±1.01
4	No coating	5.55b±0.35	8.33c±0.22	13.10b±0.40	13.82a±0.09	-	-
	Cactus mucilage	5.56b±0.22	8.27c±0.33	13.22b±0.31	12.74b±0.19	-	-
	Aloe Vera gel	4.54c±0.20	2.67f±0.25	3.50f±0.40	7.34d±1.00	10.80c±0.90	16.35cd±0.58
	Bees wax	4.69c±0.26	2.93e±0.15	4.09e±0.21	6.49e±0.94	11.20c±0.00	16.14d±0.00
6	No coating	2.88d±0.16	7.95c±0.11	11.41c±0.14	13.78a±0.0.26	21.20a±0.15	-
	Cactus mucilage	3.09d±0.37	7.92c±0.08	11.33c±0.19	12.81b±0.39	21.27a±0.96	-
	Aloe Vera gel	0.51f±0.25	1.41g±0.26	2.14g±0.34	4.17f±0.21	6.21d±0.55	13.22e±0.75
	Bees wax	0.60f±0.11	1.89g±0.41	2.15g±.11	4.41f±0.35	7.40d±0.69	13.47e±0.45
Lsd		0.51	0.72	0.48	0.80	1.33	1.36
(A)		***	***	***	***	***	***
(B)		***	***	***	***	***	Ns
(A*B)		***	***	***	***	ns	ns

***=highly significant difference, ns=non-significant

Total Soluble Solids

Statistical analysis of data revealed that the interaction of $CaCl_2$ with edible coating treatments had highly significant ($P < 0.001$) effect on total soluble solids (TSS) content of tomato fruits from the 5thday after storage to the end of the storage period, except on the 15thday among the combination of treatments (Table 2).There was a continuing rise in TSS with prolonged storage duration in all the treatments. The maximum TSS value (4.98°Brix) was recorded in control followed 6% $CaCl_2$ + CM and the main factor of edible coatings during the 10thday after storage. On the same date (the 10th day) after storage there was no significant difference observed between the main effect of $CaCl_2$ concentration and the interaction effect. While the TSS value was increased in a decreasing rate in the tomato fruits dipped in6% $CaCl_2$ + AG followed by 6% $CaCl_2$+ BW and 4% $CaCl_2$+ AG from the 20thto 30thday after storage.

However on the 5th, 10thand 15thday after storage there was no statistically different TSS value was observed on the tomato fruits dipped in 6% $CaCl_2$+ AG and 6% $CaCl_2$ + BW. On the 5thday after storage the lowest TSS was shown on the fruits treated with 2% $CaCl_2$ + AG, 6% $CaCl_2$ + AG and 6% $CaCl_2$ + BW followed by 2% $CaCl_2$+ BW. On this study, results showed that the main effect edible coatings and the main effect $CaCl_2$ as well as their combination increase the TSS value in the decreasing rate when compared to the control. However the combination of treatments reduces the TSS increment than each treatment alone. A possible reason in reduction of TSS on those samples were due to the fact that the combined treatment solution have superior moisture barrier property than each treatment alone and the fact that more concentration of $CaCl_2$ with edible coatings formed a thick layer on the surface of fruits, thus delaying degradation of stored fruit by creating internal modified atmosphere that helps to slowing down the ripening process. This result is in line with the result of Mezemir *et al*.(2017)from BW and linseed oil on Valencia orange; Shweta *et al*.(2017) from chitosan and Ca on mango; and Kuwar *et al*.(2015) from Chemical dip + AG and Chemical dip + honey on papaya where the increment of TSS on respective fruits were reduced. Oluwaseun *et al*. (2014a) also reported that combination of edible coatings with other treatments as barrier offers a greater potential for shelf life extension of fruits and vegetables by creating modified internal atmosphere to the commodity and slowing down the biochemical activity. On the other hand the high TSS value in the control sample is the result of high respiration rate and degradation of polysaccharides to simple sugars by uncontrolled ripening process. This is in agreement with the finding of (Sophia *et al*., 2015; Eric *et al*., 2015; Kator *et al*., 2018).The high TSS value is the result of degradation of polysaccharides to simple sugars (the conversion of starch to sugar) during ripening (Mezemer *et al*., 2017).From the present result 6% $CaCl_2$ +AG significantly maintained the TSS of tomato fruits to optimum level as compared to other treatments.

Table 2 effect of $CaCl_2$ and edible coating on TSS of tomato fruits storage

Treatments		**Storage period (days)**					
$CaCl_2$	Coatings	5	10	15	20	25	30
0	No coating	3.75a±0.01	4.98a±0.01	-	-	-	-
	Cactus mucilage	3.37cbd±0.04	3.69c±0.02	3.80cdef±0.01	-	-	-
	Aloe Vera gel	3.37cd±0.02	3.82cb±0.02	3.60fgh±0.10	3.69gh±0.02	4.68c±0.01	4.88a±0.09
	Bees wax	3.39cb±0.02	3.90cb±0.08	3.51fgh±0.10	3.80ef±0.10	4.85a±0.03	4.76bc±0.05
2	No coating	3.33ef±0.02	3.37d±0.03	4.16ab±0.57	-	-	-
	Cactus mucilage	3.33efd±0.01	3.37d±0.06	4.37a±0.21	-	-	-
	Aloe Vera gel	3.22ij±0.01	3.34d±0.01	3.75defg±0.45	3.96d±0.01	4.64d±0.04	4.76bc±0.01
	Bees wax	3.26hi±0.02	3.32d±0.02	3.52fgh±0.01	3.90de±0.05	4.56e±0.02	4.74c±0.06
4	No coating	3.31gf±0.06	3.40d±0.01	4.32a±0.02	4.66b±0.21	-	-
	Cactus mucilage	3.33ef±0.03	3.41d±0.03	3.94bcde±0.02	4.83a±0.07	-	-
	Aloe Vera gel	3.27hg±0.03	3.41d±0.04	3.65efg±0.02	3.66gh±0.01	4.08h±0.01	4.55d±0.03
	Bees wax	3.27hg±0.05	3.46d±0.04	3.67efg±0.01	3.78efg±0.01	4.33g±0.02	4.84ab±0.07
6	No coating	3.27hg±0.02	3.44d±0.05	4.13abc±0.02	4.23c±0.02	4.82b±0.01	-
	Cactus mucilage	3.43b±0.04	4.00b±0.50	4.06abcd±0.05	4.17c±0.02	4.44f±0.01	-
	Aloe Vera gel	3.21j±0.01	3.31d±0.03	3.31h±0.03	3.38i±0.01	3.83j±0.02	4.08f±0.01
	Bees wax	3.21j±0.02	3.42d±0.02	3.42gh±0.02	3.56h±0.02	3.93i±0.02	4.33e±0.02
Lsd		0.05	0.23	0.33	0.12	0.03	0.09
(A)		***	***	**	***	***	***
(B)		***	***	***	***	***	***
(A*B)		***	***	ns	***	***	***

***, **=highly significant at 0.1% and 1% ns=non-significant

Firmness

In this study there was a general decline in firmness from day 5 to 30thdayafter storage. The control fruits declined in firmness faster than the treated fruits. The main effects of edible coating and $CaCl_2$ concentration as well as the interaction effect of edible coating and $CaCl_2$ concentration significantly maintained the firmness of stored fruit than the control (Table 3). Firmness of tomato fruits were highly affected ($p<0.01$) by interaction effect between $CaCl_2$ treatment and edible coatings except on day 30 after storage. Starting from the 5thday to 15thday after storage both fruit samples dipped in both AG and BW with 6% $CaCl_2$ were firmer than the control and the remaining fruit samples. However on the 14thday after storage, the control fruits clearly showed the lowest firmness and went to deterioration and discarded. From day 20 to the 30thday after storage the highest firmness was maintained on the fruits treated with AG + 6% $CaCl_2$ followed by 6% $CaCl_2$ +BW.On the 5thday after storage the minimum firmness was recorded on the control, however this was insignificantly differ from fruits dipped in CM, 2% $CaCl_2$, 4% $CaCl_2$, and 2% and 4% $CaCl_2$+CM. Those treatments also deteriorated faster than the remaining samples. Results obtained from this study for firmness when the storage days increase there was a general decrease on firmness of stored fruit, however these can be slowed down with the application of edible coatings (AG followed by BW) particularly when combined with 6% $CaCl_2$ compared to the control as well as each treatment alone. This result is in agreement with the report of Shweta *et al*. (2014) who stated mango fruits coated with chitosan maintained better firmness, particularly when combined with $CaCl_2$. This indicates the combination of treatments could be a good technology for preserving the quality (Kuwar *et al*., 2015), and extending the shelf life of fresh tomato fruits as well as maintaining the physical and chemical properties. Similar results were reported by Duan and Zhang (2013) on strawberry fruits; and Kuwar *et al*. (2015) on papaya fruits in which addition of calcium to the chitosan solution and Ca with AG and honey, respectively increased their firmness.

All the sample fruits lost their firmness gradually during the storage period. The loss of firmness during the storage period is a normal behavior during the maturation of tomatoes, since it has been reported that the increase in the ethylene concentration in this stage(ripening)promotes the synthesis of polygalacturonase, the enzyme responsible for softening (Sucharitha *et al.*,2018).Softening which result from the loss of turgor pressure and degradation of cell walls, contributing to a decrease in fruit brittleness and firmness (Richard, 2014).Edible coatings can provide an additional protective coating for fresh products and can also give the same effect as modified atmosphere storage in modifying internal gas composition, there by extend shelf life and increase firmness (Athmaselvi *et al.*, 2013).Given the same coating material, tomato fruits dipped in 6% CaCl2retained significantly higher firmness than the fruits dipped in 2% $CaCl_2$ and the control. The significant interaction recorded between the concentration of $CaCl_2$ and the coating materials suggests that, for effective firming role, one needs to apply the right concentration to the coating material. This is in line with the findings of Saira *et al.* (2009) 3% $CaCl_2$+ Packaging, on apricot fruit and Eric *et al.*(2015) 6% $CaCl_2$+ dip time on tomato fruits when compared to the control and the minimum $CaCl_2$ concentration with the same packaging and dipping time respectively. On the other hand, the minimum firmness was recorded in control followed by CM, 2% $CaCl_2$ and CM + 2% $CaCl_2$. The decrease of fruit firmness in these treatments is related with the degradation of polysaccharides due to uncontrolled ripening (Tilahun, 2013) and cell wall softening due to the activity of softening enzymes such as pectin methyl-esterase. Zekirehiwot *et al.* (2017) indicated that as the length of storage period extended, uncoated tomato fruits showed a significant decrease in firmness, while loss of texture and softening were delayed in coated fruits. Delay in loss of cell wall firmness might be associated with limited availability of oxygen from the ambient atmosphere for respiration process and subsequent delay on cell wall degradation. Generally, the combined treatment effect of coating and 6% $CaCl_2$ showed beneficial effect on firmness retention as compared to uncoated fruits for distant market shipment. Even though coating materials showed significant interaction effect, but relatively minimum fruit firmness was observed when CM alone or combined with different $CaCl_2$ concentrations. This may due to an aerobic condition created by the nature of CM. This study revealed that BW coating with dipping in 6% $CaCl_2$ substantially maintained the firmness of the stored tomato fruits than the remaining treatments.

Table 3 effect of $CaCl_2$ and edible coating on firmness of tomato fruits storage

Treatments		**Storage period (days)**					
$CaCl_2$ (A)	Coatings (B)	5	10	15	20	25	30
0	No coating	3.31f±0.05	1.47h±0.10	-	-	-	-
	Cactus mucilage	3.68ef±0.06	2.67g±0.01	1.67h±0.10	-	-	-
	Aloe Vera gel	4.35c±0.07	3.55e±0.16	3.22de±0.10	3.06e±0.07	2.35ef±0.14	1.71d±0.07
	Bees wax	4.46bc±0.05	3.58e±0.15	3.45d±0.06	3.16de±0.08	2.57e±0.08	1.78d±0.11
2	No coating	3.68ef±0.08	2.65g±0.13	1.63h±0.25	-	-	-
	Cactus mucilage	3.67ef±0.06	2.66g±0.07	1.87g±0.10	-	-	-
	Aloe Vera gel	4.48bc±0.10	3.94d±0.21	3.62d±0.10	3.26d±0.09	2.95d±0.07	2.15c±0.10
	Bees wax	4.54b±0.11	4.02cd±0.20	3.73bc±0.08	3.45c±0.09	3.12c±0.10	2.14c±0.09
4	No coating	3.67ef±0.08	3.17f±0.11	2.16f±0.08	1.53g±0.11	-	-
	Cactus mucilage	3.66f±0.10	3.21f±0.12	2.13f±0.11	1.67g±0.10	-	-
	Aloe Vera gel	4.35c±0.10	4.21cb±0.16	3.68c±0.10	3.68b±0.09	3.15c±0.11	2.42b±0.11
	Bees wax	4.52b±0.11	4.35ab±0.11	3.86b±0.09	3.72b±0.10	3.23c±0.06	2.45b±0.09
6	No coating	3.84d±0.15	3.37ef±0.11	2.17f±0.11	2.11f±0.07	1.73g±0.10	-
	Cactus mucilage	3.82ed±0.15	3.37ef±0.09	2.29f±0.06	2.20f±0.10	1.87g±0.10	-
	Aloe Vera gel	4.60ab±0.09	4.33ab±0.11	4.11a±0.10	3.75b±0.11	3.43b±0.08	2.54b±0.11
	Bees wax	4.74a±0.07	4.55a±0.11	4.27a±0.10	4.13a±0.09	3.83a±0.09	2.84a±0.11
Lsd		0.15	0.22	0.18	0.16	0.16	0.77
(A)		***	***	***	***	***	***
(B)		***	***	***	***	***	**
(A*B)		**	***	**	***	**	ns

***, **=highly significant at 0.1% and 1%, ns=non-significant

pH of Tomato Juice

The main effect of edible coating and $CaCl_2$ concentration as well as interaction effect of edible coating and $CaCl_2$ concentration on the pH of tomato fruits on day 10, 15 (except coating) and 30 after storage was not significant ($P \geq 0.05$) (Table 4).Significant ($P < 0.05$) difference in pH value of tomato fruit was observed due the main effect edible coating and $CaCl_2$ as well as the interaction effect of edible coating and $CaCl_2$concentrationon day 5, 20 and 25afterstorage. On the 10^{th} day after storage the higher pH value was recorded on control that was not significantly different to the samples that received CM, 2% $CaCl_2$ + CM, 2% $CaCl_2$.The pH values increased for all the treatments as storage period advanced. However, all the treated fruits recorded the lower pH value than the control during storage except on the 10thday. The higher pH may be attributed to the rapid metabolic processes in the control compared to the treated samples. Increasing pH showing that the physiological changes taking place in the fruit led to further ripening thus reducing the acidity and increasing the sugar content of the fruits (Majid *et al*., 2011).From the 5th, 20th and 25th days after storage highly significant ($P < 0.01$) difference in pH value of tomato fruits was observed due to the interaction effect of edible coatings and $CaCl_2$ treatments. However on day 10th, 15th, and 30th, days after storage there were no statically differences were observed on the samples that received combination treatments. Moreover, the pH value of tomato fruits that treated by AG and BW and combined with $CaCl_2$ relatively slowed the increasing of pH towards the end of storage period. In general, pH increases towards the end of storage period due to ripening of the stored tomato fruit. However, AG and BW coatings combined with different concentration of $CaCl_2$ maintain better pH than control. This is in agreement with the finding of Sophia *et al*. (2015) that AG and chitosan coated mangoes under low temperature had lower value of pH at the end of storage period.

This was due to the semi-permeability created by coatings on the surface of the fruit, which might have modified the internal atmosphere i.e. endogenous O_2 and CO_2 concentrations in the fruit, thus retarding ripening (Garcia *et al*., 2015).Similarly, Kuwar *et al*. (2015) reported that AG and honey with chemical dip could reduce the metabolic reactions in papaya fruits by creating a modified internal atmosphere. Results from the experiments showed that there was a continuous increase in pH from day 0 to 30. This indicates, since the pH of fruits and vegetables are the measure of the strength of the acids in them, it declines during the ripening of process. Padmini (2006) reported that the pH of the fruit increases throughout development. Richard (2014) indicated that the maximum pH value which ranges from 4.25 –4.4 is optimum for fresh tomato fruits to ensure desirable food safety. Tomato fruits which have pH value higher than 4.4 are not suitable for processing due to the pulp are susceptible to thermophilic pathogens (Fikreyohannes and Bhalekar, 2016). This shows pH values as low as possible (up to the point that it does not adversely affect the taste) is desirable for industrial use (Mezemir *et al*., 2017). This study shows that application AG and BW coating with the combination of $CaCl_2$ treatments maintain the pH and quality of tomato fruits when the $CaCl_2$ concentration increased.

Table 4 effect of $CaCl_2$ and edible coating on pH of tomato fruits storage

Treatments		**Storage period (days)**					
$CaCl_2$ (A)	Coatings (B)	5	10	15	20	25	30
0	No coating	3.62a±0.02	3.80a±0.02	-	-	-	-
	Cactus mucilage	3.34b±0.03	3.62ab±0.02	4.08a±0.02	-	Ca-	-
	Aloe Vera gel	3.30cd±0.01	3.35c±0.03	3.54cd±0.01	3.74c±0.03	4.37a±0.02	4.34ab±0.01
	Bees wax	3.27de±0.02	3.34c±0.01	3.56cd±0.01	3.75c±0.02	4.37a±0.03	4.34ab±0.03
2	No coating	3.33cb±0.02	3.75a±0.02	3.74abcd±0.01	-	-	-
	Cactus mucilage	3.33cb±0.02	3.63ab±0.04	3.93abc±0.02	-	-	-
	Aloe Vera gel	3.26e±0.02	3.32c±0.03	3.45d±0.01	3.75c±0.02	4.37a±0.01	4.34a±0.03
	Bees wax	3.25ef±0.03	3.31c±0.00	3.65bcd±0.58	3.74c±0.01	4.38a±0.01	4.32abc±0.00
4	No coating	3.33cb±0.04	3.31c±0.00	4.01ab±0.02	4.41a±0.02	-	-
	Cactus mucilage	3.33cb±0.02	3.38c±0.00	3.78abcd±0.60	4.44a±0.01	-	-
	Aloe Vera gel	3.23f±0.02	3.32c±0.00	3.44d±0.02	3.68d±0.01	4.24b±0.02	4.31bc±0.02
	Bees wax	3.26e±0.03	3.33c±0.00	3.65bcd±0.54	3.76c±0.01	4.23b±0.01	4.32abc±0.01
6	No coating	3.27de±0.03	3.41bc±0.02	3.78abcd±0.02	3.83b±0.03	4.40a±0.06	-
	Cactus mucilage	3.33cb±0.01	3.49bc±0.57	3.74abcd±0.02	3.83b±0.02	4.39a±0.06	-
	Aloe Vera gel	3.23f±0.01	3.31c±0.01	3.47d±0.02	3.47d±0.02	4.13c±0.04	4.28d±0.01
	Bees wax	3.22f±0.02	3.31c±0.01	3.4d±0.04	3.37c±0.02	4.13c±0.02	4.29cd±0.01
Lsd		0.04	0.24	0.43	0.03	0.06	0.03
(A)		***	ns	ns	***	***	ns
(B)		***	ns	*	***	*	ns
(A*B)		***	ns	ns	***	**	ns

***, **, *=significant at 0.1%, 1% and 5%, ns=non-significant

Titratable Acidity

Titratable acidity (TA) content of tomato juice varied significantly ($P<0.001$) in fruits that received different treatments. There was a general decrease in TA of stored tomato fruits with the increasing of storage period. However, tomato fruits coated by AG and BW and dipped $CaCl_2$ can significantly reduce the rapid loss of titratable acidity. The maximum TA value was recorded in 6% $CaCl_2$+ AG, 6% $CaCl_2$+ BW followed by 4% $CaCl_2$+ AG, 4% $CaCl_2$+ BW, 2% $CaCl_2$+ AG, while the lowest was recorded on the control followed by CM, 2% $CaCl_2$ and CM +2% $CaCl_2$.The TA values of treated and untreated fruits decreased with storage time (Table 6) and the value was significantly higher($P\leq0.05$)in AG and BW coated fruits compared to the control due to the interaction effect of $CaCl_2$ concentrations and coating materials. This reduction of TA as fruit ripens may be due to further oxidation of organic acids to sugar (Majidi *et al*., 2011). The lowest TA value 0.33% on day 10 and the highest TA value 0.33% on day30after storage was observed in the control and the fruits treated with (6% $CaCl_2$+ AG and 6% $CaCl_2$+ BW) in respective days. Similarly, on the 10thday after storage the maximum TA values on the fruits coated by AG and BW and dipped in 6% $CaCl_2$were almost double of that of untreated fruits on the same day. This confirms that edible coating materials reduce the rate of acid metabolism particularly when combined with $CaCl_2$ solution as compared to control and each treatment alone. Since organic acids, such as malic or citric acid, are primary substrates for respiration, a reduction in acidity is expected in terms of rate of increase in respiration of cells of fruits(Zekrehiwot *et al*.,2017).The decreasing acidity at the end of storage might be due to use of the acids as energy source with an increase in ripening(Kator *et al*.,2018; Mezemir *et al*., 2017andBanjaw, 2017). A similar finding was reported by Richard (2014), and Garcia *et al*. (2015) who observed high TA values in tomato fruits coated with BW and AG which exhibits film forming properties on fruit surface and used as protective barriers to reduce respiration and transpiration rates. Moreover, the combinations of treatments were effective in delaying tomato ripening and slowing down the rate of TA reduction. This indicating that AG and BW with $CaCl_2$ dip could reduce the metabolic reactions by creating modified internal atmosphere. The same to this Hajilou and Fakhimrezaei, (2013) reported that the combination of Postharvest treatment with SA or $CaCl_2$ prolonged the storage life and preserved the valuable marketing characteristics of apricot fruit, presumably because of their inhibitory effects on fruit softening, ripening, and senescence. TA is directly related to the concentration of organic acids present in the fruit, which are an important parameter in maintaining the quality of fruits (Elham *et al*.,2011).The decrease in the content of acidity reduces the desire quality of fruits (Sucharitha *et al*.,2018). Similar to this the acidity of tomato plays a major role and imparts taste to the fruit (Athmaselvi *et al*., 2013). This study revealed that the combination of $CaCl_2$ treatment with AG and BW coating maintains the quality of stored tomato by slowing the increasing rate of pH and the decreasing rate of titratable acidity.

Table 5 effect of $CaCl_2$ and edible coating on TA of tomato fruits storage

Treatments		**Storage period (days)**					
$CaCl_2$ (A)	Coatings (B)	5	10	15	20	25	30
0	No coating	0.73jk±0.04	0.33j±0.02	-	-	-	-
	Cactus mucilage	0.76j±0.02	0.85de±0.03	0.47g±0.02	-	-	-
	Aloe Vera gel	0.82gh±0.01	0.70i±0.01	0.67e±0.02	0.45de±0.02	0.31d±0.01	0.24cb±0.03
	Bees wax	0.83fg±0.03	0.70i±0.01	0.69e±0.02	0.46cd±0.01	0.33cd±0.02	0.25cb±0.03
2	No coating	0.80hi±0.01	0.82ef±0.01	0.48g±0.03	-	-	-
	Cactus mucilage	0.87e±0.01	0.88bc±0.01	0.47g±0.03	-	-	-
	Aloe Vera gel	0.91bc±0.01	0.91ab±0.02	0.72cd±0.01	0.42e±0.03	0.40b±0.11	0.22c±0.02
	Bees wax	0.90dc±0.01	0.87cd±0.01	0.75bc±0.01	0.37f±0.01	0.35c±0.01	0.26b±0.01
4	No coating	0.85ef±0.01	0.81fg±0.01	0.48g±0.01	0.31g±0.01	0.24e±0.01	-
	Cactus mucilage	0.82gh±0.01	0.79gh±0.01	0.58f±0.01	0.34g±0.01	0.23e±0.01	-
	Aloe Vera gel	0.94ab±0.01	0.81fg±0.01	0.76ab±0.02	0.51b±0.02	0.33cd±0.01	0.24bc±0.03
	Bees wax	0.93abc±0.01	0.77h±0.01	0.76ab±0.01	0.48bc±0.02	0.33cd±0.02	0.24bc±0.03
6	No coating	0.88de±0.01	0.79gh±0.01	0.55f±0.02	0.32g±0.01	0.23e±0.02	-
	Cactus mucilage	0.77ij±0.01	0.71i±0.02	0.69de±0.02	0.31g±0.01	0.24e±0.01	-
	Aloe Vera gel	0.95a±0.01	0.92a±0.02	0.79a±0.02	0.61a±0.02	0.51a±0.02	0.33a±0.01
	Bees wax	0.94ab±0.01	0.90ab±0.02	0.78ab±0.01	0.62a±0.02	0.52a±0.02	0.33a±0.01
Lsd		0.03	0.03	0.03	0.03	0.03	0.04
(A)		***	***	***	***	***	ns
(B)		***	***	***	***	***	ns
(A*B)		***	***	***	***	***	ns

***=significant at 0.1%, ns=non-significant

Total Soluble Solids to Titratable Acidity Ratio

Data regarding total soluble solids to titratable acidity ratio (TSS to TA) is presented in Table 6.All $CaCl_2$ concentrations and edible coatings as well as their interactions had a significant effect on TSS to TA ratio. There was a general increase in TSS to TA ratio in all treatments; however, all the fruits treated with edible coatings revealed relatively small changes in the ratio as compared to non-treated (control) fruits during storage period. The highest TSS to TA ratio was observed in T1(control) followed by 6% $CaCl_2$+ CM as compared to other treatments on 5th and 10th day after storage, while the lowest value was recorded on fruits treated with 6% $CaCl_2$+ AG and 6% $CaCl_2$+BW respectively followed by 4% $CaCl_2$+AG in all days of storage period. The relationship of TSS to TA ratio which could be taken as ripening index showed a significant difference ($P < 0.01$)

as a function of edible coatings, to $CaCl_2$ concentration, and their interactions. But the interaction effect of edible coatings and $CaCl_2$ concentrations was non -significant on day 25th and 30th after storage. The TSS to TA ratio increased significantly along with increased storage time in both untreated and treated fruits. This indicates the increase of sugar content due the starch breakdown into free sugars by ripening of fruits. During ripening the sugar content increases and acidity decreases by the starch break down to simple sugars, that responsible to higher TSS to TA ratio (Majidi *et al*., 2011; Tessema, 2013 and Mati Ur *et al*., 2016).This result was in agreement with Zekrehiwot *et al*. (2017) chitosan and maturity stage on tomato. Elham *et al*. (2011) also reported that the TSS to TA ratio increased with increasing the storage duration. But, dipped fruits in Ca solution at different concentration with edible coatings prevented increasing of TSS to TA ratio in comparison with the other treatments. The interaction of the TSS and TA are important component of sweetness, sourness and flavor intensity in tomato (Eric *et al*., 2015). In general the TSS to TA ratio increased significantly along with increased storage time in both uncoated and coated fruits. However, sharply decreased TSS to TA ratio was resulted when tomato fruits treated with the combination of $CaCl_2$ solution with both AG and BW. The tomato fruits treated by edible coatings and those combinations with $CaCl_2$ significantly reduce TSS to TA ratio and maintain the acceptable taste.

Table 6 effect of $CaCl_2$ and edible coating on TSS/TA ration of tomato fruits storage

Treatments		**Storage period (days)**					
$CaCl_2$ (A)	Coatings (B)	5	10	15	20	25	30
0	No coating	4.79a±0.27	5.14a±0.95	-	-	-	-
	Cactus mucilage	3.61ij±0.07	4.35de±0.20	6.49d±0.22	-	-	-
	Aloe Vera gel	4.18cd±0.07	4.23def±0.26	5.07e±0.01	9.38d±0.281	4.97c±0.691	9.91ab±1.70
	Bees wax	4.22c±0.15	4.23def±0.11	4.60e±0.17	10.36e±0.05	14.75c±0.96	18.99ab±2.33
2	No coating	3.77hi±0.03	4.08efg±0.06	8.61ab±1.64	-	-	-
	Cactus mucilage	3.81h±0.03	4.88c±0.08	9.26a±0.51	-	-	-
	Aloe Vera gel	3.98efg±0.05	4.73cd±0.11	4.96e±0.61	7.86fg±0.68	12.39d±0.35	21.11a±1.82
	Bees wax	3.90fgh±0.07	4.23ef±0.08	4.92e±0.07	8.41f ±0.40	12.79d±0.46	18.05b±0.97
4	No coating	3.87gh±0.05	4.18efg±0.04	7.77c±0.09	15.22a±0.94	-	-
	Cactus mucilage	4.04def±0.07	4.28def±0.10	8.32bc±0.09	14.35b±0.17	-	-
	Aloe Vera gel	3.51j±0.10	3.80fg±0.12	4.91e±0.15	7.60gh±0.33	12.13ed±0.18	18.58ab±2.04
	Bees wax	3.59j±0.11	4.49cde±0.06	4.80e±0.09	6.17i±0.36	13.16d±0.85	19.77ab±2.26
6	No coating	4.09cde±0.03	4.36ed±0.08	5.95d±0.14	12.95c±0.18	21.03a±1.55	-
	Cactus mucilage	4.42b±0.07	5.60b±0.59	8.37bc±0.44	13.34c±0.66	18.28b±0.45	-
	Aloe Vera gel	3.54j±0.05	3.69g±0.09	4.51e±0.13	6.40i±0.37	7.52f±0.41	12.13c±0.17
	Bees wax	3.59j±0.06	3.83fg±0.11	4.64e±0.12	6.90hi±0.27	7.62f±0.31	12.87c±0.19
Lsd		0.16	0.50	0.83	0.78	1.24	2.88
(A)		***	***	***	***	***	***
(B)		***	***	***	***	***	ns
(A*B)		***	***	***	***	ns	ns

***=highly significant at 0.1%, ns=non-significant

Vitamin C

The interaction effect of $CaCl_2$ and edible coating treatments on the vitamin C content of stored tomato fruits was highly significant ($P < 0.001$) until day 15after storage as illustrated in Table 9. The ascorbic acid content of tomato juice from fruits subject to different treatments decreased with increasing storage period, but at a lower rate as compared to that of the control. Significantly, minimum reduction in vitamin C content was recorded due to the combined effect of edible coatings and $CaCl_2$ treatments throughout the storage period, but was not statistically significant on day 20, 25 and 30 after storage. The control samples did show that their values are significantly lower than all the values belonging to the treated fruits at storage periods. The control showed significantly lower values (18.21) and (10.85) than the rest of treatments on day 5 and 10 after storage followed by CM, 2% $CaCl_2$ and CM + 2% $CaCl_2$ on the same date. The higher unrestricted respiration of the control fruits might have resulted in higher change of the organic acids to TSS or other components, since ascorbic acid is a highly sensitive nutrient (Joyce *et al*., 2016).

The main effect of edible coating and $CaCl_2$ concentration resulted significantly differed vitamin C value in all storage period except on day 30 after storage. The main effect aloe Vera gel (AG) recorded the highest vitamin C value than the other coatings and the main effect $CaCl_2$ concentration except day 10. On the other hand the value of vitamin C was decreased slowly when the concentration of $CaCl_2$ increased, but not significant on day 5 after storage. Maximum ascorbic acid retention was recorded for 6% $CaCl_2$+ AG, followed by 6% $CaCl_2$+ BW and 4% $CaCl_2$+ AG treatments. The high retention of ascorbic acid by fruits receiving the above treatments might be due to the lowering of respiration of fruits or oxidation of ascorbic acid content by acting as barriers and thus modifying fruits internal air composition. This is in line with the finding of Kuwar *et al*. (2015) and Hassan *et al*. (2014) that edible coating combined with chemical dipping of fresh-cut papaya and citrnage maintained slightly higher concentration of vitamin C as compared to uncoated sample respectively. Similarly, Miguel *et al*. (2010) reported that the combinations of treatments are more effective as a barrier to respiratory gases than the control and each individual treatment. With the same coating material fruits dipped to different levels of $CaCl_2$ recorded different value. The calcium application reduced the internal breakdown and thus maintained fruit quality. Use of calcium chloride resulted in slower rate of loss of Vitamin C in tomato and carrot (Joyce *et al*., 2016 and Eric *et al*., 2015) respectively. Dipping tomato fruits in 6% $CaCl_2$ can serve as an important postharvest tool to maintain quality and extend storage life of tomatoes (Eric *et al*., 2015). Similarly 6% $CaCl_2$ was optimal for achieving high ascorbic acid retention and enhancing the anti-oxidant capacity of apricot fruit (Hajilou and Fakhimrezaei, 2013).Tomato fruit is a great source of vitamin C and the mean value of vitamin C recorded ranges from 8.4 to 59mg/100g raw edible part of the tomato (Mujtaba and Masud, 2014). Vitamin C is susceptible to oxidative deterioration as well as mild oxidation of ascorbic acid results in the formation of dehydro ascorbic acid (Hassan *et al*., 2014).

Table 7 effect of $CaCl_2$ and edible coating on vitamin C content of tomato fruits storage

Treatments		**Storage period (days)**					
$CaCl_2$ (A)	Coatings (B)	5	10	15	20	25	30
0	No coating	18.21h±0.01	10.85j±0.01	-	-	-	-
	Cactus mucilage	20.54f±0.01	15.22i±0.08	13.05i±0.11	-	-	-
	Aloe Vera gel	21.53cd±0.09	19.05d±0.09	18.33c±0.10	14.30bc±0.44	7.90d±1.12	7.39d±1.00
	Bees wax	21.43cd±0.07	19.62c±0.10	17.36e±0.10	13.27c±1.06	7.83d±1.88	7.38d±0.58
2	No coating	20.30g±0.07	15.22i±0.08	13.22i±0.10	-	-	-
	Cactus mucilage	20.74e±0.10	16.24h±0.09	14.22h±0.10	-	-	-
	Aloe Vera gel	21.58c±0.12	18.55e±0.10	18.55c±0.10	15.25b±0.33	9.62cd±1.58	8.59cd±1.00
	Bees wax	21.42d±0.10	19.55c±0.55	17.66d±0.10	13.26c±0.33	9.28cd±1.53	8.95c±1.01
4	No coating	20.34g±0.10	17.16g±0.10	15.53g±0.20	7.61e±0.26	-	-
	Cactus mucilage	20.53f±0.08	17.13fg±0.10	15.66g±0.02	7.65e±0.27	-	-
	Aloe Vera gel	21.93a±0.09	19.83c±0.11	19.28b±0.02	16.74a±0.19	10.77bc±1.15	9.56cb±0.98
	Bees wax	21.74b±0.10	18.56e±0.13	18.41c±0.21	14.96b±0.28	10.17bc±0.34	9.37cb±0.99
6	No coating	20.46fg±0.10	17.51f±0.11	16.64f±0.20	11.05d±1.00	8.03cd±0.99	-
	Cactus mucilage	20.58f±0.10	17.32fg±0.10	16.74f±0.20	11.95d±1.00	8.97cd±1.00	-
	Aloe Vera gel	22.01a±0.10	20.85a±0.16	19.82a±0.20	17.36a±1.00	13.32a±1.00	11.56a±1.49
	Bees wax	21.92a±0.11	20.26b±0.08	18.31c±0.19	17.06a±1.00	12.22ab±0.98	10.82ab±1.00
Lsd		0.16	0.30	0.28	1. 16	2.08	1.50
(A)		***	***	***	***	***	ns
(B)		***	***	***	***	**	ns
(A*B)		***	***	***	ns	ns	ns

***, **=significant at 0.1% and 1%, ns=non-significant at 5%

Conclusion

The result revealed the main effect $CaCl_2$ and edible coatings as well as interaction effect of $CaCl_2$ and edible coatings significantly ($p<0.01$) affected the quality of stored tomato fruit. Firmness test also revealed that 6% $CaCl_2$ and aloe Vera gel or bees wax could have a protective effect on tomato fruit reflected by the greater firmness of samples during storage, which could reduce economic losses due to spoilage produced from mechanical damage during handling and transportation. Chemical quality analysis also displayed pH, total soluble solids, total titratable acidity, TSS to TA ratio and vitamin C content of tomato fruits dipped in$CaCl_2$ and coated with aloe Vera gel or bees wax was substantially maintained during the course of storage time.

Significant role of $CaCl_2$ as an ethylene absorbent and this aspect together with modified internal atmosphere created by edible coatings could have less extent of spoilage on the stored tomato. Therefore, dipping tomato fruits in 6% $CaCl_2$ and aloe Vera gel or bees wax can serve as an important postharvest treatment to maintain quality and extend storage life of tomato from the given treatments. Even though 6% $CaCl_2$ + aloe Vera gel or 6% $CaCl_2$ +bees wax maintains postharvest quality of sorted tomato in this result, further experiment should be done for better recommendation.

Acknowledgment
The authors would like to acknowledge the financial support of Ethiopian minister of education.

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