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Studies on Improving Storability and Quality of Harvested Guava Fruits using Chemicals

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ABSTRACT: Guava is a highly nutritious fruit and is widely used by consumers and the food industry for a variety of applications. It is one of the most important and favorite fruit of tropical and sub-tropical region but due to its perishable nature, it is difficult to store the fruits for longer duration at room temperature. In order to use the fruit in processing industries for proper utilization of fruits and for making orchard more profitable, it is necessary to increase the shelf life by possible convenient means. The present investigation was conducted to observe the effect of different concentration of Calcium chloride, Oxalic acid, Naphthalene acetic acid and Salicylic acid on physico-chemical characteristics and overall acceptability of guava cv. L-49 stored under ambient storage condition for 12 days and observation was recorded at three days intervals on 0, 3, 6, 9 and 12th day of storage. Among all the treatments, T_3 treatment ($CaCl_2$; 3%) followed by T_{12} (Salicylic acid; 300 ppm) was found effective in reducing the physiological loss in weight, shrinkage and decay percentage of the fruits along with maintaining higher TSS, tritatable acidity, ascorbic acid, total sugar, reducing sugar, non reducing sugar and sensory characters up to 9 days of storage under ambient storage as compare to other treatments. Hence, it can be concluded that post-harvest treatment of calcium chloride (3%) and Salicylic acid (300 ppm) was effective in extending the shelf life, maintaining physico-chemical attributes and sensory quality of guava cv. L-49 under ambient storage condition.

Keywords: Guava, quality, shelf life, processing, physico-chemical, physiological loss.

INTRODUCTION

Guava (*Psidium guajava* L.) also known as 'the apple of tropics' due to its high nutritive value similar to apple, is a member of family Myrtaceae with chromosome number 2n= 22 and bears delicious fruits with great palatability, pleasant taste and available at reasonable price. Guava is believed to have originated from southern Mexico and Central America. It is widely distributed over equatorial regions growing in tropical and sub-tropical regions of the world. It was introduced in India during the 17th Century by Portuguese (Menzel, 1985). Guava is one of the popular fruit crop and its fruits generally takes about 17-20 weeks from fruit set to maturity. Guava is fifth most important fruit crop of India in production after banana, mango, citrus and papaya. Guava fruits are widely used by consumers as a fresh or are processed into a variety of value added products in the food industries such as jam, jelly, cheese, nectar, paste and other similar items because of high pectin content of fruits (Boora, 2012). When guava fruits reaches to maturity, its color changes from pale green to yellowish green. The fruits of guava show climacteric type of pattern in ripening and its shelf-life period ranges from 4-5 days at room temperature and ripen rapidly after harvesting because of having high moisture content. The different storage techniques and postharvest treatments are available to increase the shelf-life of guava fruits. Although, harvesting fruits at appropriate stage of maturity is critical in maintaining the post-harvest quality of guava fruit yet, post-harvest application of Calcium salts extend the shelf life by maintaining firmness and minimizing the rate of respiration, protein breakdown and disease incidence and thus hold promise in the quality retention of guava fruits (Selvan and Bal 2005). Storage of guava fruits by using chemicals like SA, NAA (Deepthi and Sekhar 2015), as postharvest treatment is commercially acceptable and economically feasible. Use of plant growth regulators like NAA can increase the shelf life and quality. These chemicals control the transpiration, respiration, ripening of fruits by regulating the biochemical changes in fruits; this will delay the internal ethylene synthesis in fruits and extend the period of availability of fruits in market. This will further reduce the wastage of fruits and minimize postharvest loss. Salicylic acid 3 mmol maintained their firmness, fruit colour, and palatability while dramatically reducing physiological weight loss (Kaur and Kaur 2019). Oxalic acid treatment prior to harvest increased the ascorbic acid level of the fruit at harvest, reduced the loss of fruit firmness and ascorbic acid, and increased soluble solid content (SSC) throughout storage (Zhu *et al.,* 2016). Oxalic acid is a metabolic product that possesses several functional benefits including anti-browning effect. Furthermore, studies have shown that oxalic acid is the most effective anti-browning compound for litchi

pericarp. It has been reported that oxalic acid improves the shelf life of litchi fruit by reducing anthocyanin degradation, phenolic compound oxidation and restriction of peroxidative activity (Zheng and Tian 2006). In order to use the fruit in processing industries for proper utilization of fruits and for making orchard more profitable, it is necessary to increase the shelf life by possible convenient means. Fruit quality and storage time can greatly improve by post-harvest treatments. The need of a post-harvest chemical treatment on guava fruit for transportation and storage is crucial, since it ensures the product's quality. Chemical treatments major goal is to reduce physico-chemical losses and extend the shelf life of guava fruit. So, present investigation was done to studying the improvement of storability and quality of harvested guava fruits using chemicals.

MATERIAL AND METHODS

The experiment was carried out at Post Graduate Laboratory of the Department of Horticulture, G. B. Pant University of Agriculture and Technology, Pantnagar, District Udhan Singh Nagar (Uttarakhand) on winter season guava crop during 2020-21. The guava fruits of winter season with 80 % maturity, Uniform, medium size, healthy and fully mature light green were harvested and collected in plastic crates covered with newspaper and guava leaves to protect them from bruising during transportation and brought to post harvest laboratory of the department for the further post-harvest analysis. After bringing the fruits to laboratory bruised, damaged or infected fruits were removed and best were properly sorted and graded according to size. Before starting different post-harvest operations, the fruits were subjected to pre cooling at room temperature with the help of tap water for about 10-15 minute to remove the field heat which was then cleaned with muslin cloth and dried under ceiling fan. The coating solutions of Calcium chloride, Naphthalene Acetic Acid, Salicylic acid and Oxalic Acid were made by dissolving the required quantities in 200 ml of distilled water. In case of salicylic acid it was first dissolved in alcohol and then final volume is made by adding distilled water in it. The fruits were dipped in solution for 5 minute and then they were store on a white paper sheet under ambient room temperature.

The trial was conducted in three replicate. There were 13 treatments *viz.* T_1: Calcium chloride 1%, T_2: Calcium chloride 2%, T_3: Calcium chloride 3%, T_4: Oxalic Acid 1%, T_5: Oxalic Acid 2%, T_6: Oxalic Acid 3%, T_7: Naphthalene Acetic Acid 100 ppm, T_8: Naphthalene Acetic Acid 200 ppm, T_9: Naphthalene Acetic Acid 300 ppm, T_{10}: Salicylic acid 100 ppm, T_{11}: Salicylic acid 200 ppm, T_{12}: Salicylic acid 300 ppm and T_{13}: untreated *i.e.*, Control. The treated fruits were kept at ambient temperature having 15-21°C in the postharvest laboratory. The observations on various physico-chemical attributes were studied on same day of harvest and after 3, 6, 9 and 12 day of storage.

Physical attributes. The length and breadth of fruits were measured by digital vernier callipers during the storage period as an index for shrinkage. The physiological loss in weight (PLW) of the fruits was determined by using standard procedures according to AOAC (2000). Decay percentage of coated and uncoated fruit was calculated as the number of decayed fruit divided by initial number of all fruit multiplied by 100 (El-Anany *et al*. 2009) at subsequent intervals. Chemical attributes TSS of the fruits was measured with the help of hand held digital refractometer (ERMA, Japan) of 0-32°Brix range by using standard procedures according to AOAC (2000). The titrable acidity (expressed as citric acid %) and ascorbic acid expressed in terms of mg ascorbic acid/100g of juice were determined as per method of Ranganna (1986). Lane and Eynon (1923) method as described by Ranganna (1986) was used for determining total sugar, reducing sugar and non-reducing sugar and expressed in percentage.

Sensory evaluation The organoleptic quality of guava fruits at different time intervals was determined by using taste panel consisting seven panelists from faculty of Department of Horticulture/ research students. The panelist were asked to evaluate the guava fruits for different quality attributes like appreance/ colour, texture, flavor, taste, overall acceptability. Panelist were requested to rate the product on Hedonic scale as given in the table. Score provided by panelist were summed up and average was taken.

Sensory evaluation scoring chart on 9- point hedonic scale

Organoleptic score		Rating
9	:	Like extremely
8	:	Like very much
7	:	Like moderately
6	:	Like slightly
5	:	Neither like or dislike
4	:	Dislike slightly
3	:	Dislike moderately
2	:	Dislike very much
1	:	Dislike extremely

Statistical analysis. The data were analyzed according to the procedure for analysis of two factorial completely randomized design as given by Snedecor and Cochran (1987). The overall significance of differences among the treatments was tested, using critical difference (C.D.) at 5% level of significance. The data were presented through tables.

RESULTS AND DISCUSSION

Physiological Loss in Weight. Physiological loss in weight was significantly least (8.83%) observed in T_3. However, this treatment was found to be *at par* with T_{12} (9.28%) treatment, while maximum physiological loss in weight of fruits (14.08%) was observed in control (T_{13}) (Table 1). Storage period affects physiological loss in weight significantly which increased continuously irrespective of the treatment as the storage period progressed. Similar results have been reported in pear fruits by Sandhu *et al*. (2003); Ahmad (2008); Bhat *et al*. (2011) that $CaCl_2$ treatments reduced physiological loss in weight. Loss of weight in fresh fruit was mainly due to the

loss of water caused by natural and uncontrolled phenomena of transpiration and respiration processes, along with the associated metabolic activities (Zhu *et al*., 2008). However, the reduction in weight loss in fruits during storage in calcium treated ones might be due to role of calcium in maintenance of membrane functionality and integrity as well as decreasing the enzyme activity responsible for disintegration of cellular structure, which decreases the gaseous exchange (Levy and Poovaiah 1979).

Table 1: Effect of post-harvest treatments of chemicals on physiological loss in weight of guava fruits during storage.

Treatments	Physiological loss in weight (%)					
	Storage duration					
	S_1 (0day)	S_2 (3day)	S_3 (6day)	S_4 (9day)	S_5 (12day)	Mean
T_1- $CaCl_2$ @ 1%	0.00	4.68	9.98	13.92	21.47	10.01
T_2- $CaCl_2$ @ 2%	0.00	4.64	9.82	13.73	18.77	9.39
T_3- $CaCl_2$@ 3%	0.00	3.90	8.86	13.37	18.01	8.83
T_4- OA @ 1%	0.00	5.18	11.14	17.69	20.96	10.99
T_5- OA @ 2%	0.00	4.89	10.75	16.57	20.75	10.59
T_6- OA @ 3%	0.00	4.67	10.56	16.19	20.66	10.42
T_7-NAA @100 ppm	0.00	5.77	11.98	15.89	20.18	10.76
T_8-NAA @ 200 ppm	0.00	4.79	10.93	15.69	20.07	10.30
T_9-NAA @ 300 ppm	0.00	4.71	10.32	15.63	19.94	10.12
T_{10}- SA @ 100 ppm	0.00	5.29	10.67	15.48	19.81	10.25
T_{11}- SA @ 200 ppm	0.00	5.14	10.63	15.44	18.70	9.98
T_{12}- SA @ 300 ppm	0.00	4.30	9.78	13.71	18.59	9.28
T_{13}- Control	0.00	6.28	14.23	21.82	28.09	14.08
Mean	0.00	4.94	10.74	15.78	20.46	
Factors	CD at 5%			SE(m)		
Storage Intervals (S.I.)	0.73			0.26		
Treatments (T)	1.18			0.42		
Interaction (S.I. × T)	2.64			0.94		

Per-cent Shrinkage of Fruits. The data regarding influence of different post-harvest treatments on fruit shrinkage per centage of guava cv. L-49 under ambient storage condition have been compiled in Table 2. It was clearly evident from data, as the storage interval increased there was increase in fruit shrinkage percentage. Minimum shrinkage percent (2.57%) was observed in T_3 treatment which was *at par* with T_{12} (2.80%) and T_2 (3.17%) while maximum mean % of shrinkage (6.95%) was observed in T_{13} (control). Fruit diameter and shrinkage loss occur primarily as a result of water loss through transpiration and loss of carbon reserve through respiration during storage (Vogler and Ernest 1999).

Table 2: Effect of post-harvest treatments of chemicals on shrinkage of guava fruits during storage.

Treatments	Percent Shrinkage (%)					
	Storage duration					
	S_1 (0 day)	S_2 (3 day)	S_3 (6 day)	S_4 (9 day)	S_5 (12 day)	Mean
T_1- $CaCl_2$ @ 1%	0.00	1.48	3.08	5.67	7.66	3.58
T_2- $CaCl_2$ @ 2%	0.00	1.35	2.01	5.56	6.91	3.17
T_3- $CaCl_2$ @ 3%	0.00	1.17	1.49	4.51	5.70	2.57
T_4- OA @ 1%	0.00	2.58	4.78	8.51	9.69	5.11
T_5- OA @ 2%	0.00	2.35	4.38	7.62	8.96	4.66
T_6- OA @ 3%	0.00	2.00	3.75	7.58	8.44	4.35
T_7-NAA @100 ppm	0.00	2.28	4.03	7.42	8.30	4.41
T_8-NAA @ 200 ppm	0.00	1.96	3.85	6.85	7.61	4.05
T_9-NAA @ 300 ppm	0.00	1.85	3.61	6.35	7.02	3.77
T_{10}- SA @ 100 ppm	0.00	1.98	3.18	6.29	7.78	3.85
T_{11}- SA @ 200 ppm	0.00	1.40	2.60	5.84	7.06	3.38
T_{12}- SA @ 300 ppm	0.00	1.32	1.97	4.92	5.81	2.80
T_{13}- Control	0.00	3.35	7.39	10.70	13.30	6.95
Mean	0.00	1.93	3.55	6.76	8.02	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	0.40		0.14			
Treatments (T)	0.65		0.23			
Interaction (S.I. × T)	1.46		0.52			

Per-cent Decay of Fruits. The data on decay per cent revealed that post-harvest treatments were significantly effective in controlling the decay per cent over control (Table 3). Minimum mean fruit decay (2.38%) was observed in T_3 treatment, which was significantly minimum than rest of treatments. While the highest fruit decay (19.28%) was observed in T_{13} (control). No fruit decay was observed in $CaCl_2$ and SA treated fruits till 6th day of storage. Guava post-harvest quality was principally affected by fast loss of green color, severe

softness, high rotting incidence and loss of turgidity. In the present study, T_3 treatment found to be very effective for reducing the decay percent. Because calcium is a key component of the middle lamella in cell walls and it alters cell wall stiffness by thickening the middle lamella of the cell wall by increased formation and deposition of Ca-pectate and formation of new cross-links between anionic homogalacturonans and strengthening the cell wall which slowed the rate of degradation (Dey and Brinson 1984). Similar findings with decay of plum fruits were reported by Mahajan *et al*. (2008). Therefore calcium dips increase the possibility of producing fruits less susceptible to decay during storage. While untreated fruits have higher decay content due to a lack of tissue strength and cellular instability. Conway *et al.* (1993) have also indicated that calcium-enriched tissue develops resistance to fungal attack by stabilizing or strengthening cell walls, thereby making them more resistant to harmful enzymes produced by fungi, and ultimately delays ageing of fruits.

Table 3: Effect of post-harvest treatments of chemicals on decay percent of guava fruits during storage.

Treatments	Decay (%)					
	Storage duration					
	S_1 (0 day)	S_2 (3 day)	S_3 (6 day)	S_4 (9 day)	S_5 (12 day)	Mean
T_1- $CaCl_2$ @ 1%	0.00	0.00	0.00	1.92	13.40	3.07
T_2- $CaCl_2$ @ 2%	0.00	0.00	0.00	1.93	13.20	3.03
T_3- $CaCl_2$ @ 3%	0.00	0.00	0.00	1.89	10.00	2.38
T_4- OA @ 1%	0.00	0.00	2.53	15.00	25.00	8.51
T_5- OA @ 2%	0.00	0.00	2.57	12.00	23.00	7.51
T_6- OA @ 3%	0.00	0.00	2.51	10.00	23.00	7.10
T_7-NAA @100 ppm	0.00	0.00	2.20	15.00	24.00	8.24
T_8-NAA @ 200 ppm	0.00	0.00	1.96	13.00	22.90	7.57
T_9-NAA @ 300 ppm	0.00	0.00	2.11	12.00	22.00	7.42
T_{10}- SA @ 100 ppm	0.00	0.00	0.00	2.32	15.00	3.46
T_{11}- SA @ 200 ppm	0.00	0.00	0.00	1.97	14.00	3.19
T_{12}- SA @ 300 ppm	0.00	0.00	0.00	1.91	13.00	2.98
T_{13}- Control	0.00	0.00	12.78	31.28	52.34	19.28
Mean	0.00	0.00	2.05	9.25	20.91	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	0.08		0.03			
Treatments (T)	0.13		0.05			
Interaction (S.I. × T)	0.29		0.10			

pH. The data pertaining to the effect of chemicals on pH of guava fruits cv. L-49 during the storage period have been presented in Table 4. T_{13} fruits had maximum mean pH (4.19) which was significantly higher than rest of the treatments and it was minimum (4.00) in T_3. Overall increasing trend in pH was observed with advancement of storage period in all the treatments. The increase in pH may be due to acid hydrolysis of some polysaccharides into disaccharides like starch into sucrose, fructose and glucose etc. because of respiration during storage. These reactions might have increased the sweetness and decreased sourness, as a result of which pH increased. Njoroge and Kerbel (1993); Bhattarai and Gautam (2006) have also reported the significant effect of Calcium on pH of tomato fruit and it was higher in control than that of calcium treated fruits. Hayat *et al.* (2005) reported that increasing calcium chloride prevented decline in the acidity of the apple fruits.

Table 4: Effect of post-harvest treatments of chemicals on pH of guava fruits during storage.

Treatments	pH					
	Storage duration					
	S_1 (0 day)	S_2 (3 day)	S_3 (6 day)	S_4 (9 day)	S_5 (12 day)	Mean
T_1- $CaCl_2$ @ 1%	3.49	3.91	4.16	4.36	4.51	4.09
T_2- $CaCl_2$ @ 2%	3.49	3.89	4.15	4.34	4.48	4.07
T_3- $CaCl_2$ @ 3%	3.49	3.78	4.11	4.30	4.39	4.00
T_4- OA @ 1%	3.49	3.90	4.19	4.35	4.51	4.09
T_5- OA @ 2%	3.49	3.91	4.18	4.34	4.49	4.08
T_6- OA @ 3%	3.49	3.87	4.16	4.31	4.47	4.06
T_7-NAA @100 ppm	3.49	3.87	4.18	4.36	4.49	4.08
T_8-NAA @ 200 ppm	3.49	3.86	4.13	4.29	4.50	4.06
T_9-NAA @ 300 ppm	3.49	3.85	4.17	4.30	4.41	4.05
T_{10}- SA @ 100 ppm	3.49	3.89	4.14	4.35	4.53	4.08
T_{11}- SA @ 200 ppm	3.49	3.86	4.13	4.31	4.48	4.06
T_{12}- SA @ 300 ppm	3.49	3.86	4.12	4.31	4.45	4.05
T_{13}- Control	3.49	3.80	4.27	4.41	4.98	4.19
Mean	3.49	3.87	4.16	4.33	4.52	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	0.046		0.016			
Treatments (T)	0.074		0.027			
Interaction (S.I. × T)	N/A		0.059			

Total Soluble Solid. The increasing trend was found in TSS content among all treatments. Table 5 showed that maximum fruit TSS (13.67°Brix) was recorded in (T_3) followed by (13.58°Brix) in (T_{12}) and minimum (11.77°Brix) was recorded in control (T_{13}) on 12th day of storage. A critical examination of data showed a significant effect of different treatments and storage duration on fruit TSS and their interaction were also showed significant influence on TSS. The increase in TSS on advancement of storage intervals may be attributed to increased activity of enzymes that were responsible for hydrolysis of higher polysaccharides such as starches into simple soluble sugars or hydrolysis of pectin and decomposition of glycoside units during respiration (Wills *et al*., 1980) and also due to increase in dry matter percentage as loss of moisture from the fruits during ambient storage condition. Application of calcium chloride and salicylic acid on the fruits reduces the respiration rate. During storage period, weight loss may occur due to reduction in moisture and gas permeability, treated fruits show reduction in rate of metabolic process therefore maintaining the total soluble solids since the starch hydrolysis to sugar takes place at much lower rate. Similar findings were obtained by Jan *et al*. (2012) in apple who concluded that TSS significantly increased during storage in $CaCl_2$ treated fruits while decreased in the fruits which were untreated (control). An initial increase then loss of TSS in loquat has also been reported by Akhtar *et al*. (2010), in peach (Sohail *et al*., 2015; Rahman *et al*., 2016).

Table 5: Effect of post-harvest treatments of chemicals on Total Soluble Solids of guava fruits during storage.

Treatments	TSS (°Brix)					
	Storage duration					
	S_1 (0 day)	S_2 (3 day)	S_3 (6 day)	S_4 (9 day)	S_5 (12 day)	Mean
T_1- $CaCl_2$ @ 1%	12.21	12.42	13.57	13.59	12.30	12.82
T_2- $CaCl_2$ @ 2%	12.21	12.40	13.55	13.61	13.49	13.06
T_3- $CaCl_2$ @ 3%	12.21	12.39	13.56	13.80	13.67	13.11
T_4- OA @ 1%	12.21	12.57	13.82	13.59	10.81	12.60
T_5- OA @ 2%	12.21	12.53	13.79	13.61	10.92	12.61
T_6- OA @ 3%	12.21	12.51	13.78	13.63	10.98	12.62
T_7-NAA @100 ppm	12.21	12.60	13.69	13.67	11.26	12.69
T_8-NAA @ 200 ppm	12.21	12.55	13.71	13.66	11.55	12.74
T_9-NAA @ 300 ppm	12.21	12.51	13.73	13.64	11.69	12.76
T_{10}- SA @ 100 ppm	12.21	12.49	13.60	13.70	12.28	12.86
T_{11}- SA @ 200 ppm	12.21	12.43	13.59	13.63	13.38	13.05
T_{12}- SA @ 300 ppm	12.21	12.40	13.52	13.66	13.58	13.08
T_{13}- Control	12.21	12.89	14.05	9.01	7.12	11.06
Mean	12.21	12.51	13.69	13.28	11.77	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	0.14		0.052			
Treatments (T)	0.22		0.084			
Interaction (S.I. × T)	0.52		0.18			

Titratable Acidity (%). The results in relation to the effect of treated chemicals on fruit titratable acidity of guava cv. L-49 under ambient conditions are presented in Table 6. Maximum fruit titratable acidity (0.51%) in T_3 followed by (0.49%) in T_{12} while minimum tiratable acidity (0.37%) was recorded in T_{13} (Control). Fruit titratable acidity was significantly decrease with the advances of storage days. The higher acidity in calcium treated fruits might have been due to reduced hydrolysis of organic acids and subsequent accumulation of organic acids in the fruits which were oxidized at slower rate because of slower respiration rate. During storage, rate of respiration increases which consume organic acid and reduce the fruit acidity that affect the fruit flavor. With advancement of ripening processes, starch is converted into sugar as a result of hydrolysis, which is ultimately responsible for accelerated sugar level and reduction in acidity per cent (Baraiya *et al.,* 2014). Results of present finding are also supported with the finding on passion fruit (*Passiflora edulis*) variety 'Afruvec' (Arruda *et al*., 2011), peach (*Prunus persica* L.) cultivar 'Maciel' (Barreto *et al*., 2018). Similar results have been reported in peach (Rahman *et al*., 2016) that the maximum titratable acidity was retained in fruits which were treated with $CaCl_2$ solution as compared to untreated.

Table 6: Effect of post-harvest treatments of chemicals on titratable acidity of guava fruits during storage.

Treatments	Titratable acidity (%)					
	Storage duration					
	S_1 (0 day)	S_2 (3 day)	S_3 (6 day)	S_4 (9 day)	S_5 (12 day)	Mean
T_1- $CaCl_2$ @ 1%	0.62	0.51	0.45	0.37	0.25	0.44
T_2- $CaCl_2$ @ 2%	0.62	0.53	0.46	0.40	0.28	0.46
T_3- $CaCl_2$ @ 3%	0.62	0.58	0.53	0.45	0.36	0.51
T_4- OA @ 1%	0.62	0.49	0.39	0.30	0.19	0.40
T_5- OA @ 2%	0.62	0.50	0.39	0.32	0.21	0.41
T_6- OA @ 3%	0.62	0.51	0.41	0.33	0.22	0.42
T_7-NAA @100 ppm	0.62	0.49	0.40	0.32	0.21	0.41
T_8-NAA @ 200 ppm	0.62	0.51	0.41	0.34	0.22	0.42
T_9-NAA @ 300 ppm	0.62	0.52	0.42	0.35	0.23	0.43
T_{10}- SA @ 100 ppm	0.62	0.51	0.43	0.38	0.24	0.44
T_{11}- SA @ 200 ppm	0.62	0.52	0.45	0.39	0.27	0.45
T_{12}- SA @ 300 ppm	0.62	0.56	0.51	0.41	0.33	0.49
T_{13}- Control	0.62	0.50	0.37	0.25	0.13	0.37
Mean	0.62	0.52	0.43	0.36	0.24	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	0.005		0.002			
Treatments (T)	0.008		0.003			
Interaction (S.I. × T)	0.019		0.007			

Ascorbic acid (mg/100g). The data pertaining to the effect of chemicals on fruit ascorbic acid during ambient storage condition were presented in Table 7. Perusal of data showed that maximum fruit ascorbic acid (239.63 mg/100g) was recorded in T_3 which was *at par* with (237.05 mg/100g) in T_{12} while T_{13} (control) was retained minimum ascorbic acid (194.26 mg/100g) irrespective of storage periods. The ascorbic acid content decreased under all the treatments with the advancement of storage period. The loss of ascorbic acid is due to its antioxidant activity under postharvest storage (Demarty *et al*., 1984). During the storage, oxidizing enzymes like ascorbic acid oxidase, peroxidase and polyphenol oxidase facilitates the reduction of ascorbic acid content of fruits. Calcium chloride treated fruits showed increased ascorbic acid content as compared to control fruits. This might be due to continued synthesis of L- ascorbic acid from its precursor glucose-6- phosphate and additive effect of slow rate oxidation in respiration process. Present findings are in close agreement in guava by Chawla *et al.* (2018), in loquat by Akhtar *et al.* (2010) and in pear by Sajid *et al*. (2019).

Table 7: Effect of post-harvest treatments of chemicals on ascorbic acid of guava fruits during storage.

Treatments	Ascorbic acid (mg/100g)					
	Storage duration					
	S_1 (0 day)	S_2 (3 day)	S_3 (6 day)	S_4 (9 day)	S_5 (12day)	Mean
T_1- $CaCl_2$ @ 1%	253.52	240.89	231.39	215.70	201.51	228.60
T_2- $CaCl_2$ @ 2%	253.52	246.91	234.21	220.40	208.35	232.68
T_3- $CaCl_2$ @ 3%	253.52	253.23	246.85	229.30	215.24	239.63
T_4- OA @ 1%	253.52	239.78	221.59	179.21	162.25	211.27
T_5- OA @ 2%	253.52	241.28	224.56	188.79	164.50	214.53
T_6- OA @ 3%	253.52	244.57	229.25	191.93	167.08	217.27
T_7-NAA @100 ppm	253.52	241.91	222.98	184.98	162.95	213.27
T_8-NAA @ 200 ppm	253.52	245.86	228.56	193.15	173.91	219.00
T_9-NAA @ 300 ppm	253.52	248.12	233.45	199.09	179.05	222.65
T_{10}- SA @ 100 ppm	253.52	241.98	230.91	210.90	200.12	227.49
T_{11}- SA @ 200 ppm	253.52	247.81	235.58	214.91	206.94	231.75
T_{12}- SA @ 300 ppm	253.52	250.95	243.95	225.98	210.87	237.05
T_{13}- Control	253.52	224.25	212.83	161.42	119.28	194.26
Mean	253.52	243.66	230.47	201.21	182.47	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	2.79		0.99			
Treatments (T)	4.51		1.61			
Interaction (S.I. × T)	10.09		3.60			

Sugars (%). The data illustrated in the Table 8, 9, 10 clearly showed that with respect to the effect of various post-harvest treatments, there was a significant increase in the total sugar, reducing sugar and non-reducing sugar content of treated as well as untreated guava fruits during the storage period. Maximum mean total sugar (7.37%) was observed in T_3 which was *at par* with T_{12} (7.32%) and T_2 (7.24%), while minimum sugar content (6.23%) was observed in T_{13} (control) treatment.

Maximum reducing sugar (4.68%) was recorded in T_3 which was *at par* with (4.66%) in T_{12}, (4.62%) in T_2 and (4.61%) in T_{11} and it was minimum (4.23%) in T_{13} (control). Maximum non reducing sugar (2.56%) was observed in T_3 which was found to be *at par* with T_{12},

T_{11}, T_1, T_2 and T_{10} treatments and it was minimum (1.90%) in T_{13} (Control).

The initial rise in sugars during storage may possibly due to hydrolysis of insoluble polysaccharides into sugars, loss of water from fruits through transpiration and inhibition of activities of enzymes responsible for degradation of sugars, while the subsequent decline may be due to utilization of sugars in respiration. Due to slow ripening process of treated fruits, sugar increases at slower rate till 9th days of storage compare to control. In $CaCl_2$ and SA treated fruits it is higher may be due to slow hydrolysis of starch into sugars and gradual build-up of sugars, may also be attributed to retarded ripening. $CaCl_2$ treatment deactivates the activity of hydrolytic enzymes that are responsible for conversion of starch into sugars. Similar findings were reported in peach by Singh *et al*. (2017); Rahman *et al*. (2016), in guava by Chawla *et al*. (2018); Riberio *et al*. (2020) and in pear by Sajid *et al*. (2019).

Table 8: Effect of post-harvest treatments of chemicals on total sugar, reducing sugar and non reducing sugar of guava fruits during storage.

Treatments	Total sugar (%)					
	Storage duration					
	S_1 (0 day)	S_2 (3 day)	S_3 (6 day)	S_4 (9 day)	S_5 (12 day)	Mean
T_1- $CaCl_2$ @ 1%	6.52	6.84	7.71	7.79	6.87	7.15
T_2- $CaCl_2$ @ 2%	6.52	6.78	7.65	7.85	7.28	7.24
T_3- $CaCl_2$ @ 3%	6.52	6.73	7.61	8.19	7.82	7.37
T_4- OA @ 1%	6.52	7.21	8.11	6.38	5.69	6.78
T_5- OA @ 2%	6.52	7.12	8.17	6.61	5.72	6.83
T_6- OA @ 3%	6.52	7.08	8.19	6.84	5.79	6.88
T_7-NAA @100 ppm	6.52	7.03	7.88	6.53	5.74	6.74
T_8-NAA @ 200 ppm	6.52	7.01	7.85	6.81	5.82	6.80
T_9-NAA @ 300 ppm	6.52	6.99	7.85	7.05	5.85	6.85
T_{10}- SA @ 100 ppm	6.52	6.81	7.79	7.70	6.80	7.12
T_{11}- SA @ 200 ppm	6.52	6.79	7.78	7.81	7.29	7.22
T_{12}- SA @ 300 ppm	6.52	6.77	7.67	7.92	7.73	7.32
T_{13}- Control	6.52	7.49	8.40	5.01	3.71	6.23
Mean	6.52	6.97	7.90	7.12	6.32	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	0.08		0.029			
Treatments (T)	0.13		0.047			
Interaction (S.I. × T)	0.29		0.104			

Table 9.

Treatments	Reducing sugar (%)					
	Storage duration					
	S_1 (0 day)	S_2 (3 day)	S_3 (6 day)	S_4 (9 day)	S_5 (12 day)	Mean
T_1- $CaCl_2$ @ 1%	4.33	4.41	5.13	5.42	3.58	4.57
T_2- $CaCl_2$ @ 2%	4.33	4.39	4.93	5.76	3.69	4.62
T_3- $CaCl_2$@ 3%	4.33	4.38	4.85	5.86	3.97	4.68
T_4- OA @ 1%	4.33	4.50	5.41	4.42	2.98	4.33
T_5- OA @ 2%	4.33	4.42	5.71	4.73	3.07	4.45
T_6- OA @ 3%	4.33	4.40	5.82	4.79	3.12	4.49
T_7-NAA @100 ppm	4.33	4.45	5.39	4.75	3.15	4.41
T_8-NAA @ 200 ppm	4.33	4.49	5.46	4.81	3.19	4.46
T_9-NAA @ 300 ppm	4.33	4.42	5.62	4.83	3.22	4.48
T_{10}- SA @ 100 ppm	4.33	4.43	5.17	5.30	3.49	4.54
T_{11}- SA @ 200 ppm	4.33	4.41	4.99	5.72	3.57	4.61
T_{12}- SA @ 300 ppm	4.33	4.39	4.91	5.81	3.85	4.66
T_{13}- Control	4.33	4.95	5.91	3.94	2.01	4.23
Mean	4.33	4.77	5.57	4.42	3.30	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	0.53		0.019			
Treatments (T)	0.08		0.03			
Interaction (S.I. × T)	0.19		0.07			

Table 10.

Treatments	Non reducing sugar (%)					
	Storage duration					
	S_1 (0 day)	S_2 (3 day)	S_3 (6 day)	S_4 (9 day)	S_5 (12 day)	Mean
T_1- $CaCl_2$ @ 1%	2.08	2.31	2.45	2.25	3.13	2.45
T_2- $CaCl_2$ @ 2%	2.08	2.27	2.58	1.99	3.41	2.47
T_3- $CaCl_2$ @ 3%	2.08	2.23	2.62	2.21	3.66	2.56
T_4- OA @ 1%	2.08	2.58	2.57	1.86	2.58	2.33
T_5- OA @ 2%	2.08	2.56	2.34	1.79	2.52	2.26
T_6- OA @ 3%	2.08	2.54	2.25	1.95	2.54	2.27
T_7-NAA @100 ppm	2.08	2.45	2.36	1.69	2.46	2.21
T_8-NAA @ 200 ppm	2.08	2.39	2.27	1.90	2.50	2.23
T_9-NAA @ 300 ppm	2.08	2.44	2.12	2.11	2.50	2.25
T_{10}- SA @ 100 ppm	2.08	2.26	2.49	2.28	3.14	2.45
T_{11}- SA @ 200 ppm	2.08	2.26	2.65	1.98	3.54	2.50
T_{12}- SA @ 300 ppm	2.08	2.26	2.62	2.00	3.69	2.53
T_{13}- Control	2.08	2.41	2.36	1.02	1.62	1.90
Mean	2.08	2.38	2.44	1.93	2.87	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	0.092		0.033			
Treatments (T)	0.149		0.053			
Interaction (S.I. × T)	0.33		0.119			

TSS: Acid ratio. The data regarding effect of different treatments on TSS: acid ratio of guava cv. L-49 during different storage intervals are presented in Tables 11. TSS: acid ratio was increased during storage as breakdown of carbohydrate into sugar leads to increase in TSS of the fruits during the period while acidity markedly dropped. Maximum mean TSS: acid ratio (36.62) was recorded in T_4. This might be due to higher TSS than acid and minimum (26.98) was found in T_3 ($CaCl_2$ 3%). Low increase in TSS: acid ratio in calcium chloride treated fruits might be due to the consumption of citric acid by microorganism during the postharvest period. Likewise, increase in TSS: acid of the fruits might be attributed mainly by hydrolysis of starch into soluble sugars like sucrose and glucose or fructose during ripening. The results obtained in the present investigation were in accordance with Elham *et al.* (2011) who reported the increment in TSS: acid ratio with increased storage duration. Apple fruits dipped in Ca solution at different concentration prevented increasing trend of TSS: acid ratio in comparison with control and found that calcium chloride (2 and 4%) fruit had TSS: TA values lower than control.

Table 11: Effect of post-harvest treatments of chemicals on TSS: Acid ratioof guava fruits during storage.

Treatments	TSS: acid ratio					
	Storage duration					
	S_1 (0day)	S_2 (3day)	S_3 (6day)	S_4 (9day)	S_5 (12day)	Mean
T_1- $CaCl_2$ @ 1%	19.73	24.37	30.19	36.74	49.28	32.06
T_2- $CaCl_2$ @ 2%	19.73	23.38	29.45	34.09	48.26	30.98
T_3- $CaCl_2$ @ 3%	19.73	21.36	25.51	30.38	37.96	26.98
T_4- OA @ 1%	19.73	25.65	35.46	45.34	56.91	36.62
T_5- OA @ 2%	19.73	25.06	35.42	42.53	52.01	34.95
T_6- OA @ 3%	19.73	24.53	33.61	41.32	49.95	33.82
T_7-NAA @100 ppm	19.73	25.73	34.28	42.74	53.65	35.22
T_8-NAA @ 200 ppm	19.73	24.62	33.44	40.21	52.50	34.10
T_9-NAA @ 300 ppm	19.73	24.05	32.69	38.97	50.85	33.25
T_{10}- SA @ 100 ppm	19.73	24.51	31.64	36.06	51.17	32.62
T_{11}- SA @ 200 ppm	19.73	23.90	30.22	34.97	49.59	31.68
T_{12}- SA @ 300 ppm	19.73	22.16	26.51	33.33	41.16	28.58
T_{13}- Control	19.73	25.78	37.97	36.07	54.86	34.87
Mean	19.73	24.24	32.03	37.90	49.86	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	0.61		0.22			
Treatments (T)	0.99		0.35			
Interaction (S.I. × T)	2.22		0.79			

Sensory Parameter. The data pertaining to the effect of post-harvest chemical treatments on overall acceptability of guava fruits were presented in Table 12. It is evident that various treatments and storage interval significantly influenced the overall acceptability of fruits. Maximum rating (7.06) was seen in T_3 followed by (6.93) in T_{12} and it was minimum (6.34) in T_{13} (Control). Overall acceptability of guava fruits significantly affected by storage days which decreased gradually as the storage period progressed. The decrease in sensory rating with the advancement of storage period might be associated with over-ripening, onset of senescence, loss of texture and decrease in acidity. Color, taste and texture are important for their role in perception of overall

acceptability by the consumers. During ripening, transitions of chlorophyll into carotenoids (Kays, 1991), biochemical conversions of starch into sugars, loss of organic acids through oxidation (Campestre *et al.*, 2002) are responsible for the changes in sensory attributes. The initial increase in overall scores could be due to the development of appropriate colour, aroma and taste during ripening while decline towards end of storage could be due to the initiation of senescence. The results obtained in the present investigation were in accordance with Kumar and Thakur (2017) in pear**.**

Table 12: Effect of post-harvest treatments of chemicals on overall acceptability of guava fruits during storage.

Treatments	Overall acceptability score					
	Storage duration					
	S_1 (0day)	S_2 (3day)	S_3 (6day)	S_4 (9day)	S_5 (12day)	Mean
T_1- $CaCl_2$ @ 1%	8.00	7.77	7.62	6.19	4.72	6.86
T_2- $CaCl_2$ @ 2%	8.00	7.90	7.64	6.24	4.80	6.92
T_3- $CaCl_2$ @ 3%	8.00	7.99	7.80	6.38	5.11	7.06
T_4- OA @ 1%	8.00	7.60	7.47	6.09	4.50	6.73
T_5- OA @ 2%	8.00	7.63	7.49	6.12	4.61	6.77
T_6- OA @ 3%	8.00	7.69	7.53	6.13	4.67	6.80
T_7-NAA @100 ppm	8.00	7.71	7.51	6.11	4.71	6.81
T_8-NAA @200 ppm	8.00	7.78	7.58	6.13	4.72	6.84
T_9-NAA @300 ppm	8.00	7.83	7.60	6.16	4.75	6.87
T_{10}- SA @ 100 ppm	8.00	7.75	7.59	6.16	4.72	6.84
T_{11}- SA @ 200 ppm	8.00	7.85	7.62	6.22	4.77	6.89
T_{12}- SA @ 300 ppm	8.00	7.88	7.68	6.26	4.78	6.93
T_{13}- Control	8.00	7.56	6.95	5.47	3.71	6.34
Mean	8.00	7.77	7.55	6.13	4.66	
Factors	CD at 5%		SE(m)			
Storage Intervals (S.I.)	0.082		0.029			
Treatments (T)	0.133		0.047			
Interaction (S.I. × T)	N/A		0.106			

CONCLUSIONS

The stage of maturity or ripeness at harvest and postharvest treatments with Calcium chloride, Oxalic acid, Naphthalene acetic acid and Salicylic acid had a significant effect on fruit quality and shelf life of guava cv. L-49 stored under ambient storage condition for 12 days and observation was recorded at three days intervals on 0, 3, 6, 9 and 12th day of storage. However, maturity stage at harvest strongly influenced the ripening behaviour of guava fruits as evidenced by changes in firmness, acidity, ascorbic acid and sugar content. In the present study, it could be concluded that post-harvest treatment of calcium chloride (3%) and Salicylic acid (300 ppm) was effective in extending the shelf life, maintaining physico-chemical attributes and sensory quality of guava cv. L-49 under ambient storage condition.

FUTURE SCOPE

We can extend the shelf life of guava fruits as well as other fruit crops in the future by using some chemicals like calcium chloride, oxalic acid, naphthalene acetic acid, and salicylic acid. Formers that use these techniques also earn the highest return on their crops.

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