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Effect of post-harvest treatments on shelf life and quality of Guava (*Psidium guajava*) fruits

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Abstract

The study was carried out at Post Harvest Laboratory, College of Agriculture, JNKVV, Jabalpur during the year 2018, on various ripening related changes in guava fruits to determine appropriate maturity stage and postharvest treatment for better quality and desirable shelf life under room storage. Effect of post harvest treatments with Calcium chloride (1 and 2%), Calcium nitrate (0.5 and 1%) and Azadirachta decoction (10 and 20%) on the storage behaviour of guava fruits harvested at colour turning stages during storage at room temperature were studied. Fruits were kept in tray and dipped each for 2 or 4 minutes, storage at room temperature and evaluated after 3, 6, 9 and 12 days for various physico-chemical attributes like. The maximum physiological weight loss 23.34% in untreated fruits and minimum 16.59% in calcium nitrate 1% treated, the maximum TSS was recorded 13.06 °brix in calcium nitrate 1% treated and minimum 11.23 °brix untreated fruits, the maximum total sugar was recorded 7.09% in calcium nitrate 1% treated and minimum 6.23% in untreated fruits, the maximum reducing sugar was recorded 3.58% in calcium nitrate 1% treated and minimum 3.19% in untreated fruits, the maximum 3.51% in calcium treated 1% and minimum 3.04% in untreated fruits, the maximum acidity recorded was 0.64% in calcium nitrate 1% and minimum 0.42% in untreated fruits and the maximum ascorbic acid was recorded 165.33mg in calcium treated 1% and minimum 133.33mg in untreated fruits at end of the storage period. It was observed that PLW increased, acidity and ascorbic acid decreased during storage irrespective of maturity stages and Calcium treatments studied. However, TSS total sugar, reducing sugar and non reducing sugar increased upto 6 days with all the treatments except control but subsequently decreased thereafter during storage. However, mature green stage fruits exhibited longer shelf life and better fruit quality with all the Calcium treatments compared to calcium treatments stage during storage. Similarly, calcium proved beneficial in delaying the ripening related changes in guava fruits, while application of Ca(NO₃)₂ (1%) recorded a potential shelf life of 12 days under storage.

Keywords: Guava (*Psidium guajava*), calcium chloride (CaCl₂), calcium nitrate Ca(NO₃)₂ and azadirachta decoction

Introduction

Guava (*Psidium guajava* L.) is one of the most well known edible tree fruits grown widely in more than sixty countries throughout the tropical and sub-tropical regions in the world. Guava 'The apple of the tropics' is one of the most delicious and nutritious fruit crops grown in India. Guava is considered to be superior to several other fruits by virtue of its commercial and nutritional value (Menzel, 1985) [22]. Guava is fifth most important fruit crop in production after banana, mango, citrus and papaya. The total area, production and productivity of guava in India is about 261.7 ha with 3,648.2 million tones production and 13.9 mt/ha productivity respectively. Madhya Pradesh has total area production and productivity of guava are 30.31 hectare and 523.75 million tones and 17.28 mt/ha respectively (NHB, 2017) [1]. The fruits are delicious, rich in vitamin 'C', pectin and minerals like calcium, phosphorous and iron. Guava fruits are normally consumed as fresh or processed into several products like jam, jelly, cheese, nectar, paste etc. (Boora, 2012) [4]. There is a great demand of guava fruits in both domestic and international markets for fresh and processing purposes. The share of guava in fresh fruit export from India is mere 0.65 per cent which can be further boosted, if fruit is properly handled after harvest to earn more foreign exchange (Mitra *et al.*, 2008) [21].

Guava is a perishable fruit and highly prone to bruising and mechanical injuries. Due to such perishability, control of fruit ripening is fundamental and this generates the necessity to search for new technologies to increase shelf life, reach distant markets and thus improve the marketing process (Mitra *et al.*, 2012) [24]. Fruits attaining maturity show signs of changing colour from pale green to yellowish green.

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If the fruit is to be shipped to distant markets, it should be mature, full sized and firm texture, but without an obvious colour break on the surface. Fruits for local market can be harvested in a more advanced stage of maturity (Singh, 2007) [34]. However, harvesting fruits at appropriate stage of maturity is critical in maintaining the post harvest quality of guava fruits (Azzolini *et al.*, 2004 and Patel *et al.*, 2015) [3, 29]. Storage under low temperatures has been considered the most efficient method to maintain quality of most fruits and vegetables due to its effects on reducing respiration rate, transpiration, ethylene production, ripening, senescence and disease incidence. On the other hand, enzymatic reactions occur slowly at low temperatures, extending shelf life of perishables (Bron *et al.*, 2005) [5]. Post harvest applications of calcium salts and Azadirachta decoction extend the shelf life of many fruits by maintaining PLW and minimizing the rate of respiration, protein breakdown and disease incidence. They have shown promise in the quality retention of guava fruits also (Singh *et al.*, 1981; Hiwale and Singh, 2003; Tamilselvan and Bal, 2005a & b) [35, 14, 37, 38].

Materials and Methods

Uniform medium sized guava fruits apparently free from diseases and bruises were harvested at mature stages from winter season crop. When maximum growth of fruits had been attained and their skin colour changes from dark green to light green; colour turning stage (calcium treatment) is when the skin colour turns slightly yellow from light green. They were divided into requisite lots for further handling. The experiment consisted of three replications and 13 treatment combination. For each replication, 130 fruits (approx. 15 Kg) each for stages were selected and subjected to treatment with calcium salts and Azadirachta decoction. The fruits were dipped in aqueous solutions of calcium chloride (1 and 2%), calcium nitrate (0.5 and 1%) and Azadirachta decoction (10 and 20%) separately each for 2-4 minutes. The control fruits were dipped in distilled water for 2-4 minutes and kept for comparison. The fruits kept in tray storage in room temperature. Post-harvest Laboratory, Department of Horticulture, JNKVV, Jabalpur at room temperature. Physiological loss in weight (PLW) of fruit was calculated as loss of weight in grams to the initial weight and expressed in percentage. The TSS content of fruits was measured by using Erma Hand refractometer of 0-32° Brix range, following the

procedure described in A.O.A.C. (1980) [2]. Total sugar reducing sugar and non reducing sugar determination by Rangana (1986) [31]. Acidity was estimated by simple acid-alkaline titration method as described in A.O.A.C and ascorbic acid contents of fruits were estimated by adopting the procedure described by Ranganna (1986) [31]. The shelf life was determined by recording the number of days the fruits remained in good condition without spoilage in each replication during storage. When the spoilage (over-ripening, skin browning and rotting) of fruits under different treatments exceeded 50 per cent, it was considered as the end of storage period, which was judged by visual scoring.

Results and Discussion

Physiological loss in weight (%)

Physiological loss in weight (%) PLW, In general, physiological loss in weight increase with the advancement of storage period. In the present investigation, the minimum (16.59%) physiological loss in weight during storage was recorded with T9 (calcium nitrate 1.0% dip for 4 minutes) and the maximum (21.05%) physiological loss in weight was recorded under control (Distilled water). The possible reason for reduced weight loss by chemical might be due to evaporation and transpiration processes. Calcium extends the shelf life of guava fruit by maintaining their firmness and minimizing respiration rate, proteolysis and tissue breakdown. It also acts as an anti-senescence agent by preventing cellular disorganization through protein and nucleic acid synthesis.

The higher weight loss in guava fruits harvested at colour turning stage could be due to higher rates of respiration and transpiration with the advancement of harvest maturity (Elgar *et al.*, 1999) [12]. This might be due to the role of calcium on altering the membrane permeability of cell wall and thereby limiting the rate of respiration (Bengerth, 1979) [6]. True to these findings, calcium application has been reported to be effective in terms of membrane functionality and integrity maintenance with lower losses of phospholipids and proteins with reduced ion leakage (Lester and Grusak, 1999) [20], which perhaps might be responsible for the lower weight loss in calcium treated fruits. Bharathi and Srihari (2004) [7] in sapota also reported that calcium nitrate (1% or 2%) had effectively reduced weight loss during storage. CaCl_2 treatments were inferior to $\text{Ca}(\text{NO}_3)_2$ in reducing the weight loss of guava fruits.

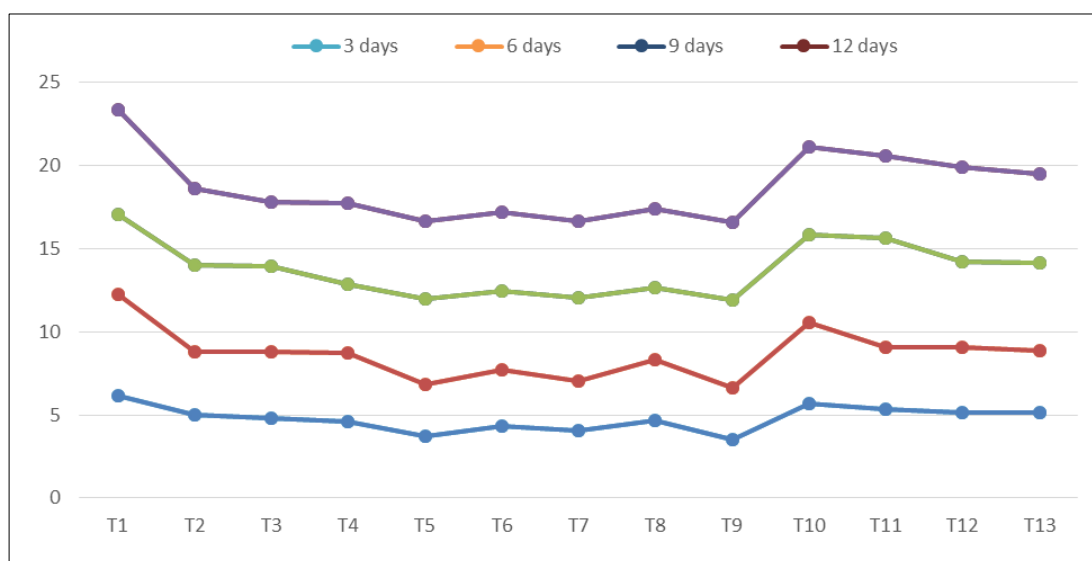


Fig 1: Effect of different post harvest treatments on physiological loss in weight (%) of guava during storage

T1 : Control (Distilled water); T2 : Calcium Chloride 1.0%; T3 : Calcium Chloride 1.0%; T4 : Calcium Chloride 2.0%; T5 : Calcium Chloride 2.0%; T6 : Calcium Nitrate 0.5%; T7 : Calcium Nitrate 0.5%; T8 : Calcium Nitrate 1.0%; T9 : Calcium Nitrate 1.0%; T10 : Azadirachta decoction 10%; T11 : Azadirachta decoction 10%; T12 : Azadirachta decoction 20%; T13 : Azadirachta decoction 20%

Chemical Characteristics

Total soluble solids (^o Brix)

There was gradual increase in TSS content of fruit with all the treatments up to 6th day of storage was recorded and presented in Table 2. TSS content of fruits afterwards declining trend in this parameter was observed under all the treatments. The highest TSS content was maintained by T9 (13.06%) and the lowest in T1 control (11.23%). Higher TSS level was retained by 1.5% Ca(NO₃)₂ treated fruits during storage and shelf-life. This was due to the role of Ca(NO₃)₂ in maintaining the lowest metabolic activity during storage of fruits. Similar results were reported by Selvan and Bal (2005) [37] in guava and Mahajan and Dhatt (2004) [23] in pear.

Hydrolysis of starch or conversion of acids to sugars could be the reason for increased TSS with advancement of storage period. At later stages, these sugars along with other organic acids were utilized for respiration at a much faster rate (Wills *et al.*, 1981) [42]. However, there were significant differences in the TSS contents of guava fruits with respect to Calcium treatments and control.

On the other hand, untreated fruits recorded minimum increase in TSS, which was probably due to the less concentration of juice as a result of dehydration. The increased in TSS during storage period upto 6 days was due to the breakdown of complex polymers in to simple substances by hydrolytic enzymes, which at later storage period got utilized during respiration. Similar findings have been reported by Bhalerao *et al.* (2010) [9] and Ramakrishna *et al.* (2001) [33] in papaya, Wahdan *et al.* (2011) [41], Vidya *et al.* (2014) [40] in mango, Desai (2016) [11] in sapota.

Acidity (%)

Gradual and progressive decrease in acidity was observed under all the treatments during storage and this progressive decline might be due to utilization of acid in metabolism. The maximum (0.64%) acidity during storage was observed in fruits treated in T9 (calcium nitrate 1% dip for 4 minutes) and the minimum (0.42%) under control (distilled water dip) results presented in Table 2.

Among the different calcium treatments studied, 0.5 and 1 per cent calcium nitrate concentrations were found almost equally

effective in maintaining higher acidity during low temperature storage. The higher acidity in fruits treated with calcium might be due to decreased hydrolysis of organic acids and subsequent accumulation of these acids which are oxidized at a slower rate because of decreased respiration (Gupta *et al.*, 2011) [13]. The decrease in acidity with calcium nitrate has also been reported in sapota by Patel *et al.* (2017) [28], Deepthi *et al.* (2016) [27], also reported in guava.

Ascorbic acid (mg/100g)

The ascorbic acid content decreased under all the treatments with the advancement of storage period result was presented in Table 2. At the end of storage period, the maximum (165.33 mg/100 g) ascorbic acid significantly decreased in the treatment T9 (1.0% calcium nitrate in 4 minute) and the minimum (113.33 mg/100 g) ascorbic acid was observed in control. Calcium nitrate treatments increased the ascorbic acid content of fruits compared to control fruits. This might be result of continued synthesis of L- ascorbic acid from its precursor glucose-6- phosphate and additive effect of slow rate oloxidation in respiration process. The decrease in ascorbic acid with calcium nitrate has also been reported in guava by Singh (1998) [39] and Jayachandran *et al.* (2004). Similar findings had been reported by Singh *et al.* (1998) [39] in mango fruits Kumar *et al.* (2005) [19] in aonla fruits, Mahajan *et al.* (2003) [26] and Ray *et al.* (2005) [30] in litchi fruits.

Total Sugar (%)

Total sugars increased initially with the highest on the 6th day of storage and thereafter declined trend was seen in all the treated fruits of guava cv. Allahabad safeda and control also was presented in Table 3. The initial rise may be due to water loss from fruits through evapo-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. Fruits treated with calcium nitrate (1.0%) recorded the highest total sugar content (7.09%) and lower total sugar observed in control fruits end of the storage. The increase in total sugar during initial storage period might be due to the hydrolysis of starch into sugar as on complete hydrolysis of starch, no further increase occurs and subsequently a decline in total sugar is predictable. The present investigation is in conformity with the results reported by Lakshmana and Reddy (1999) [18], Bhalerao *et al.* (2010) [9] and Desai (2016) [11] in sapota, Rajkumar *et al.* (2006) [32] in papaya, Wahdan *et al.* (2011) [41] and Vidya *et al.* (2014) [40] in mango, Bisen *et al.* (2014) [10] in guava.

Table 2: Bio-chemical changes in guava fruits as influenced by different post harvest treatment under ambient storage

Treatments	TSS (^o Brix)					Acidity (%)					Ascorbic acid (mg/100gm)				
	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
T ₁ : Control (Distilled water)	13.17	13.25	13.43	12.80	11.23	0.76	0.72	0.63	0.52	0.42	243.33	206.67	185.33	153.33	113.33
T ₂ : Calcium Chloride 1.0%	13.32	13.00	13.13	13.50	12.33	0.76	0.73	0.68	0.64	0.59	240.33	220.00	210.00	185.33	151.67
T ₃ : Calcium Chloride 1.0%	13.00	13.13	13.50	12.33	11.40	0.75	0.71	0.66	0.63	0.56	246.33	223.33	211.33	187.33	156.67
T ₄ : Calcium Chloride 2.0%	13.17	13.28	13.50	12.33	11.93	0.75	0.70	0.64	0.61	0.55	246.00	225.00	210.00	189.33	163.00
T ₅ : Calcium Chloride 2.0%	13.32	13.40	13.78	13.57	13.00	0.76	0.72	0.69	0.64	0.63	243.00	223.33	213.33	192.33	162.33
T ₆ : Calcium Nitrate 0.5%	12.67	12.83	13.17	12.90	11.80	0.75	0.70	0.65	0.60	0.54	240.67	226.67	211.67	193.67	161.33
T ₇ : Calcium Nitrate 0.5%	13.17	13.50	13.67	13.37	12.53	0.74	0.71	0.67	0.63	0.59	246.33	230.33	220.33	190.33	162.33
T ₈ : Calcium Nitrate 1.0%	13.00	13.30	13.50	13.23	12.33	0.76	0.74	0.68	0.65	0.60	240.33	230.33	220.33	192.67	160.33
T ₉ : Calcium Nitrate 1.0%	13.67	13.78	13.93	13.77	13.06	0.76	0.74	0.70	0.67	0.64	246.67	236.67	227.00	197.67	165.33
T ₁₀ : Azadirachta decoction 10%	13.17	13.32	13.50	13.20	12.10	0.74	0.68	0.61	0.55	0.48	240.33	218.00	200.33	170.33	140.33
T ₁₁ : Azadirachta decoction 10%	13.33	13.47	13.67	13.30	12.00	0.75	0.69	0.62	0.54	0.45	243.33	224.33	195.33	166.33	135.33
T ₁₂ : Azadirachta decoction 20%	13.33	13.45	13.50	13.37	12.23	0.76	0.70	0.63	0.56	0.49	240.00	221.33	201.00	170.33	141.00

T ₁₃ : Azadirachta decoction 20%	13.50	13.62	13.72	13.40	12.03	0.76	0.70	0.63	0.56	0.49	240.00	216.33	196.33	166.33	138.33
SEm±	0.10	0.09	0.08	0.12	0.10	0.01	0.01	0.02	0.02	0.01	0.83	0.90	1.82	0.97	0.94
CD at 5% level	0.30	0.26	0.24	0.35	0.28	NS	0.03	0.06	0.05	0.04	2.42	2.61	5.29	2.81	2.74

Reducing Sugar (%)

Different chemicals shows significant effect on the accumulation of reducing sugar result was presented in Table 3. The significantly maximum reducing sugar (4.25, 4.39, 4.50, 3.82 and 3.58) was observed with T₉ (Ca(NO₃)₂ 1%) at 0,3,6,9 and 12 day of storage period, respectively. The increase of reducing sugar content by calcium application might be due to the less utilization of sugar in respiration and conversion of starch into sugar, while the subsequent decline was perhaps due to consumption of sugar for respiration during storage. Similar findings have been reported by Bhalerao *et al.* (2010)^[9] and Desai (2016)^[11] in sapota.

Non-reducing sugar (%)

Non-reducing sugar was found maximum with T₉ (Ca(NO₃)₂ 1%) i. e. 3.69, 4.07, 3.34 and 3.87 per cent at 0, 3, 6 and 9 day of storage period result was presented in Table 3. While, at 12 day of storage period the significantly maximum non-reducing sugar (3.51) was found with T₉ [(Ca(NO₃)₂ 1%]. The increase in non-reducing sugar during storage was due to the conversion of starch into sugar. While, decrease in sugar is may be due to the consumption of sugar for respiration during storage period. The findings obtained in the present investigation can be compared to those obtained by Bhalerao *et al.* (2010)^[9] and Desai (2016)^[11] in sapota, and Bisen *et al.* (2014)^[10] in guava.

Table 3: Bio-chemical changes in guava fruits as influenced by different post harvest treatment under ambient storage

Treatments	Total Sugar (%)					Reducing Sugar (%)					Non Reducing Sugar (%)				
	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
T ₁ : Control (Distilled water)	7.51	8.07	8.50	7.45	6.23	4.27	4.03	4.08	3.53	3.19	3.25	3.71	4.08	3.92	3.04
T ₂ : Calcium Chloride 1.0%	7.76	8.03	8.65	7.62	6.47	4.26	4.37	4.47	3.75	3.50	3.50	3.66	4.19	3.88	3.25
T ₃ : Calcium Chloride 1.0%	7.71	8.17	8.43	7.73	6.49	4.29	4.37	4.48	3.76	3.51	3.42	3.80	3.95	3.51	3.10
T ₄ : Calcium Chloride 2.0%	7.67	8.16	8.77	7.57	6.77	4.23	4.33	4.45	3.80	3.55	3.10	3.46	3.99	3.69	3.23
T ₅ : Calcium Chloride 2.0%	7.33	7.78	8.44	7.76	7.02	4.24	4.35	4.45	3.79	3.54	3.43	3.82	4.32	3.78	3.23
T ₆ : Calcium Nitrate 0.5%	7.52	8.21	8.83	6.97	5.87	4.23	4.36	4.47	3.78	3.54	3.29	3.86	4.36	3.96	3.33
T ₇ : Calcium Nitrate 0.5%	7.61	8.16	8.61	7.55	6.71	4.26	4.36	4.48	3.74	3.50	3.35	3.80	4.13	3.81	3.21
T ₈ : Calcium Nitrate 1.0%	6.91	7.85	8.31	7.44	6.47	4.00	4.14	4.30	3.76	3.52	3.36	3.86	4.14	3.88	3.23
T ₉ : Calcium Nitrate 1.0%	7.94	8.45	8.84	7.87	7.09	4.25	4.39	4.50	3.82	3.58	3.69	4.07	4.34	3.87	3.51
T ₁₀ : Azadirachta decoction 10%	6.82	7.36	7.75	6.88	5.88	4.26	4.35	4.44	3.73	3.45	3.25	3.70	4.09	3.79	3.21
T ₁₁ : Azadirachta decoction 10%	7.25	7.75	8.51	7.47	6.49	4.28	4.37	4.46	3.72	3.44	2.97	3.39	4.06	3.76	3.05
T ₁₂ : Azadirachta decoction 20%	6.48	7.44	8.08	7.12	5.99	4.24	4.35	4.45	3.73	3.44	3.24	3.38	3.96	3.48	3.10
T ₁₃ : Azadirachta decoction 20%	7.24	7.80	8.25	7.27	6.39	4.27	4.35	4.41	3.55	3.30	2.97	3.45	3.84	3.72	3.09
SEm±	4.93	0.12	0.18	0.10	0.13	0.05	0.06	0.04	0.04	0.04	0.18	0.11	0.17	0.11	0.31
CD at 5% level	NS	0.35	0.53	0.30	0.38	NS	0.19	0.12	0.13	0.11	0.51	0.31	0.50	0.32	0.89

Shelf Life (days)

In the present study, it was observed that all the Calcium treatments and Azadirachta decoction were significantly superior over control in extending shelf life of guava fruits during storage at room temperature. However, recorded extended shelf life than control which might be due to a shift in climacteric peak because of delayed physiological and biochemical changes during ripening and the delay in these changes being more prominent in cold storage. Tandon *et al.* (1989)^[36] also reported that larger and more mature fruits of guava had shorter shelf life and hence could be transported only to shorter distances. Low temperature could be an added advantage for much higher storage life of both the treated and untreated fruits during storage. Among the Calcium salts studied in the present experiment, post harvest application of calcium nitrate (1%) irrespective of concentrations was found to be superior over calcium chloride(1%and 2%) and Azadirachta decoction (10% and 20%) in extending the storage life of guava fruits. The observed difference between the two calcium salts might be due to differential absorption of calcium by the fruit from different sources (Bhagwan, 1998)^[8]. Calcium nitrate (1%) treated guava fruits could be stored for a period of 12 days as against control (9 days) and the extension of storage life by calcium could possibly be due to delay in the early onset of senescence. Similar reports were also made by Singh *et al.* (1981)^[35] and Jayachandran (2000) in guava, Bharathi and Srihari (2004)^[7] in sapota and Mahajan *et al.* (2008) in plum. However, Jawandha *et al.* (2009)^[25] reported that calcium treated ber fruits at colour

break stage prolonged the storage life for 20 days under low temperature and Deepti *et al.* (2016)^[27] reported calcium proved beneficial in delaying the ripening related changes in guava fruits, while application of Ca(NO₃)₂ (2%) recorded a potential shelf life of 23.83 days under cold storage.

Conclusion

On the basis of present investigation, it is concluded that fruits treated with calcium salt (calcium nitrate and calcium chloride) especially calcium nitrate 1% retained excellent firmness of fruits and were in good state of edibility and marketable. The shelf life was improved by 12 days when compared to control. Most physiological (PLW) and chemical parameters (TSS, acidity, TSS/Acid ratio, ascorbic acid, total sugar, reducing sugar and non reducing sugar) of fruit were positively influenced by treatment calcium nitrate 1% upto 12 days of storage. The treatment was found effective in increasing the post harvest life of guava fruits up to 12 days over control without adversely affecting the fruit quality. It gave the highest consumer acceptability while, maintaining sufficient level of TSS, acidity, ascorbic acid, TSS/acid ratio, total sugar, reducing sugar and non reducing sugar content of fruits. Whereas, fruits treated with Azadirachta decoction (10% and 20%) increase self life then but appearance is also same untreated fruits. The untreated fruits exhibited lesser post harvest life due to appearance of brownish spots on the surface of fruits ultimately, which deteriorated the physico-chemical composition of the fruits.

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