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Effect of post-harvest treatments on shelf life and physico-chemical changes of Guava 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 (1and 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 fruit length of (5.50cm) was recorded in calcium nitrate (1%) treated and the minimum (4.33cm) in control, the maximum fruit diameter (5.92cm) was recorded under calcium nitrate (1%) treatment and minimum (5.28cm) under control treatment, the maximum fruit volume was recorded (125.27ml) under calcium nitrate (1%) treated fruit treatment and the minimum (92.80ml) in control, the maximum fruit decay percent was recorded in T1 (control) 12.38 % and minimum 6.14 % was recorded in the Azadirachta decoction treatment fruits after 9th and 12th days. No decayed fruits were observed among all calcium treatments at the end of storage period (12 days), the maximum total sugar was recorded (7.09%) in calcium nitrate (1%) treated and minimum (6.23%) in untreated fruits. It was observed that PLW increased, fruits length, diameter and volume decreased during storage irrespective of maturity stages and Calcium treatments studied. Total 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 $Ca(NO_3)_2$ (1%) recorded a potential shelf life of 12 days under storage.

Keywords: Guava (*Psidium guajava*), calcium chloride ($CaCl_2$), calcium nitrate $Ca(NO_3)_2$

Introduction
Guava (*Psidium guajava*) family Myrtaceae is widely grown all over the tropics and sub-tropics though Origin of guava is the tropical America but in this sub-continent, guava has been in cultivation since early 17th century (Mitra and Bose, 1990) [19]. 'The apple of the tropics' is one of the most delicious and nutritious fruit crops grown in India it is fifth most important fruit crop in production after banana, mango, citrus and papaya. It is popular among the people of all social strata due to its comparative low price than some other fruits, nourishing value and good taste. It is a rich source of vitamin C (260 mg/100 g) which is the second after amla (600 mg/100 g). It is also rich in pectin. It is a fare source of vitamin A and good source of calcium and phosphorus. 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, 2017-18). 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) [17].
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) [18]. 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. 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) [24, 12, 26, 27].

Materials and Methods

Uniform medium sized guava fruits 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 distill 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. 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 Table 1**.** 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) [11]. 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) [2]. 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) [16], which perhaps might be responsible for the lower weight loss in calcium treated fruits. Bharathi and Srihari (2004) [3] in sapota also reported that calcium nitrate (1% or 2%) had effectively reduced weight loss during storage. $CaCl_2$ treatments were inferior to $Ca(NO_3)_2$ in reducing the weight loss of guava fruits.

Fruit size length and diameter (cm)

The fruit size (length and diameter) decreased with increase storage period in Table 1. However, the treated fruits maintained higher values of fruit size as compared to control. At the end of the storage, the minimum reduction in fruit size (length and diameter) was observed in T9 (calcium nitrate 1.0% dip for 4 minutes) and maximum in T1 (control) distilled water. The reduction in fruit size during storage period might be due to shrinking of fruits caused by transpiration and ethylene production. Application of calcium nitrate might have decreased the rate of transpiration and physiological loss in weight resulting in retention of better size of fruits during storage. The research result was supported by Phani *et al*. (2017)

Fruit volume (ml)

The fruit volume decreased with the advancement of storage period up to 12th day of storage Table 2. However, the reduction in fruit volume of guava fruits was significantly affected by various post harvest treatments. At the end of 12th day of storage, the maximum (110.67 ml) fruit volume of guava fruits was recorded in treatment T9 (calcium nitrate 1.0% dip for 4 minutes), whereas minimum (92.80 ml) fruit volume of guava fruits was recorded in treatment T0 (control distilled water), respectively. The result was supported by Pila *et al*. (2010) [22].

Decay loss (%)

The losses due to decay were observed from the 9thday of storage and onwards increased significantly up to 12th day of storage in Table 2. However, the result showed that all the calcium treatments gave a longer storage life than the control and Azadirachta decoction. The maximum fruit decay percent was recorded in T1 (control) 12.38 % and minimum 6.14 % was recorded in the Azadirachta decoction treatment fruits after 9th and 12th days. No decayed fruits were observed among all calcium treatments at the end of storage period (12 days). Decaying of the fruit is another important fruit rotting parameter and occurrence of rotting adversely affects the shelf-life of fruits. Rotting caused due to infection by fruit rot makes the fruit soft and affected fruits develop bad odour. Dipping of guava fruits in Calcium nitrate, calcium chloride and Azadirachta decoction decreased fruit rot and preserved storage quality, also treated fruits received significantly higher quality ratings than untreated fruits (control). The current study demonstrates that application of calcium chloride has merit in reducing spoilage in guava fruits which may be due to their positive role in decaying the senescence of fruits by maintaining cell wall integrity and thus lowering the spoilage. Beneficial effects of calcium against post harvest decay have been shown for various fruit species. Cheour *et al*. (1990) [7]. Post-harvest calcium application decreased decay incidence has been reported in guava by Madhukar and Reddy (1990) [20], Crisosto and Michailides (1991) [8] and Phani *et al*. (2016).

Total sugar (%)

Total sugars increased initially with the highest on the 6th day of storage and thereafter declined this trend was seen in all the treated fruits of guava cv. Allahabad safeda and control also Table 2. 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) [15], Bhalerao *et al*. (2010) [3] and Desai (2016) [10] in sapota, Rajkumar *et al*. (2006) [23] in papaya, Wahdan *et al*. (2011) [29] and Vidya *et al*. (2014) [28] in mango, Bisen *et al*. (2014) [6] in guava.

Table 1: Physico-chemical changes in guava fruits as different post harvest treatment under room temperature

Treatments	(%)					Fruit length (cm)					Fruit diameter (cm)				
	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
T_1 : Control (Distilled water)	0.00	6.17	12.25	17.07	23.34	5.54	5.37	5.21	4.68	4.33	5.89	5.73	5.58	5.44	5.28
T_2 : Calcium Chloride 1.0%	0.00	4.97	8.81	13.98	18.64	5.32	5.21	5.06	4.95	4.85	5.78	5.70	5.60	5.49	5.35
T_3 : Calcium Chloride 1.0%	0.00	4.77	8.77	13.92	17.77	5.54	5.36	5.20	5.05	4.81	5.87	5.80	5.71	5.62	5.47
T_4 : Calcium Chloride 2.0%	0.00	4.63	8.74	12.86	17.73	5.51	5.42	5.34	5.21	5.08	5.86	5.81	5.73	5.64	5.50
T_5 : Calcium Chloride 2.0%	0.00	3.74	6.86	11.96	16.63	5.28	5.17	5.04	4.91	4.78	5.90	5.85	5.79	5.73	5.58
T_6 : Calcium Nitrate 0.5%	0.00	4.32	7.68	12.44	17.20	5.57	5.47	5.36	5.29	5.16	5.88	5.82	5.75	5.66	5.50
T_7 : Calcium Nitrate 0.5%	0.00	4.04	7.00	12.01	16.62	5.46	5.41	5.31	5.23	5.11	5.92	5.87	5.82	5.76	5.61
T_8 : Calcium Nitrate 1.0%	0.00	4.65	8.35	12.66	17.42	5.45	5.41	5.32	5.26	5.15	5.77	5.71	5.66	5.56	5.42
T_9 : Calcium Nitrate 1.0%	0.00	3.51	6.66	11.88	16.59	5.50	5.44	5.36	5.30	5.17	5.92	5.88	5.83	5.75	5.66
T_{10} : Azadirachta decoction 10%	0.00	5.65	10.57	15.85	21.13	5.29	5.12	4.96	4.81	4.69	5.89	5.77	5.65	5.49	5.31
T_{11} :Azadirachta decoction 10%	0.00	5.37	9.09	15.61	20.54	5.40	5.19	4.99	4.86	4.72	5.91	5.85	5.72	5.55	5.36
T_{12} :Azadirachta decoction 20%	0.00	5.14	9.04	14.23	19.87	5.36	5.29	5.17	5.03	4.89	5.90	5.78	5.69	5.56	5.37
T_{13} : Azadirachta decoction 20%	0.00	5.13	8.89	14.12	19.50	5.65	5.54	5.39	5.28	5.14	5.92	5.80	5.68	5.56	5.38
SEm±	0.00	0.05	0.07	0.08	0.11	0.05	0.08	0.08	0.10	0.09	0.05	0.06	0.05	0.07	0.07
CD at 5% level	0.00	0.14	0.20	0.23	0.31	0.15	0.24	0.22	0.28	0.27	NS	NS	0.14	0.19	0.21

Table 2: Physico-chemical changes in guava fruits as different post harvest treatment under room temperature

Treatments	Fruit volume (ml)					Decay loss (%)					Total sugar (%)				
	0	3	6	9	12	0	3	6	9	12	0	3	6	9	12
T_1 : Control (Distilled water)	125.17	119.83	112.00	103.33	92.80	0.00	0.00	0.00	6.67	12.28	7.51	8.07	8.50	7.45	6.23
T_2 : Calcium Chloride 1.0%	122.90	119.23	113.57	109.00	104.67	0.00	0.00	0.00	0.00	0.00	7.76	8.03	8.65	7.62	6.47
T_3 : Calcium Chloride 1.0%	124.70	118.37	114.33	108.67	103.33	0.00	0.00	0.00	0.00	0.00	7.71	8.17	8.43	7.73	6.49
T_4 : Calcium Chloride 2.0%	121.17	119.00	115.00	112.00	108.67	0.00	0.00	0.00	0.00	0.00	7.67	8.16	8.77	7.57	6.77
T_5 : Calcium Chloride 2.0%	117.87	114.67	110.67	106.00	102.33	0.00	0.00	0.00	0.00	0.00	7.33	7.78	8.44	7.76	7.02
T_6 : Calcium Nitrate 0.5%	118.97	114.67	110.67	105.00	101.00	0.00	0.00	0.00	0.00	0.00	7.52	8.21	8.83	6.97	5.87
T_7 : Calcium Nitrate 0.5%	120.70	116.00	114.00	110.67	105.00	0.00	0.00	0.00	0.00	0.00	7.61	8.16	8.61	7.55	6.71
T_8 : Calcium Nitrate 1.0%	123.57	120.67	115.67	111.67	107.67	0.00	0.00	0.00	0.00	0.00	6.91	7.85	8.31	7.44	6.47
T_9 : Calcium Nitrate 1.0%	125.27	121.33	118.00	114.67	110.67	0.00	0.00	0.00	0.00	0.00	7.94	8.45	8.84	7.87	7.09
T_{10} : Azadirachta decoction 10%	123.30	118.33	112.00	103.00	93.33	0.00	0.00	0.00	3.33	6.14	6.82	7.36	7.75	6.88	5.88
T_{11} : Azadirachta decoction 10%	124.23	119.00	116.00	108.00	98.67	0.00	0.00	0.00	0.00	6.14	7.25	7.75	8.51	7.47	6.49
T_{12} : Azadirachta decoction 20%	123.10	117.67	107.33	100.33	90.33	0.00	0.00	0.00	0.00	6.14	6.48	7.44	8.08	7.12	5.99
T_{13} : Azadirachta decoction 20%	123.30	117.33	107.33	100.33	90.67	0.00	0.00	0.00	0.00	6.14	7.24	7.80	8.25	7.27	6.39
SEm±	3.50	0.64	0.97	0.70	0.73	0.00	0.00	0.00	1.31	2.41	4.93	0.12	0.18	0.10	0.13
CD at 5% level	NS	1.87	2.82	1.05	1.12	0.00	0.00	0.00	3.80	7.01	NS	0.35	0.53	0.30	0.38

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) [25] 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) [4]. 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) [24] and Jayachandran (2000) [13] in guava, Bharathi and Srihari (2004) [3] in sapota and Mahajan *et al.* (2008) [21] in plum. However, Jawandha *et al.* (2009) [14] 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) [9] reportedcalcium 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.

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