The Pharma Innovation Journal 2022; 11(9): 2140-2144

www.ThePharmaJournal.com

The Pharma Innovation

ISSN (E): 2277-7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2022; 11(9): 2140-2144

www.thepharmajournal.com
Received: 06-06-2022
Accepted: 12-07-2022

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Effect of post-harvest treatment of ethylene absorbent with and without carrier materials on biochemical composition of Guava (*Psidium guajava* L.) cv. Allahabad Safeda during the storage period

Nisarga DD, Patel VK and Amarjeet STH

Abstract
Being a climacteric fruit, guava increases the rate of ripening after harvest which leads to perishable during storage and have a very short shelf life. An investigation was framed to determine the effect ethylene absorbent with and without carrier materials on biochemical composition of Guava (*Psidium guajava* L.) cv. Allahabad Safeda during the storage period. The experiment was conducted at Department of Horticulture, Anand Agricultural University, Anand during the month of January, 2022. The treatments comprised of 10 different combinations of ethylene absorbent ($KMnO_4$) with and without carrier materials. The experiment was laid out in Completely Randomized Design with 3 repetitions. Periodical observation was taken at initial, 3rd, 5th, 7th and 9th day after storage (DAS). The results revealed that treatment T6 [Kaolin + $KMnO_4$ (20 g)] was recorded best in terms of quality conservation and it was at par with the treatment T3 [Talc + $KMnO_4$ (20 g)]. Total soluble solids (TSS) and total sugar contents was found increased up to 5th DAS in T6 and T3 but in others treatments gradually deceased from the 3rd DAS. In case of acidity, ascorbic acid and phenol content progressively decreased after harvesting. However, significantly maximum ascorbic acid and numerically higher acidity and phenol content were maintained in T6 followed by T3. At 9th DAS, significantly higher TSS (7.93 ºBrix), acidity (0.35 %), ascorbic acid (138.14 mg/100 g), total sugar (6.41 %), reducing sugar (3.49 %), non-reducing sugar (2.92 %) was registered under the treatment T6 while total phenol (37.22 mg/100 g) was recorded maximum in T3 which rightly reflects to the prolongation of shelf life of guava.

Keywords: Guava, Allahabad Safeda, $KMnO_4$, kaolin and talc, biochemical parameters

Introduction
Guava is one of the commercially cultivated fruit crops in worldwide and it is consumed widely as fresh fruit. In India it occupied an area of 308 ('000 ha) with the production of 4582 ('000 MT) during the year 2020-21 (Anon. 2021a) [4]. The overall post-harvest loss of guava was as high as 15.88 per cent in India as per the study conducted by Central Institute of Post-Harvest Engineering and Technology (Anon, 2021b) [5]. The guava fruits have yellowish-green colour at the mature stage. It is a rich source of pectin and vitamin C, normally 2-5 times more vitamin C than fresh orange juice (300 mg/100 g of pulp) and provides 677.86 calories of energy/Kg of fruits (Singh *et al*, 1976) [23]. When harvesting is done at the right stage of maturity, fruit of high table quality can be obtained. Fruits become mealy and overripe within a week under normal conditions. Fruit will start to ripe within 2-3 days and become over-ripe and spoiled within 5 days after harvesting. Guava fruit industries face more challenges when it comes in terms of post-harvest handling. The high temperature will accelerate the process of deterioration and increase the disease development in fruits at the time of storage (Patel, 1996) [17]. In climacteric fruit, the rate of respiration increases after harvest which accelerates ripening, Senescence, abscission and physiological disorders and subsequent postharvest pathogenic infection.

To prevent ethylene accumulation is to ensure good air circulation, inhibition of ripening process or removal of ethylene by using ethylene absorbent can be minimized the post-harvest losses in climacteric fruits. Potassium permanganate ($KMnO_4$) is commonly used as an ethylene absorbent which oxidized the ethylene with $KMnO_4$ to produce CO_2 and H_2O resulting in an increase in CO_2 content in the storage atmosphere (Sammi and Masud 2007) [19]. It is most important to know the concentration of $KMnO_4$ with which it gives the best result in terms of increasing the shelf life of fruits with the conservation of various quality traits.

Moreover, carrier material is a substance that encapsulates the active agent and its purpose is to improve the properties of accompanying substances as well as prevent the deterioration of valuable compounds from the environmental factors by forming thin protective wall layers. On this background the present investigation was framed to find out the most suitable concentration of ethylene absorbent with and without carrier materials during the storage period of guava.

Materials and Method

Potassium permanganate ($KMnO_4$) was used as principle for ethylene absorption and commonly available Talc [Magnesium silicate hydroxide, $Mg_3Si_4O_{10}$ (OH)] and Kaolin [Hydrated aluminium silicate, $Al_2Si_2O_5$ (OH)] was used as carrier materials in present experiment. Ethylene absorbent was prepared by mixing the carrier materials in saturated solution of $KMnO_4$. 1 M solution of $KMnO_4$ was prepared by dissolving 158 gram of laboratory-grade in one litre of hot water (50 ºC). Then, 200 ml of 1 M $KMnO_4$ solution was used to dissolve 500 gram of carrier material for making paste and then it was spread into a sheet. Then made into small cubes by cutting with a knife and kept it for air drying. The air-dried ethylene absorbent with carrier material and without carrier material was weighed accurately depending upon the treatment requirement *i.e.*, 5, 10 and 20 g and it was placed in a well-ventilated small polythene pouch with holes of 5 mm diameter. The details of treatment are given in Table 1.

Table 1: Post-harvest treatments details used in the guava storage

Sr. No.	Treatment code	Treatments details
1	T_1	Talc + $KMnO_4$ (5g)
2	T_2	Talc + $KMnO_4$ (10g)
3	T_3	Talc + $KMnO_4$ (20 g)
4	T_4	Kaolin + $KMnO_4$ (5g)
5	T_5	Kaolin + $KMnO_4$ (10g)
6	T_6	Kaolin + $KMnO_4$ (20 g)
7	T_7	$KMnO_4$ (5g)
8	T_8	$KMnO_4$ (10g)
9	T_9	$KMnO_4$ (20 g)
10	T_{10}	Control

Results and Discussion

Total soluble solids (ºBrix)

Descriptive statistical analysis showed that the TSS content of guava during the different storage period was significantly influenced by various treatments under ambient storage conditions (Table 2). On 3rd DAS, TSS content was increased in all the treatments including control followed by gradually declined in the following storage period. However, there was a less increased in TSS content at 3rd DAS in treatment T6 (9.43 ºBrix) and T3 (9.63 ºBrix) which was further increased at 5th DAS (T6: 10.65 ºBrix; T3: 10.45 ºBrix). Therefore, from the above results it knew that in all the treatments maximum ripening was reached at 3rd DAS while in treatment T6 and T3 maximum ripening was occurred at 5th DAS. After maximum ripening has been occurred it was started to decline in TSS content. The increase in TSS was mainly due to the conversion of starch to soluble forms of sugars such as glucose, fructose and sucrose that producing in the flavor (Chitarra and Chitarra, 2005) [11]. The low TSS content in $KMnO_4$ treated fruit might be due to the ethylene absorbing capacity of $KMnO_4$ which delayed the ripening of fruits. Ishaq *et al.* (2009) [13] also reported a considerable increase in TSS during storage due to the fully conversion of starches into soluble sugars. The decline in TSS during subsequent storage is attributed to the fermentation of soluble sugars into alcohol, CO_2 and water. Similar results were reported by Kumari *et al.* (2017) [14] in banana, Tabasum *et al.* (2019) [26] in guava.

Table 2: Effect of different postharvest treatments on Total soluble solids of guava cv. Allahabad Safeda under storage ambient conditions

Treatments	Total soluble solids (ºBrix)				
	Initial	3rd day	5th day	7th day	9th day
T_1: Talc + $KMnO_4$ (5g)	9.43	11.53^{a}	9.31^{d}	8.53^{c}	6.29^{c}
T_2: Talc + $KMnO_4$ (10g)	9.33	10.27^{c}	9.90^{c}	8.75^{c}	6.83^{b}
T_3: Talc + $KMnO_4$ (20 g)	9.07	9.63^{ef}	10.45^{ab}	9.84^{ab}	7.78^{a}
T_4: Kaolin + $KMnO_4$ (5g)	9.23	11.43^{a}	9.33^{d}	8.48^{cd}	6.12^{c}
T_5: Kaolin + $KMnO_4$ (10g)	9.17	10.27^{c}	9.84^{c}	8.73^{c}	6.25^{c}
T_6: Kaolin + $KMnO_4$ (20 g)	9.03	9.43^{f}	10.65^{a}	9.99^{a}	7.93^{a}
T_7: $KMnO_4$ (5g)	9.27	10.77^{b}	9.34^{d}	8.17^{d}	6.00^{c}
T8: $KMnO_4$ (10g)	9.40	10.00^{d}	9.41^{d}	8.67^{c}	6.21^{c}
T_0: $KMnO_4$ (20 g)	9.17	9.73^{e}	10.28^{b}	9.55^{b}	7.76^{a}
T_{10}: Control	9.24	10.48	9.71	8.80	6.66
Mean	9.24	10.48	9.71	8.80	6.66
S.Em. ±	0.10	0.08	0.09	0.11	0.09
C.D. at 5%	NS	0.24	0.27	0.33	0.27
C.V. %	1.81	1.34	1.65	2.22	2.36

Note: Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5% level of significance.

Acidity (%)

The data pertaining to acidity of guava fruits was non-significantly influenced by different treatments at the various levels under ambient storage condition (Table 3). However, numerically maximum acidity percentage was found in the treatment of Kaolin + $KMnO_4$ (20 g) *i.e.*, 0.75, 0.71, 0.56 and 0.35 % recorded at 3rd, 5th, 7th and 9th day of storage, respectively followed by treatment T3. Meanwhile, lowest acidity content was found in control during the whole storage period *i.e.*, 0.70, 0.65, 0.483 and 0.30 % at 3rd, 5th, 7th and 9th DAS, respectively. With advancement of ripening there is decrease in acidity in climacteric fruits on account of the utilization of organic acids as respiratory substrates (Wills *et al.*, 1980) [27] and other metabolism process during the storage. Similar trends indicating the reduction in fruit acidity with progression of storage have been reported earlier by Sharma and Singh (2010) [24] in apple and Shalini *et al.* (2018) [22] in kiwifruit.

Table 3: Effect of different postharvest treatments on acidity of guava cv. Allahabad Safeda under storage ambient conditions

Treatments	Acidity (%)				
	Initial	3rd day	5th day	7th day	9th day
T1: Talc + KMnO4 (5g)	0.76	0.73	0.68	0.53	0.31
T2: Talc + KMnO4 (10g)	0.77	0.73	0.69	0.53	0.32
T3: Talc + KMnO4 (20 g)	0.76	0.74	0.70	0.57	0.34
T4: Kaolin + KMnO4 (5g)	0.77	0.72	0.67	0.53	0.31
T5: Kaolin + KMnO4 (10g)	0.76	0.73	0.67	0.55	0.33
T6: Kaolin + KMnO4 (20 g)	0.77	0.75	0.71	0.58	0.35
T7: KMnO4 (5g)	0.76	0.71	0.66	0.53	0.31
T8: KMnO4 (10g)	0.76	0.73	0.67	0.54	0.31
T0: KMnO4 (20 g)	0.77	0.75	0.69	0.56	0.32
T10: Control	0.76	0.73	0.68	0.54	0.32
Mean	0.76	0.73	0.68	0.54	0.32
S.Em. ±	0.005	0.011	0.013	0.018	0.011
C.D. at 5%	NS	NS	NS	NS	NS
C.V. %	1.09	2.65	3.40	5.93	5.89

Note: Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5% level of significance.

Ascorbic acid (mg/100 g)

The statistical data analysis shows that ascorbic acid content measured at initial, 3rd, 5th, 7th and 9th day of storage of guava fruits exhibited significant effect by different treatments and is presented in Table 4. It was non-significant at initial period. The treatment of Kaolin + $KMnO_4$ (20 g) recorded significantly maximum ascorbic acid recorded at 3rd (237.60 mg/100 g), 5th (219.93 mg/100 g), 7th (198.08 mg/100 g) and 9th (138.14 mg/100 g) DAS. And, it was statistically at par with the treatment, T3 [Talc + $KMnO_4$ (20 g)]. However minimum ascorbic acid content was recorded in control *i.e.*, 215.86, 198.83, 146.25 and 75.40 mg/100 g at 3rd, 5th, 7th and 9th day of storage, respectively. Ascorbic acid is highly sensitive to degradation due to its oxidation of ascorbic acid into dehydro-ascorbic acid compared to other nutrients during processing and storage in fruits. Ascorbic acid levels generally tend to decrease during the storage of most fruits. The present finding is an associated with the property of $KMnO_4$ on reducing or delaying the activity of ascorbate oxidase and consequently maintaining ascorbic acid content during the storage period. Ishaq *et al.* (2009) [13] also reported that $KMnO_4$ treatment maintained higher ascorbic acid concentrations due to slower respiration or less oxidation of ascorbic acid in apricot fruits. Similar results were also revealed by AL-Bamarny *et al.* (2015) [1] in pear, Bala and Kumar (2017) [8] in sapota, Dalvadi *et al.* (2017) [12] in mango, Murmu and Mishra (2018) [15] in guava.

Table 4: Effect of different postharvest treatments on ascorbic acid of guava cv. Allahabad Safeda under storage ambient conditions

Treatments	Ascorbic acid (mg/100 g)				
	Initial	3rd day	5th day	7th day	9th day
T1: Talc + KMnO4 (5g)	244.90	218.38^{de}	200.06^{de}	161.31^{c}	95.06^{d}
T2: Talc + KMnO4 (10g)	245.98	229.10^{bc}	214.39^{ab}	178.80^{b}	105.17^{cd}
T3: Talc + KMnO4 (20 g)	245.36	237.26^{a}	219.24^{a}	196.62^{a}	136.05^{ab}
T4: Kaolin + KMnO4 (5g)	245.29	219.41^{de}	204.95^{cd}	162.91^{c}	95.34^{d}
T5: Kaolin + KMnO4 (10g)	245.75	227.61^{c}	210.58^{bc}	181.77^{b}	125.40^{b}
T6: Kaolin + KMnO4 (20 g)	244.53	237.60^{a}	219.93^{a}	198.08^{a}	138.14^{a}
T7: KMnO4 (5g)	244.62	220.59^{d}	204.02^{de}	161.73^{c}	102.41^{d}
T8: KMnO4 (10g)	245.06	231.12^{bc}	211.97^{b}	176.53^{b}	113.55^{c}
T9: KMnO4 (20 g)	244.99	233.19^{ab}	214.06^{ab}	192.94^{a}	127.69^{ab}
T10: Control	244.80	215.86^{e}	198.83^{e}	146.25^{d}	75.40^{e}
Mean	245.13	227.01	209.80	175.69	111.42
S.Em. ±	1.57	1.48	1.79	1.64	3.32
C.D. at 5%	NS	4.36	5.28	4.83	9.80
C.V. %	1.11	1.13	1.48	1.61	5.16

Note: Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5% level of significance.

Total sugar (%)

The data of total sugar significantly influenced by various treatments under ambient storage conditions (Table 5). Total sugar content was increased from initial period to 3rd DAS in all the treatments except T6 and T3. In treatment T6 and T3, the total sugar content was increased up to 5th DAS followed by decreased in subsequent storage period (7th and 9th DAS). Because of that significantly higher total sugar content was maintained at 5th (8.48 %), 7th (7.75 %) and 9th (6.41 %) DAS in T6 and it was at pat with the treatment T3. The total sugar content of guava fruits increased with the advancement of the storage period up to certain stage of storage followed decrease due to decomposition as well as use in metabolic processes. Ethylene absorbent significantly slowed down the accumulation of total sugar during storage. All these biochemical changes are observed due to ethylene-induced ripening and senescence. The initial increase in sugar content of the fruits was attributed to the breakdown of starch and complex carbohydrates into simpler sugars while the decrease in later stages might be due to the utilization of sugars as a

substrate in respiration (Wills *et al*., 1980) [27]. Similar results were also reported by Rouf (2012) [19] in banana, Al-bamarny and Al-Atrushy (2016) [2] in apricot, Kumari *et al.* (2017) [14] in banana, Shalini *et al.* (2018) [22] in kiwi.

Table 5: Effect of different postharvest treatments on total sugar of guava cv. Allahabad Safeda under storage ambient conditions

Treatments	Total sugar (%)				
	Initial	3rd day	5th day	7th day	9th day
T_1: Talc + $KMnO_4$ (5g)	7.47	8.50^{ab}	7.89^{cde}	6.83^{de}	5.53^{e}
T_2: Talc + $KMnO_4$ (10g)	7.49	8.34^{abc}	8.04^{cd}	7.22^{b}	5.92^{cd}
T_3: Talc + $KMnO_4$ (20 g)	7.50	8.03^{d}	8.37^{ab}	7.56^{a}	6.38^{a}
T_4: Kaolin + $KMnO_4$ (5g)	7.52	8.48^{ab}	7.83^{de}	6.86^{cde}	5.41^{e}
T_5: Kaolin + $KMnO_4$ (10g)	7.52	8.43^{abc}	8.12^{bc}	7.12^{bc}	6.07^{bc}
T_6: Kaolin + $KMnO_4$ (20 g)	7.51	7.90^{d}	8.48^{a}	7.75^{a}	6.41^{a}
T_7: $KMnO_4$ (5g)	7.48	8.41^{abc}	7.65^{e}	6.67^{e}	5.46^{e}
T_8: $KMnO_4$ (10g)	7.52	8.33^{bc}	7.81^{de}	6.95^{bcd}	5.83^{d}
T_9: $KMnO_4$ (20 g)	7.53	8.25^{c}	8.12^{bc}	7.20^{b}	6.22^{ab}
T_{10}: Control	7.54	8.57^{a}	7.13^{f}	6.27^{f}	4.32^{f}
Mean	7.51	8.32	7.94	7.08	5.76
S.Em. ±	0.04	0.07	0.09	0.08	0.07
C.D. at 5%	NS	0.20	0.25	0.24	0.20
C.V. %	1.03	1.42	1.86	1.99	2.07

Note: Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5% level of significance.

Total phenol (mg/100 g)

The data pertaining to the total phenol of guava fruits during storage period was non-significantly influenced by present treatments under ambient storage conditions (Table 6). However, numerically maximum phenol content was registered under the treatment T6 at 3rd (126.11 mg/100 g), 5th (117.27 mg/100 g) and 7th (70.52 mg/100 g). While at 9th DAS, it was significantly maximum in treatment T3 (37.22 mg/100 g) but it was at par with the treatment T6 (37.04 mg/100 g). The lowest phenol content, 121.96, 113.09, 65.15 and 32.04 mg/100 g was recorded at 3rd, 5th, 7th and 9th day of storage respectively in control. By use of ethylene absorbent ($KMnO_4$) retard the process of ripening which delayed the deterioration or conversion into phenolic compounds into other forms ultimately it helps to maintain the higher level of total phenol in the fruit at the end of storage. During the storage period the total phenolic content was decrease either due to the decrease in synthesis or higher in oxidation. Total phenolics accumulation phenomenon during storage period can be correlated with the phenolic metabolism attributed by ethylene (Blankenship and Unrath, 1988) [9]. The results were in agreement with previous findings (Ali *et al.* 2015; Bal, 2016) [3, 7].

Table 6: Effect of different postharvest treatments on total phenol of guava cv. Allahabad Safeda under storage ambient conditions

Treatments	Total Phenol content (mg/100 g)				
	Initial	3rd day	5th day	7th day	9th day
T_1: Talc + $KMnO_4$ (5g)	135.91	122.76	116.30	68.86	32.74
T_2: Talc + $KMnO_4$ (10g)	134.51	123.99	116.33	69.18	34.53
T_3: Talc + $KMnO_4$ (20 g)	135.99	125.55	116.91	69.90	37.22
T_4: Kaolin + $KMnO_4$ (5g)	134.56	122.65	115.11	67.19	33.01
T_5: Kaolin + $KMnO_4$ (10g)	134.98	123.45	116.20	69.77	34.55
T_6: Kaolin + $KMnO_4$ (20 g)	135.36	126.11	117.27	70.52	37.04
T_7: $KMnO_4$ (5g)	134.91	123.17	114.85	67.57	32.34
T_8: $KMnO_4$ (10g)	134.77	124.49	114.53	67.53	33.58
T_9: $KMnO_4$ (20 g)	135.50	125.17	116.72	69.68	36.17
T_{10}: Control	135.57	121.96	113.09	65.15	32.04
Mean	135.21	123.93	115.73	68.54	34.32
S. Em. ±	0.79	0.90	0.90	1.07	1.28
C.D. at 5%	NS	NS	NS	NS	NS
C.V. %	1.01	1.26	1.35	2.70	6.46

Note: Treatment means with the letter/letters in common are not significantly different by Duncan's New Multiple Range Test at 5% level of significance.

Conclusion

From the above results, it can be concluded that ethylene absorbent ($KMnO_4$) with (Kaolin/Talc) or without carrier materials was effective to maintain the biochemical parameters in guava cv. Allahabad Safeda during the storage period at an ambient conditions. Acidity, ascorbic acid and phenol content decreased with increasing storage period. Whereas TSS and total sugar content increased up to 5th DAS followed decreased with advancement of storage period. At the end of storage period (9th DAS) the maximum TSS, acidity, ascorbic acid and total sugar was maintained in the treatment containing of Kaolin + $KMnO_4$ (20 g) which was at par with Talc + $KMnO_4$ (20 g).

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