Journal of Pharmacognosy and Phytochemistry

Available online at www.phytojournal.com

E-ISSN: 2278-4136
P-ISSN: 2349-8234
www.phytojournal.com
JPP 2021; 10(3): 281-287
Received: 13-02-2021
Accepted: 15-03-2021

Umme Seema N
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

MD. Jameel Jhalegar
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

SL Jagadeesh
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Bhuvaneshwari G
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Mallikarjun G Awati
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Tanveer Ahmed
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Corresponding Author:
Umme Seema N
College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India

Effect of potassium permanganate and salicylic acid chemicals on the shelf life and quality of sapota (*Manilkara achras*) fruits

Umme Seema N, MD. Jameel Jhalegar, SL Jagadeesh, Bhuvaneshwari G, Mallikarjun G Awati and Tanveer Ahmed

Abstract
The experiment on post-harvest dipping of sapota fruits to increase the shelf life and quality of fruits was done with the different concentrations of salicylic acid and Potassium permanganate ($KMnO_4$) absorbent. The harvested fruits were dipped in 0.5 mM, 1 mM and 1.5 mM of salicylic acid and potassium permanganate (treated fruits packed in CFB boxes and conventional packaging) and evaluated for their effect on physical and chemical characteristics of fruits. Among the two post harvest treatments fruits treated with $KMnO_4$ (packed in CFB box) showed least PLW (11.95 %), respiration rate (68.49 ml CO_2 kg^{-1} h^{-1}), witnessed higher firmness (54.71 N), showed less spoilage (10.82%), recorded least polygalactouranase (PG) activity (71.57 µg -galatouronic acid-FW g^{-1} h^{-1}) and electrolyte leakage (6.20 %) without adversely affecting physico-chemical and organoleptic qualities even up to 8 days of storage while fruits under control were spoiled on the 8th day of storage. Main objective of the study was to know the response of Potassium permanganate ($KMnO_4$) and salicylic acid on extending the marketability of sapota fruit.

Keywords: salicylic acid, *Manilkara achras*, potassium permanganate, polygalactouranase activity (PG), electrolyte leakage

1. Introduction
Sapota (*Achras zapota* L.), belongs to the family Sapotaceae. It is one of the delicious fruit of humid tropical and sub-tropical regions, native to Central America but now spread to almost all tropical countries of the world. In India, its cultivation was first reported at Maharashtra in 1898. It is also called by other names such as chikku, sapota plum, sapodilla or prickly pear. The fruit when fully riped is delicious and is eaten as dessert fruit, fruit skin can also be eaten since it is richer in nutrients than the pulp. The pulp is also made into Sherbets and Halvas. Fully ripe sapota flesh is honey brown in colour, soft and granular in texture and sweet in taste with a slight astringent flavor. Latex is also tapped from the bark for chuckle gum, the base for chewing gum. Sapota fruit is a good source of digestible sugar, which ranging from 12 to 20 per cent and minerals such as iron and calcium (Bose and Mitra, 1990) [4]. The fruits have an appreciable amount of protein, fat, fibre, calcium, phosphorus, iron, carotene and vitamin C (Shanmugavelu and Srinivasan, 1973) [17]. Further it is also used for many indigenous medicines because of the tannin content present in it, young fruits are boiled and the decoction is consumed to stop diarrhea. An infusion of the young fruits and the flowers is drunk to relieve pulmonary

The irreversible first step of senescence is ripening. The most characteristic change that fruits witness during ripening is softening or loss of firmness of skin and flesh, which is a due to cell wall and middle lamellae degradation making the fruit palatable. Ethylene is the hormone responsible for triggering and coordinating ripening events in climacteric fruits. The level of ethylene production in sapota fruits increased slowly from the beginning of ripening and reached its peak, which was followed by a decline (Selvaraj and Pal, 1984) [15]. Sapota being a very high ethylene evolving fruit, perishable in nature due to its high respiration rate and faster softening. Extension of shelf life can be made possible by reducing the rate of transpiration, respiration, ethylene evolution, which may be achieved by proper storage and by post harvest practice, treatments like best packing material, skin coating and treatment with novel chemicals. Various chemicals have been used to delay ripening process, to reduce post harvest losses to maintain the colour and quality of the fruit. These chemicals act as barrier for respiration, transpiration, arrest the growth and ultimately lead to an increased shelf life and maintain the marketability of the fruit for a longer period.

Thus, if technology is developed to maintain quality and enhance postharvest life of commodities. Treating of produce with novel chemicals to hasten or delay ripening is on the rise in post harvest management sector, used to reduce losses, to improve or to maintain the colour and quality by slowing down the metabolic activities of the fruit. Salicylic acid (SA) is a plant hormone inhibiting ethylene biosynthesis and delaying senescence (Ozeker, 2005) [13]. It inhibits ethylene biosynthesis in plant tissues by blocking the conversion of 1-amino-cyclopropane-1-carboxylic acid (ACC) to ethylene. Potassium permanganate an inorganic chemical compound with the formula $KMnO_4$. It is strong oxidizing agent. There are several ways that may be used to remove ethylene from produce storage areas. One of the simplest and safest methods is to oxidize it with potassium permanganate.

2. Materials and Methods

2.1 Materials and treatments

The present investigation was undertaken in the Dept of Post-Harvest Technology, University of Horticultural Sciences, Bagalkot, India during the year 2016-17. Cricket ball a commercially important sapota cultivar of this region was used for the study. Fruits of cricket ball are large sized, which are round in shape, less seeded (1-4 seeds). Pulp is gritty and granular and not very sweet. Fruits were procured from Kaladagi, a place known for production of sapota, near Bagalkot. Fruits of uniform size, shape and maturity free from any visible damage, scratch and decay were manually selected for the experiment to maintain the uniformity. Different concentration of salicylic acid and $KMnO_4$ were evaluated for their effect on physiological, biochemical and physical characteristics of sapota under ambient temperature.

2.2 Methodology

2.2.1 Salicylic acid

Different concentration of salicylic acid solutions (0.5 mM, 1.0 mM, 1.5 mM) were prepared by dissolving 69.06mg, 138.12mg and 207.18 mg of salicylic acid, respectively in ethyl alcohol and volume was made up to 1000 ml with distilled water. The fruits were dipped in individual solution for five minutes and removed to air-dry under ceiling fan. The control fruits were dipped in distilled water for 5 minutes. The treated as well as untreated fruits (control) were kept under ambient conditions for further observation. Following were the treatments.

T_1: SA @ 0.5mM T_2: SA @ 1.0 mM T_3: SA @ 1.5 mM T_4: Ethylene absorbent in CFB boxes.

T_5: Ethylene absorbent in Conventional packaging T_6: Control.

2.2.2 Potassium permanganate (KMnO4)

A saturated solution of potassium permanganate ($KMnO_4$) was prepared by dissolving 10g $KMnO_4$ powder in 100 ml of distilled water. Saturation was indicated by the sedimentation of $KMnO_4$ powder at the base of the beaker even after thorough stirring. Later rough paper shreds were dipped in the saturated solution and allowed to soak for 5 min. Then the paper shreds were drained out from the solution and dried. Sapota fruits were packed in CFB box with these $KMnO_4$paper shreds and stored in ambient conditions.

2.3 Physiological loss in weight (%)

To determine the physiological loss in weight (PLW), sapota fruits from each replication were weighed at beginning of storage which was recorded as initial weight. On subsequent dates of observation during storage, the fruits were reweighed and recorded as final weight on every 2 days intervals. PLW was calculated by using following formula and expressed in percentage.

$$\text{Physiological loss in weight (\%)} = \frac{\text{Initial weight (g)} - \text{Final weight(g)}}{\text{Initial weight (g)}} \times 100$$

2.4 Fruit decay (%)

At regular intervals the number of rotten (spoiled) fruits were counted in each replication and the decay was expressed in per cent. Extent of decay was determined by number of rotten/spoiled fruits at each interval of observation and percentage was calculated on the basis of total number of fruits stored in each treatment.

$$\text{Fruit decay (\%)} = \frac{\text{Number of rotten/spoiled fruits}}{\text{Total number of fruits}} \times 100$$

2.5 Fruit firmness

Fruit firmness was determined using texture analyzer using shear test. The sapota fruit were cut using a cutting/shear probe by programmed setting.

Mode : measure shear force
Pre speed : 5.0 mm/s
Test speed : 5.0 mm/s
Post test speed : 10.0 mm/s
Distance : 38 mm

Firmness was defined as maximum force (kgf) required during the cut, which was expressed in Newtons (N)

2.6 Respiration rate (ml CO_2 $kg^{-1}h^{-1}$)

Respiration rate was measured by using auto gas analyzer (Model: Checkmate 9900 O 2 /CO 2, PBI Dansensor, Denmark) and expressed as ml CO2 kg-1 h -1. For this, two sapota fruits were trapped in 500 ml airtight containers having twist-top lid fitted with a silicone rubber septum at the center of the lid. The containers were kept at 25ºC for 1h for accumulation of respiratory gases at the headspace. After specified time, the head space gas was sucked to the sensor of the analyzer through the hypodermic hollow needle and the displayed value of evolution rate of CO_2 concentration (%) was recorded. Rate of respiration was calculated on the basis of rate of evolution of CO_2 from the sample per unit weight per unit time using the following formula.

$$\text{Rate of respiration (CO2/kg/h)} = \frac{\text{CO2 (\%)} \times \text{Head space}}{100 \times \text{weight of fruit (kg)} \times \text{Time (hr)}}$$

2.7 Polygalactouronase (PG) activity

Polygalactouronase (PG) activity in sapota was measured following the method of Lazan *et al*. (1989) [12] with minor modifications.

Reagents

a. Sodium acetate buffer 0.2M Ph (6.0) 0.2M of Sodium acetate buffer with 6.0 pH was prepared by dissolving 27.2g of sodium acetate in small amount of distilled water and volume made up to 1 litre with distilled water and then pH adjusted to 6.0 with glacial acetic acid.
b. 0.4% sodium acetate buffer (pH 3.8) 0.4g of sodium acetate was first dissolved in small amount of distilled water and volume made to 100 ml with distilled water and thereafter, pH was adjusted to 3.8 with glacial acetic acid. 32
c. 5% phenol solution 5 g of phenol was first dissolved in small amount of distilled water and volume made to 100

ml with distilled water and this solution was stored in brown bottle.

d. PG enzyme assay mixture For the preparation of enzyme assay mixture, 0.45 g of pectin and 0.1g casein were dissolved in 0.4% sodium acetate buffer (pH 3.8) and then the solution was diluted to 100 ml with 0.4% sodium acetate buffer (pH 3.8) Preparation of enzyme extract One gram of sapota pulp was weighed and homogenized in 10 ml sodium acetate buffer (0.2 M; pH 6.0) with a pinch of $Na_2S_2O_4$ and polyvinylpyrrolidine in chilled mortar. The homogenate was centrifuged at 15000 ´ g for 20 min at 4°C and supernatant was used for the assay of Polygalactouronase (PG) activity.

2.8 PG enzyme assay

For measuring the PG enzyme activity, 0.2ml of enzyme extract was added to 2ml of assay mixture and incubated at 37 C for 2 h. From this incubated mixture, 0.05 ml was added to 1ml 5% phenol; followed by 5 ml of 96%H_2SO_4 was poured over a mixture and allowed to react for 15 min. the content was diluted with 5 ml distilled water, thoroughly mixed and cooled to room temperature. The absorbance was recorded at 490nm in spectrophotometer. Blank was prepared by adding distilled water instead of enzyme extract in the assay mixture.

Calculation

PG activity was expressed as (288.07´OD) "µg galactouronic acid FW g^1 h^{-1}"

2.8 Electrolyte leakage (%)

Fifteen freshly cut fruit discs (0.5 cm2 each) were rinsed 3 times (2-3 min) with demineralised water and subsequently floated on 10 mL of demineralised water. The electrolyte leakage in the solution was measured after 22 h of floating at room 33º temperature using a conductimeter (Crison 522, Crison Instruments, S.A., Spain). Total conductivity was obtained after keeping the flasks in an oven (90 °C) for 2 h. Results were expressed as percentage of total conductivity.

2.9 Total soluble solids (°Brix)

The juice extracted by crushing the pulp of the sapota and strained through muslin cloth was used for measuring total soluble solids. Total soluble solids were estimated using FISHER Hand Refractrometer (0 -50). The results were expressed as degree brix.

2.10 Total sugar (%)

Total sugars were determined following the method described by AOAC, 1980). Fifty ml lead free filtrate was taken in a 100 ml volumetric flask and to it 5 ml of concentrated HCl was added, mixed well and then kept for 24 hours at room temperature. Acid was then neutralized with NaOH using a drop of phenolphthalein indicator till the pink colour persisted for at least few seconds. Then volume was made up to 100 ml. Total sugars were then estimated by taking this solution in a burette and titrating it against standard Fehling's solution mixture of A and B (1:1) using methylene blue as an indicator till brick red colour is formed and noted as an end point.

$$\text{Total sugar (\%)} = \frac{\text{Factor} \times \text{volume made up}}{\text{titre value} \times \text{weight of sample}} \times 100$$

2.11 Experimental design and data analysis

The experiment was carried out with 6 treatments and the experiment was repeated 4 times and pooled data was subjected to statistical analysis. Fruits were arranged in Complete Randomised Design. Randomly selected fruits were taken to analyse physiological loss in weight, respiration rate, Total Soluble Solids (TSS), total sugar, firmness, Polygalactouronase activity and Electrolyte leakage. Statistical analyses were performed using Web Agri Stat Package (WASP) Version 2. Significant differences among means at P = 0.05 were determined by post hoc tests using Duncan's multiple range test

3. Results and Discussion

3.1 Physiological loss in weight (PLW) (%)

Physiological loss in weight is most important parameter referring to loss in weight of the produce due to physiological process such as transpiration and respiration. Irrespective of the treatments, there was an increase in physiological loss in weight (PLW) with the increase in storage period from 2nd day (6.55%) to 8th day (24.24%). PLW was maximum in untreated (control) fruits (24.50%) and minimum in fruits treated with $KMnO_4$ (packed in CFB box) (11.95%) followed by those fruits pretreated with salicylic acid @ 1.5 mM (12.92%). Higher PLW in untreated fruits might be due to the lack of physical barrier leading to more transpiration and gaseous exchange inturn to maximized weight loss. However, other concentration of $KMnO_4$ and salicylic acid treatments showed intermediate results, which were significant over control. Interestingly PLW increased steadily in $KMnO_4$ and salicylic acid treated fruits with the increase in the storage period, whereas, in untreated fruits the PLW showed a sharp increase (Table 1). The interaction between treatment (T) x storage period (D) was also significant. The use of ethylene absorbent in CFB boxes during ambient storage could be a promising postharvest technology for delaying softening and weight loss. This is primarily due to lowering down the ethylene accumulation in the package thus blocking the autocatalytic production of ethylene and slowing down the metabolic activities. Similar results were reported by Bhutia *et al*. (2011) [3] and Dhua *et al*. (2006) [6] in sapota.

The positive reports of salicylic acid may be due to closure of stomata which results in suppressed respiration rate and minimized weight loss of fruits (Zheng and Zhang., 2004). Similar work has been reported in peach fruits cv. 'Delicia' treated with SA exhibited less weight loss than control by Abbasi *et al*. (2010) [1] and Wang *et al*. (2006) [21].

3.2 Fruit decay

Interestingly neither treated fruits nor untreated fruits (control) showed any symptoms of fruit decay up to 3rd day of storage. However, irrespective of storage period, fruit decay was significantly higher in the control fruits (23.00%) than compared to treated ones (Table 2). Among different treatments of $KMnO_4$ and salicylic acid, the decay percentage was minimum in fruits treated with $KMnO_4$ (packed in CFB box) (10.82%) significantly followed by those pretreated with salicylic acid @ 1.5 mm (11.70%). Other $KMnO_4$ and salicylic acid treatment showed intermediate results, which were significantly over control. The interaction between treatment (T) x storage period (D) was also significant.

Application of KMnO4 reduced the spoilage due to its antifungal activity and enhances shelf-life of fruits by absorbing evolved ethylene, slowing ripening process and decreasing spoilage. The similar results were reported by Szczerbanik *et al*. (2005) [19] in pear and Bhutia *et al*. (2011) [3] in sapota.

Salicylic acid is reported to induce disease resistance by coordinate activation of a specific set of PR-genes many of which encode for proteins with antimicrobial activity. Bhutia *et al*. (2011) [3] in sapota stated that Salicylic acid treatment of grapes decreased fungal infections which showed significant differences with control. The results of the present study also corroborate the results of Geransayeh *et al*. (2015) in strawberry

3.3 Fruit firmness

Fruit firmness (N), was significantly influenced by $KMnO_4$ and salicylic acid Table 3. Fruits pretreated either with any concentration of $KMnO_4$ or salicylic acid had better firmness, over untreated fruits (33.83N). Among different treatments, fruits treated with $KMnO_4$ (packed in CFB box) were the most firm (54.71 N) followed by those pretreated with salicylic acid @ 1.5 mM (52.80 N). The untreated fruits (control) had the least firmness (33.83 N). Further, fruits firmness decreased with the increase in storage period from 2nd (61.16 N) day to 8th day (29.59 N). Fruit firmness was significantly retained by $KMnO_4$ (CFB boxes), which may be due to changes in the amount of pectin materials cementing the cell walls and the hydrolysis of starch, hemicelluloses in the fruit. Further the firmness indicates the progression of ripening in climacteric fruits. The similar results were reported by Chaves *et al*. (2007) [5] in sugar apple and Zewter *et al*. (2012) [22] in banana.

Salicylic acid is also reported to have positive effects in maintaining the maximum firmness. Fruits treated by SA at 1.5 mM concentration were more firm. Softening of fruits is a main and critical quality change. Positive effect of salicylic acid on fruit firmness has been previously reported (Shafiee *et al*., 2010; Ranjbaran *et al*., 2011) [16, 14]. According to Srivastava and Dwivedi. (2000) [18] in banana.

3.4 Respiration rate (ml CO_2 /kg/hr)

Irrespective of treatments, respiration rate increased significantly with the increasing in the storage period from 2 nd day (64.78 ml CO_2 kg-1 h -1) to 6th day (75.94 ml CO_2 kg-1 h -1) and declined sharply under ambient conditions (Table 4). Among the different treatments of KMnO4 and salicylic acid, fruits treated with $KMnO_4$ (packed in CFB box) showed least respiration rate (68.49 ml CO_2 kg-1 h -1) significantly followed by those pretreated with salicylic acid @ 1.5 mm (70.92 ml CO_2 kg-1 h -1). Therefore, fruit receiving $KMnO_4$ (packed in CFB box) treatment exhibited least respiration rate than other treatment during the storage period, but the other treatments of $KMnO_4$ and salicylic acid gave intermediate results with no peak noticed till 8 days after storage but in case of T1, T2, T5 the peak respiration rate was seen, on 6 DAS itself, but surprisingly, the same peak of respiration rate activity in control was witnessed on 4 DAS itself.

The minimum respiration rate was recorded in T4 ($KMnO_4$ + CFB boxes) followed by treatment T3 (salicylic acid @ 1.5 Mm), which may be attributed to their action of scavenging the ethylene, which is known to trigger respiration in fruits, especially in climacteric types and also it delays in climacteric peak of respiration and retards the ripening by maintaining ethylene at a low level for a long period Wills *et al*. (1989) similar result reported by Elamin and Abu-Goukh.(2010) [7] in banana and Chaves *et al*. (2007) [5] in sugar apple.

3.5 Polygalactouranase (PG) activity

PG activity increased significantly from 2nd day (37.42 µg-galatouronic acidFW g-1 h-1) to 6th day (66.71 µg-galatouronic acid-FW g-1 h-1) and then declined sharply (Table 5). Similarly, untreated fruits showed very higher PG activity (89.72 µg- -galatouronic acid-FW g-1 h-1) on 4th day of storage than the pretreated fruits. Among different treatments of $KMnO_4$ and salicylic acid, fruits receiving $KMnO_4$ (packed in CFB box) showed least PG activity (71.57µg -galatouronic acid-FW g-1 h-1), significantly followed by salicylic acid @ 1.5 mm (73.04µg -galatouronic acid-FW g-1 h-1), with no peak noticed till 8 days after storage but in case of T1,T2,T5 the peak PG activity was seen, on 6 DAS itself, but surprisingly, the same peak of PG activity in control was witnessed on 4 DAS itself.

Fruit softening results from cell wall degradation by cell wall hydrolases such as polygalactosidases (PG), PME, b-galactosidase (b-Gal), and xylanase along with cell membrane deterioration Srivastava and Dwivedi. (2000) [18]. Reduction in PG activity delays fruit softening leading to increase in shelf life of fruit. The significantly lower PG activity in KMnO4 treated fruits may be due to absorbtion of evolved ethylene from fruits by KMnO4 from fruits, which might have delayed ripening and slowed down the PG activity. The effect of CFB and KMnO4 on least PG activity can also be attributed to the cross-linkage to the carboxyl group of the pectic substances in the cell wall, resulting in rigidification, which blocks the access of degrading enzymes (PG) and thereby reducing rate of fruit softening Valero *et al*., (2002) [20]. As an ethylene inhibitor, SA delays fruit ripening and prevents fruit softening by reducing the activity of cell wall-degrading enzymes. Srivastava and Dwivedi. (2000) [18] in banana reported that SA reduced PG, xylanase and cellulase enzyme activity in harvested banana fruits, in which cellulase and PG were most sensitive to SA treatment.

3.6 Electrolyte leakage

Electrolyte leakage increased from 2 nd day (5.49 %) to 8 th day (14.36%) Table 6. Similarly, untreated fruits showed very higher electrolyte leakage (14.42 %) than the pretreated fruits. Among different treatments of $KMnO_4$ and salicylic acid, fruits receiving $KMnO_4$ (packed in CFB box) showed least electrolyte leakage (6.20 %), significantly followed by salicylic acid @ 1.5 mm (7.47 %) Other treatments of $KMnO_4$ and salicylic acid gave intermediate result. The electrolyte leakage in the untreated fruits increased at a shaper rate from 2nd day (6.90%) to 8th day (21.74%). Electrolyte leakage was minimum in fruits treated with $KMnO_4$ and salicylic acid compared to other treatments, which may linked to membrane selective permeability loss related to color development and pulp consistency loss. $KMnO_4$ treated fruits maintained membrane selective permeability was also efficient in delaying color development and in reducing pulp consistency loss. The results pointed to an effect of KMnO4 in delaying fruit senescence. The similar results were reported by Freitas *et al*. (2017) [8].

3.7 TSS and total sugar

Interestingly, untreated (control) fruits showed highest TSS and total sugar in 2nd (19.59 °B and 9.75 %) to 6th (22.95 °B and 16.40 %) day of storage but thereafter, it declined, whereas, treated fruits it went on increasing up till 8th day of storage but at slower rate. Among different treatments of $KMnO_4$ and salicylic acid, fruit receiving $KMnO_4$ (packed in CFB boxes) showed least TSS and total sugar (19.83°B and 12.24%) significantly followed by those pretreated with salicylic acid @ 1.5 mm (20.47 °B and 12.88 %) but the other treatments of $KMnO_4$ and salicylic acid gave intermediate

results. Similarly, irrespective of treatments, TSS and total sugar increased with increase in storage period from 2nd day (19.59°B and 9.75 %) to 8th day (21.89 °B and 17.75%) The interaction effect of treatment (T) x storage period (D) was also significant.

$KMnO_4$ resulted in gradual and slow increase in total soluble solids and sugar at the end of the experiment. Starch modifies to sugars like glucose phosphate by the activity of sucrose phosphate synthetase which enhances TSS during maturity, these enzymes are activated by release of ethylene. The absorption of ethylene by $KMnO_4$ results in the prevention of such enzyme activity. Thus starch dose doesn't modify to sugar and TSS content remains in low amount. Maintaining the TSS at lower level by $KMnO_4$ treatment may also be due to slow rate of respiration and ripening processes. This result of the study are in line with the report of Ishaq *et al*. (2009) [11] in apricot fruit and Heydari *et al*. (2011) [10] in mango. Salicylic acid showed least mean TSS and total sugar, which may be probably due to the reduced or delayed fruit ripening and respiration rate which thus, reduced the increase of TSS. The increase in the TSS level is always associated to an ethylene synthesis increase. Similar were the findings of Aghdam *et al*. (2009) who suggested that a lower TSS and total sugar of kiwifruit treated with methyl salicylic acid.

Table 1: Effect of post harvest treatments on physiological loss in weight (%) of sapota fruit cv. Cricket ball during storage at ambient conditions

Treatments	PLW (%)				
	2 DAS	4 DAS	6 DAS	8 DAS	Mean
T_1	6.73	15.14	19.78	23.57	16.30
T_2	4.38	12.77	17.76	22.93	14.46
T_3	3.81	10.33	16.55	21.00	12.92
T_4	3.06	9.35	15.39	19.99	11.95
T_5	8.82	15.91	20.56	25.51	17.70
T_6	12.50	23.89	29.15	32.44	24.50
Mean	6.55	14.57	19.86	24.24	
S. Em±	0.06	0.10	0.06		
C.D. at 1%	0.34	0.46	0.35		

T_1- Salicylic acid @ 0.5mM
T_2- Salicylic acid @ 1.0 mM
T_3- Salicylic acid @ 1.5 mM
T_4- Ethylene absorbent in CFB box
T_5 - Ethylene absorbent in Conventional packaging
T_6- Control

Table 2: Effect of post harvest treatments on fruit decay (%) of sapota fruit cv. Cricket ball during storage at ambient conditions

Treatments	Fruit decay (%)			
	4 DAS	6 DAS	8 DAS	Mean
T_1	8.36	15.28	19.84	14.49
T_2	6.45	14.11	17.83	12.79
T_3	5.66	12.96	16.52	11.70
T_4	4.72	12.07	15.68	10.82
T_5	9.46	17.23	21.98	16.22
T_6	12.83	20.97	35.19	23.00
Mean	7.91	15.43	21.20	
Initial	0.00			
S. Em±	0.03	0.12	0.15	
C.D. at 1%	0.19	0.49	0.56	

Table 3: Effect of post-harvest treatments on fruit firmness (N) of sapota fruit cv. Cricket ball during storage at ambient condition

Treatments	Firmness (N)				
	2 DAS	4 DAS	6 DAS	8 DAS	Mean
T_1	58.96	49.55	36.31	29.33	43.54
T_2	60.84	53.95	42.90	30.61	47.07
T_3	67.29	59.08	48.56	36.27	52.80
T_4	68.52	61.60	50.68	38.06	54.71
T_5	59.75	48.44	39.46	26.17	43.45
T_6	51.61	37.17	29.45	17.10	33.83
Mean	61.16	51.63	41.23	29.59	
Initial	77.12 N				
S. Em±	0.03	0.19	0.04	0.18	
C.D. at 1%	0.34	0.78	0.36	0.76	

Table 4: Effect of post harvest treatments on respiration rate (ml CO_2 kg^{-1} h^{-1}) of sapota fruit cv. Cricket ball during storage at ambient conditions

Treatments	Respiration rate (ml CO_2 kg^{-1} h^{-1})				
	2 DAS	4 DAS	6 DAS	8 DAS	Mean
T_1	63.56	71.88	84.45	43.7	65.90
T_2	62.82	70.3	80.55	41.64	63.83
T_3	61.34	67.75	74.62	79.97	70.92
T_4	60.96	66.29	70.17	76.54	68.49
T_5	63.87	71.91	89.79	45.35	67.73
T_6	76.13	85.29	56.07	20.63	59.53
Mean	64.78	72.24	75.94	51.31	
Initial	52.32				
S. Em±	0.17	0.12	0.13	0.07	
C.D. at 1%	0.72	0.959	0.566	0.301	

Table 5: Effect of post harvest treatments on Polygalactouranse enzyme activity (µg-galatouronic acid-FW g^{-1} h^{-1}) of sapota fruit cv. Cricket ball during storage at ambient conditions

Treatments	Polygalactouranse enzyme activity (µg-galatouronic acid-FW g^{-1} h^{-1})				
	2 DAS	4 DAS	6 DAS	8 DAS	Mean
T_1	36.00	66.11	83.56	43.93	57.40
T_2	35.05	59.26	78.64	61.19	58.54
T_3	34.35	58.69	73.04	84.98	62.76
T_4	34.25	57.99	71.57	80.20	61.00
T_5	36.55	69.40	88.83	38.86	58.41
T_6	48.30	89.72	62.15	29.22	57.35
Mean	37.42	66.86	76.30	56.39	
Initial	24.35				
S. Em±	0.03	0.09	0.12	0.19	
C.D. at 1%	0.34	0.54	0.76	0.85	

Table 6: Effect of post harvest treatments on Electrolyte leakage (%) of sapota fruit cv. Cricket ball during storage at ambient conditions

Treatments	Electrolyte leakage (%)				
	2 DAS	4 DAS	6 DAS	8 DAS	Mean
T_1	6.37	8.68	10.68	14.66	10.10
T_2	4.88	7.70	9.75	13.93	9.06
T_3	3.65	6.54	8.93	10.75	7.47
T_4	3.25	5.15	7.00	9.38	6.20
T_5	7.89	9.93	11.73	15.67	11.31
T_6	6.90	12.39	16.67	21.74	14.42
Mean	5.49	8.40	10.79	14.36	
Initial	3.12				
S. Em±	0.03	0.10	0.09	0.07	
C.D. at 1%	0.34	0.46	0.42	0.32	

Table 7: Effect of post harvest treatments on TSS (°B) of sapota fruit cv. Cricket ball during storage at ambient conditions

Treatments	TSS (°B)				
	2 DAS	4 DAS	6 DAS	8 DAS	Mean
T_1	20.15	22.43	23.05	21.36	20.86
T_2	19.96	20.34	24.04	21.71	20.68
T_3	17.87	19.51	22.88	24.75	20.47
T_4	17.68	19.00	22.00	23.12	19.83
T_5	20.35	22.17	23.77	21.09	20.94
T_6	21.56	23.53	21.97	19.34	20.75
Mean	19.59	21.16	22.95	21.89	
Initial	17.34				
S. Em±	0.01	0.02	0.06	0.10	
C.D. at 1%	0.12	0.26	0.34	0.48	

Table 8: Effect of post harvest treatments on Total sugar (%) of sapota fruit cv. Cricket ball during storage at ambient conditions

Treatments	Total sugar				
	2 DAS	4 DAS	6 DAS	8 DAS	Mean
T_1	9.89	13.20	18.09	16.28	14.36
T_2	9.22	12.26	14.08	16.52	13.02
T_3	8.87	10.55	13.26	18.85	12.88
T_4	7.52	9.58	12.21	19.67	12.24
T_5	10.70	14.11	19.84	18.47	15.78
T_6	12.30	16.54	20.95	16.70	16.62
Mean	9.75	12.71	16.40	17.75	
Initial	5.94				
S. Em±	0.05	0.04	0.07	0.06	
C.D. at 1%	0.340	0.446	0.345	0.475	

4. Conclusion

Our results have shown that two chemicals at different concentration i.e. salicylic acid (0.5 mM, 1.0 mM and 1.5 mM) and potassium permanganate (packed in CFB box and conventional packaging), the potassium permanganate (packed in CFB box) was found to be more effective followed by salicylic acid at 1.5 mM concentration as compared to untreated fruits. The combined application of Potassium permanganate + CFB box treated fruits stored in cold storage condition had proved to be best post harvest treatment for transportation and storage of sapota cv. 'Cricket ball' from the point of reduction in loss in weight, fruit softening, enzyme activity and suppress the respiration, ethylene evolution rate compared to control. Further, this treatment was also successful in maintaining higher TSS and sugars content during storage

5. Acknowledgments

We are thankful to the Department of Post Harvest Technology, College of Horticulture, University of Horticultural Sciences, Bagalkot, Karnataka, India for providing the laboratory facilities and technical support.

6. References

1. Abbasi NA, Hafeez S, Tareen MJ. Salicylic acid prolongs shelf life and improves quality of mari delicia peach fruit. Acta Hort 2010;880:191-197
2. Aghdam MS, Mostofi Y, Motallebiazar A, Ghasemneghad M, Fattahi MJ. Methyl salicylic acid affects the quality of Hayward kiwifruit during storage at low temperature. J Agri Sci. 2011;3(1):149-156.
3. Bhutia W, Pal RK, Sangita, Jha SSK. Response of different maturity stages of sapota (*Manilkara achras* Mill.) cv. Kalipatti to in-package ethylene absorbant. *J. Food Sci. Tech*., 2011;48(6):763-768.
4. Bose TK, Mitra SK. Fruits: Tropical and Subtropical, 1990;II:329.
5. Chaves MA, Bonomo RCF, Silva AAL, Santos LS, Carvalho BMA, Souza TS *et al*. Use of potassium permanganate in the sugar apple post-harvest preservation uso de permanganato de potasio en la preservación post-cosecha de frutas de chirimoya. CYTA-J. Food 2007;5(5):346-351.
6. Dhua RS, Nath S, Kabir J. Ethylene absorbents and ripening behavoiur of sapota fruit. Proceedings of the national symposium on production, utilization and export of underutilized fruits with commercial potentialities, Kalyani, Nadia, West Bengal, India 2006, 249-253
7. Elamin MA, Abu-Goukh AA. Effect of polyethylene film lining and potassium permanganate on quality and shelf-life of banana fruits. J Univ. Gezira 2010;7(2):1-3.
8. Freitas WES, Almeida MLB, Morais PLD. potassium permanganate effect on the quality and postharvest conservation of sapodilla fruit under modified atmosphere, Acta agronomica 2017;66(3):331-337.
9. Geransayeh M, Sepahvand S, Abdossi V. Extending post harvest longevity and improving quality of strawberry (*Fragaria anonasa* duch cv *gaviota*) fruit by postharvest salicylic acid treatment. J agr. stud 2015;3(2):17-36.
10. Heydari M, Mirza-Alian A, Moradi N. Investigating the effects of potssium permanganate on mango quality and storability. Horti Sci 2011;25(2):130-136.
11. Ishaq S, Rathore HA, Majeed S, Awan S, Shah ZS. The Studies on the physico-chemical and organoleptic characteristics of apricot (*Prunus armeniaca* L.) produced in Rawalakot, Azad Jammu and Kashmir during storage. Pakistan J Nutr 2009;8(6):856-860.
12. Lazan H, Ali ZM, Liang KS, Yee KL. Polygalactouronase activity and variation in ripening of papaya fruits with tissue depth and heat treatment. Physiol. Plant 1989;77:93-98.
13. Ozeker E. Salicylic acid and its effects on plants. European Faculty of Agric 2005;22:13-14
14. Ranjbaran R, Jyothi MH, Ekbote S. Effect of chemicals on physicochemical characters of storage behavior of grape berry fruit. Adv. in Agri. Res. in India 2011;8(2):1-7.
15. Selvaraj Y, Pal DK. Changes in chemical composition and enzyme activity of the sapodilla cultivars during development and ripening. J Horti. Sci 1984;59:275-281.
16. Shafiee M, Taghavi TS, Babalar M. Addition of salicylic acid to nutrient solution combined with postharvest treatments (hot water, salicylic acid, and calcium dipping) improved postharvest fruit quality of strawberry. Scientia Horti 2010;124:40-45.

17. Shanmugavelu KG, Srinivasan G. Composition of fruits of sapota cultivars (*Achras zapota* L.). South Ind. Hort 1973;21(1):107-108.
18. Srivastava MK, Dwivedi UN. Delayed ripening of banana fruit by salicylic acid. Pl. Sci. 2000;158:87-96.
19. Szczerbanik MJ, Scott KJ, Paton JE, Best DJ. Effects of polyethylene bags, ethylene absorbent and 1-methylcyclopropene on the storage of Japanese pears. J Hort. Sci. Biotech 2005;80:162-166.
20. Valero D, Perez-Vicente A, Martinez-Romero D, Castillo S, Guillen G, Serrano M. Plum storability improved after calcium and heat postharvest treatments: role of polyamines. J Food Sci 2002;67:2571-2575.
21. Wang L, Chen S, Kong W, Li S, Archbold DD. Salicylic acid pretreatment alleviates chilling injury and affects the antioxidant system and heat shock proteins of peaches during cold storage. Postharvest Biol. and Tech., 2006;41:244-251.
22. Zewter A, Woldetsadik K, Workneh TS. Effect of 1-methylcyclopropene, potassium permanganate and packaging on quality of banana. African J Agri. Res., 2012;7(16):2425-2437.
23. Zheng Y, Zhang Q. Effect of polyamines and salicylic acid postharvest storage of ponkan mandrain. Acta horti. 2004;632(1):317-320.