International Journal of Chemical Studies

P-ISSN: 2349–8528
E-ISSN: 2321–4902
www.chemijournal.com
IJCS 2020; 8(4): 3810-3813

Received: 15-06-2020
Accepted: 19-07-2020

Rajesh M
PG Research Scholar, Department of Fruit Science, Horticultural College and Research Institute (TNAU), Periyakulam, Tamil Nadu, India

V Premalakshmi
Assistant Professor, (Horticulture), Department of Post- Harvest Technology, HC & RI, TNAU, Periyakulam, Tamil Nadu, India

J Rajangam
Professor and Head, Department of Fruit Science, HC&RI, TNAU, Periyakulam, Tamil Nadu, India

V Vani
Assistant Professor (Food Science), Department of Post-Harvest Technology, HC & RI, TNAU, Periyakulam, Tamil Nadu, India

KS Subramanian
Director of Research, TNAU, Coimbatore, Tamil Nadu, India

Corresponding Author:
V Premalakshmi
Assistant Professor, (Horticulture), Department of Post- Harvest Technology, HC & RI, TNAU, Periyakulam, Tamil Nadu, India

Post-harvest dip of enhanced freshness formulation (EFF) to extend the shelf-life of Sapota (*Achras sapota* Mill.*)* Cv. PKM-1

Rajesh M, V Premalakshmi, J Rajangam, V Vani and KS Subramanian

DOI: https://doi.org/10.22271/chemi.2020.v8.i4av.10245

Abstract
The present study was undertaken to determine the effects of a nano-emulsion carrying hexanal, an Enhanced freshness formulation (EFF), as a post-harvest dip technology to minimize the post-harvest losses and to extend the shelf life of sapota. The sapota fruits were harvested at harvest maturity stage was treated with EFF (0.5, 1.0, 1.5 and 2.0 per cent for 5 min) was stored under ambient (28 °C ± 2 °C, RH 60 ± 10%) and cold storage (14 °C ± 2 °C, RH 90 ± 5%) conditions and evaluated the physical and biochemical parameters. The EFF at 2.00% concentration was recorded lower physiological loss in weight (15.92 per cent), higher firmness (4.67 lbs) with increased shelf life (28 days) at cold storage (14 °C ± 2 °C, RH 90 ± 5%) and nine days under ambient storage condition. The treated fruit had low total soluble solids (21.36°Brix), total sugars (11.66%), and high acidity (0.13%) indicating improved fruit quality during storage, in addition to an extended shelf life (28 days). Overall, the results clearly indicated that the EFF-treated sapota *cv.*PKM1 fruits were delayed in the ripening process and had an extended shelf life. Post-harvest dipping using hexanal formulation is a potential technology that could be adopted in pack house for domestic and export markets.

Keywords: Sapota**,** PKM1, shelf life, dip technology, enhanced freshness formulation (EFF)

Introduction

Sapota (*Achras sapota* Mill.) belongs to the family Sapotaceae. It is originated from Tropical America and it is being cultivated in many parts of the tropical region. It exhibits a climacteric pattern of respiration and ethylene production. India is the leading producer of sapota in the world with a production of 13.08 lakh tons in the year 2017-18 (Indian Horticulture Database, 2018) [15] but the export constitutes very minor fraction. So far many attempts had been made to extend the shelf life which include calcium dip treatment (Onanong, 1989 and Chittham *et al.*, 2002) [16, 8], application of gibberellic acid (GA) as dipping or spray (Kadu and Gajipara, 2009) [12], Waxol coating (Bojappa and Venkatesh Reddy, 1990) [5] and hot water treatments (Brito and Narendra, 2002) [6]. But these were not able to increase the storage life to appreciable level as the MAP (Mohamed *et al.*, 1996) [14] does which was expensive and need technical expertise make it necessary to introduce new formulations that are eco-friendly and economically feasible.

Hexanal is a naturally occurring six carbon aldehyde compound produced in the lipoxygenase pathway and released from plants during tissue damage.It is an important precursor for the formation of six carbon alcohols and esters, with an important role in extending fruit freshness by inhibiting the enzyme phospholipase-D (Brown *et al*., 1990; Jandus *et al.*, 1997) [7, 11]. It is generally recognized as safe (GRAS). Several studies has been carried out in enhancing the shelf life and post-harvest quality of fruits. Vegetables and flowers (Paliyath and Murr, 2007) treated with hexanol. Hence, a new formulation based on hexanal has been found to enhance the shelf life of many fruit crops *viz.*, apple, pears, peach, grapes, sweet cherries, guava, mango and strawberry (Corbo *et al*., 2000; Spotts *et al*., 2007; Paliyath and Murr, 2008) [9, 21, 17].

In the view of above, an attempt was made to investigate the effect of hexanal formulation (EFF) on post-harvest quality and shelf life enhancement in sapota.

Materials and Methods

The present investigation was carried out at Department of Fruit science, Horticultural College and Research Institute, TNAU Periyakulam, during the 2019-2020. The experiment was laid out in Factorial Completely Randomized Design (FCRD) with five treatments and four replication. The fresh sapota fruits were harvested at harvest maturity and maximum efforts were made to select uniformly-sized fruit that were free from injuries and diseases. Fruits were treated with EFF at various levels *viz*., 0.5, 1.0, 1.5 and 2.0 per cent for 5 minutes and then air-dried. The untreated fruits dipped in water for 5 minutes and then air-dried served as control. Three kg fruits for each replications of each treatment were stored under ambient (28 °C ± 2 °C, RH 60 ± 10%) and cold (14 °C ± 2 °C, RH 90 ± 5%) conditions.

The observations like Physiological loss in weight , firmness and shelf life were recorded and fruit biochemical parameters *viz.,*Total soluble solids (TSS), Ascorbic acid content (mg/100g), Titrable acidity (%) and Total sugars (%) were determined by adopting the A.O.A.C (1990) [1] method as follows.

Physiological loss of weight

The physiological loss in weight (PLW) was estimated by difference in weight and expressed in *per cent* loss of weight once in two days till the produce become unmarketable which is estimated by visual scoring.

$$\text{PLW (\%)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \text{ X } 100$$

Fruit firmness

Fruit firmness was measured on opposite sides of the equatorial axis using fruit pressure tester model FT 27(1227 lbs) with a plunger 5/16 inches was used for the determination of rupture force and the readings were expressed as lbs.

Shelf life

Shelf life of the fruit was determined by recording the number of days the fruits remained in marketable condition without spoilage in each replication during storage and expressed in days.

Total Soluble Solids

The total soluble solids of the fruits were determined with the help of Erma hand refractometer. with range 0-32 *per cent* and the values were expressed in degree brix after making the temperature correction at 20 ^{o}C.

Titratable Acidity

The titratable acidity was estimated by titrating 10 ml of juice against 0.1 N NaOH, using 1 per cent phenolphthalein as an indicator. Acidity was expressed as per cent of citric acid.

$$\text{Acidity (\%)} = \frac{\text{Titre x Normality of alkali x 0.0064 x 100}}{\text{Volume of the sample taken (ml)}}$$

Ascorbic acid

Ascorbic acid content of the sapota fruit flesh was estimated using 2, 6-dichlorophenol indophenols dye visual titration method and expressed in mg/100g

Statistical analysis

Effect of post-harvest dip of EFF on the observed parameters were analysed in a Factorial Completely Randomized Design at 5% significance level using AGRESS software.

Results and Discussion

Physiological loss in weight (%)

The results showed that minimum physiological loss in weight (4.78, 19.42 and 34.54%) was observed in T5 (EFF @ 2.00%) on 3rd, 6th and 9th day after storage followed by treatment T4 (EFF @ 1.50%). *i.e*. 5.34, 20.38 and 36.78%), while maximum physiological loss in weight (6.86, 24.68 and 48.72%) was observed in treatment T1 (control) on 3rd, 6th and 9$^{th\ day}$ after storage under ambient condition. In cold storage, maximum physiological loss in weight (2.80, 13.78, 28.10 and 56.98%) was observed in treatment T1 (control) on 28th day and minimum physiological loss in weight was observed in treatment T5 (EFF @ 2.00%) (0.63, 4.58, 11.00 and 15.92%) on 3rd, 12th, 20th and 28th day after storage under cold condition. The reduction in weight loss might be due to the maintenance of firmness of fruit by EFF which decreased the enzyme activity responsible for disintegration of cellular structure and decreases the gaseous exchange. Similar findings have been reported by Aradhya *et al*. (2006) [3] in sapota, Sharma *et al*., (2010) [20] in sweet cherry. (Table 1)

Firmness (lbs)

The highest firmness (4.89 lbs) was observed in T5 (EFF@2.00%). The lowest firmness (3.16 lbs) was observed in treatment T1 (control) under ambient storage. In low temperature storage condition, maximum firmness (4.67 lbs) was recorded in T5 (EFF@2.00%) and minimum firmness of 3.12 lbs was recorded in T1 (control). Firmness of the fruit is an important characteristic that is used to determine stability and it is predominantly determined by cell wall composition and structure. EFF treatments have been known to delay the softening and improve the fruit quality. Similar findings have been reported by Tsomu and Patel (2014) [24] in sapota. (Table 1)

Shelf life (days)

The data presented in Table 1 revealed that different concentration of EFF treatments significantly influenced the shelf life of sapota PKM1 fruits. The highest shelf life of sapota fruits (9.00 days) was recorded in T5 (EFF @ 2.00%) followed by T4 (EFF@1.50%) (8.70 days) and it was on par with T3 (EFF@1.00%) and T2 (EFF@0.50%) recorded 7.30 and 6.50 days whereas, the lowest shelf life 6.20 days was recorded in T1 (control) under ambient storage. Whereas in cold storage maximum shelf life was recorded in T5 (EFF @ 2.00%) (28.00 days) and minimum shelf life of 21.50 days was recorded in T1 (control). Effect of EFF was found to be most effective to prolong shelf life by higher firmness and minimum physiological loss in weight there by improving the shelf life. The similar result on shelf life was also reported by Amarjeet *et al*., (2016) [2] in sapota.

Total soluble solids (° Brix)

The minimum TSS (22.22°Brix) was recorded in T5 (EFF@2.00%) which was followed by T4 (EFF@1.50%) (22.35°Brix). The treatments, T3 (EFF@1.00%) and T2 (EFF@0.50%) recorded 22.57 and 23.25°Brix both are on par with each other. The maximum TSS (23.72°Brix) was observed in T1 (control) under ambient storage. In cold storage condition, the lowest TSS (21.36°Brix) was recorded in T5 (EFF@2.00%) and highest TSS (23.55°Brix) was recorded in T1 (control). This may be due to the increase in soluble solids content and total soluble sugars caused by hydrolysis of polysaccharides like starch, cellulose and pectin sub-stances into simpler substances. Similar findings have been reported by Sudha *et al*., (2007) [22] in sapota. (Table 2)

Ascorbic acid (mg\100g)

The maximum Ascorbic acid (16.36mg\100g) was recorded in T5 (EFF@2.00%) which was followed by T4 (EFF@1.50%) T3 (EFF@1.00%), and T2 (EFF@0.50%) recorded 15.73, 13.48 and 13.37 mg \100g respectively. Whereas, minimum Ascorbic acid (12.34 mg\100g) was observed in T1 (control) under ambient storage. In cold storage condition, the lowest Ascorbic acid (10.11 mg\100g) was recorded in T1 (control) and highest Ascorbic acid (18.78 mg\100g) was recorded in T5 (EFF@2.00%) indicating that the slowness of ripening due to EFF treatment and it might be due to retard the oxidation process and hence the rate of conversion of L-ascorbic acid in to de-hydro ascorbic acid was slow down. Similar findings were reported by Desai (2016) in sapota, Paliyath and Subramanian (2008) [17] in strawberry. (Table 2)

Titratable acidity (%)

The maximum titrable acidity (0.17%) was recorded in T5 (EFF@2.00%) followed by T4 (EFF@1.50%) was 0.15% and minimum acidity (0.10%) was recorded in T1 (control) under ambient storage. Whereas, the lowest titrable acidity (0.08%) was recorded in T1 (control) and highest titrable acidity (0.13%) was recorded in T5 (EFF@2.00%) under cold storage. The treatment with EFF recorded the maximum titrable acidity might be due to delayed respiration rate and conversion of organic acids into sugars. The similar result on acidity was also reported by Patel *et al*., (2017) [18] in sapota. (Table 2)

Total sugars (%)

The treatment T5 (EFF@2.00%) recorded significantly minimum total sugars (11.27%) and it was followed by T4 (EFF@1.50%)was 12.14%.The maximum total sugars (12.82%) registered in T1 (control) under ambient storage. In low temperature condition, the lowest total sugars (11.66%) was recorded in T5 (EFF@2.00%) and highest total sugars (14.93%) was recorded in T1 (control). The gradual 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. Similar findings have been reported by Tsomu and Patel (2014) [24] in sapota. The lower sugar content under reduced temperature storage conditions may be due to the inhibition of acid metabolism and dehydration, which reduced soluble sugar concentrations in fruit Kanmani *et al.* (2018.) [13] in banana. (Table 2)

Conclusion

On the basis of research findings, it can be concluded that postharvest dip of sapota fruits cv. PKM 1 with EFF@2% found effective for increase in shelf life with minimum physiological loss in weight and maximum fruit firmness. The fruit biochemical quality parameters were revealed that a gradual increase in total soluble solids, total sugars with maximum acidity and ascorbic acid content in sapota fruits at both ambient and cold storage condition.

Table 1: Effect of post-harvest dip of EFF on Physiological loss in weight (%), Firmness (lbs) and Shelf life (days) of sapota cv. PKM1 under ambient and cold storage

Physiological loss in weight (%)											
Storage	Ambient storage (28 °C ± 2 °C)					Cold storage (14 °C ± 2 °C)					
Treatments	3 DAS	6 DAS	9 DAS	Firmness (lbs)	Shelf life	3 DAS	12 DAS	20 DAS	28 DAS	Firmness (lbs)	Shelf life
T_1 - Control	6.86	24.68	48.72	3.16	6.20	2.80	13.78	28.10	56.98	3.12	21.50
T_2 - EFF@ 0.50%	6.45	22.45	42.64	3.28	6.50	1.86	16.30	32.19	36.56	3.24	23.25
T_3 - EFF@ 1.00%	5.76	22.56	38.52	3.62	7.30	1.55	6.45	14.22	18.48	3.46	23.75
T_4 - EFF@ 1.50%	5.34	20.38	36.78	4.43	8.70	0.96	6.06	12.32	17.70	4.26	26.50
T_5 - EFF@ 2.00%	4.78	19.42	34.54	4.89	9.00	0.63	4.58	11.00	15.92	4.67	28.00
MEAN	5.83	21.89	40.24	3.87	7.54	1.56	9.43	19.57	29.13	3.75	24.60
SE(d)	0.091	0.333	0.420	0.032	0.103	0.027	0.148	0.359	0.351	0.059	0.560
CD(p=0.05)	0.195	0.717	0.904	0.069	0.221	0.057	0.318	0.771	0.754	0.106	1.260

Table 2: Effect of post-harvest dip of EFF on fruit biochemical characters of sapota cv.PKM1 under ambient **(**28 °C ± 2 °C**)** and cold (14°C ± 2 °C) storage condition

Treatments	Total soluble solids (TSS) (ºBrix)		Ascorbic acid (mg\100g)		Titrable Acidity (%)		Total sugar (%)	
	Ambient	Cold	Ambient	Cold	Ambient	Cold	Ambient	Cold
T_1 - Control	23.72	23.55	12.34	10.11	0.10	0.08	12.82	14.93
T_2 - EFF@ 0.50%	23.25	23.33	13.48	12.55	0.11	0.09	12.48	14.77
T_3 - EFF@ 1.00%	22.57	22.77	13.37	15.66	0.14	0.11	12.33	14.55
T_4 - EFF@ 1.50%	22.35	21.44	15.73	16.77	0.15	0.12	12.14	13.55
T_5 - EFF@ 2.00%	22.22	21.36	16.36	18.78	0.17	0.13	11.27	11.66
MEAN	22.82	22.49	14.26	14.77	0.13	0.11	12.21	13.89
SE(d)	0.119	0.157	0.144	0.114	0.007	0.003	0.066	0.068
CD(p=0.05)	0.256	0.318	0.309	0.231	0.015	0.006	0.141	0.137

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