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ORIGINAL ARTICLE

Storage behavior of mango as affected by post harvest application of plant extracts and storage conditions

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Abstract The use of plant extracts could be a useful alternative to synthetic fungicides in the post harvest handling of fruits and vegetables. The aim of this study was to access the efficacy of extracts obtained from four plants (*neem*, *Pongamia*, custard apple leaf and marigold flowers) on the extension of shelf life of mango fruits cv. Dashehri under two storage conditions (Cool store and ambient condition). The fruits were treated with 2 concentrations of each plant extracts (10 % and 20 %) were placed in perforated linear low density poly ethylene bags and stored in storage conditions viz., cool storage and ambient condition, respectively. The treatment of *neem* leaf extract in combination with cool storage gave encouraging results. Up to the end of the storage study the treatment combination of 20 % *neem* leaf extract and cool store completely inhibited the pathogens, and no spoilage was observed. There was minimum physiological loss in weight (6.24 %), minimum girth reduction (0.62 %), maximum ascorbic acid content (29.96 mg/100 g of pulp), maximum acidity (0.19 %), minimum pH (5.28), maximum total soluble solids (20.96 %), maximum total sugars (12.50 %), reducing sugars (4.12 %) and non- reducing sugars (7.96 %) and best organoleptic score (7.93/10) in this interaction. The inhibitory effect of *neem* leaf extract was ascribed to the presence of active principle *azadirachtin*.

Keywords Mango storage · Plant extracts · Neem · Custard apple · Pongamia · Marigold

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Mango (*Mangifera indica* L.) is one of the most important fruit crops of India having socio-economic significance. Country wide it covers an area of 2,297 thousand ha with an annual production of 15,188 thousand MT (Anonymous 2011). Mango fruits are considered to be a good source of carotenoid (precursor of Vitamin A), Vitamin C, fair source of organic acids, carbohydrates and minerals. 'Dashehari' is one of the most popular mango varieties of North India, widely acclaimed for its exquisite taste and pleasant aroma. It has attractive yellow pulp, firm and non-fibrous, with very sweet taste fruits and pleasant aroma.

Mango is classified as 'climacteric fruit' and suffers 20–30 % losses each year due to shorter storage life and rapid ripening process. Fungal spoilage is the main cause of post harvest rots of fresh fruits and vegetables during storage and transport (Moss 2002) and cause significant losses in commercialization phase. For the last few years the post harvest application of various fungicides, growth regulators and waxing materials have gained popularity among growers, to enhance the shelf life of fruits. However, owing to increased resistance of some post harvest fungal pathogens against authorized fungicides (Reimann and Deising 2000; Dianz et al. 2002), their residual toxicity, environmental pollution and their side effects on human health (Lingk 1991; Unnikrishnan and Nath 2002) there has been increased efforts to develop alternative control measures (Smilanick et al. 2008; Droby et al. 2009; Casals et al. 2010). Extracts obtained from plants have recently gained popularity and scientific interest for their antibacterial and antifungal activity (Lee et al. 2007; Santas et al. 2010).

A number of plants found in India have been successfully used for therapeutic purpose (Chopra et al. 1965). The antimicrobial activity of many plants against post harvest pathogens have been demonstrated in citrus (Singh et al. 2011), mango (Banos et al. 2002), papaya (Banos et al.

2002) and yam (Okigbo and Ogbonnaya 2006). Grainage et al. (1984) have also documented and classified a number of plants belonging to various families having growth regulating and fungicidal properties. Plants like *neem* (*Azadirachta indica* J., Meliaceae), have shown excellent results and there already are commercial products in the market made from it. Similarly leaf extracts of Karanj (*Pongamia pinnata*), custard apple (*Annona squamosa*) and flower extract of marigold (*Tagetes erecta*) are known to posses germicidal, insecticidal and growth regulating properties. Some work has already been done on the evaluation of potential of plant extracts of *neem*, Karanj, custard apple leaves and Marigold flower for increasing the post harvest shelf life of apple fruits cv. 'Starking Delicious'(Chauhan et al. 2008) and mango cv. 'Langra'(Singh et al. 2000). Therefore, the objective of the present study was to evaluate the effect of these plant extracts on the post harvest shelf life and physicochemical changes during storage of mango fruits cv. Dashehari at ambient condition and at low temperature.

Material and methods

Fresh leaves of custard apple (*Anona squamosa),* Karanj (*Pongamia pinnata*), *neem* (*Azadiracta indica)* were collected from a farm nearby the College. Fresh marigold flowers (*Tegetus erects)* had been procured from government nursery, Kota. Fresh leaves and floral petals were shade dried in the laboratory. After drying the plant material was ground in a mechanical grinder to prepare a fine powder. Now 200 g of powder was soaked in 1,000 ml of sterile distilled water for 6 h and then passed through the muslin cloth. The filtrate was used as a stock solution (100 %) for preparing coating solution of different strengths by further dilution.

Fully matured, uniform sized fruits of mango, variety Dashehari were used for the study. The fruits were procured from the local market with prior arrangements. They were brought to the laboratory and sorting was done to select only uniform size, shape and maturity stage. After sorting, the fruits were washed thoroughly in the running water to remove dirt and dust and air dried. Whole lots of fruits was randomly divided into 9 lots and given all the plant extract treatments. Distilled water (control) (T_1), *neem* leaves extract 10 % and 20 %(T_2 and T_3), custard apple leaves extract 10 % and 20 %(T_4 andT_5), *Pongamia* leaves extract 10 % and 20 %(T_6 and T_7) and Marigold flower extract 10 % and 20 %(T_8 and T_9). With each treatment 2 % guar gum was also added to act as sticker. Control fruits were treated with distilled water containing 2 % guar gum. The fruit were dipped in respective treatment for 5 min followed by placing them on newspaper sheet for drying in shade for 30 min. After treatment the fruits of each lot were packed in polythene bags of 200 gauge thickness with 3 % area under perforation. The above mentioned treatments were duplicated, for storing in Storage at cool store (13±1 °C and 85 % relative humidity) and under ambient storage condition (Average temperature 36 °C and 75.8 % RH).

Observations regarding physiological loss in weight (PLW), spoilage, organoleptic score, TSS, acidity, ascorbic acid, total sugars and reducing sugars were recorded at 4 days interval during the storage period of 12 days. PLW was calculated by weighing the fruits on physical balance, spoilage was calculated on % basis, Total soluble solids (TSS) was measured by Erma's hand refractometer and expressed in percentage, acidity and ascorbic acid content of the sample was determined by titrometric method as described by Ranganna (1997) and total and reducing sugar content was determined by colorimetric methods (Sadasivum and Manickam 1992). Organoleptic evaluation was carried out by a panel of 7 judges who scored on 9 point hedonic scale (Amerine et al. 1965). The initial values as observed at the start of the experiment (0 days) were- sensory score: 6.14, total soluble solids: 17.5 %, acidity: 0.35 %, ascorbic acid: 46.29 mg/ 100 g of pulp, total sugars: 11.06 % and reducing sugars: 3.1 %.

Statistical analysis The experiment was arranged in factorial completely randomized design (factorial CRD), with 18 treatment combinations each having 3 replicates. Each replicate was comprised of 7 uniform sized fruits of mango cv. Dashehri. Data were subjected to analysis of variance (ANOVA) using statistical software OPSTAT, CCS HAU, Haryana, India and the critical difference (C.D. $P \le 0.05$) was used to compare the means (Gomez and Gomez 1984). Data expressed as percentage were transformed in to arcsin square root values to normalize the distribution before analysis of variance; however, the percentages are shown as untransformed data.

Results and discussion

PLW Physiological loss in weight was found to be very slow in fruits treated with 20 % *neem* leaf extract as compared to control and other treatments (Tables 1 and 2), which could be due to its ability to retard moisture loss and senescence mechanism as reported by Gakhukar (1996). The ability of *neem* leaf extract to check the growth of microbes, responsible for rotting and high metabolic rate might be another probable reason behind its efficacy in reducing PLW (Singh et al. 2000; Chauhan et al. 2008). Among storage conditions, the mango fruits stored in cool storage showed minimum PLW as compared to ambient condition during storage. The low temperature and high humidity prevalent in cool storage might have brought about

Table 1 Effect of plant extracts and storage conditions on physiological loss in weight (%) of mango fruits cv. Dashehari

Treatments	Storage period(days)								
	4			8			12		
	C.S.	A.T.	Mean	C.S.	A.T.	Mean	C.S.	A.T.	Mean
Control	3.2 [a](10.3)	8.8 (17.2)	5.9 (13.8)	6.1 (14.3)	21.6 (27.8)	13.9 (21.0)	9.2 (17.7)	35.2 (36.4)	22.2 (27.0)
Neem 10 %	1.8 (7.8)	4.8 (12.6)	3.3 (10.2)	5.3 (13.3)	16.7 (24.1)	11.0 (18.7)	6.9 (15.2)	19.6 (26.3)	13.3 (20.8)
Neem 20 %	1.7 (7.5)	4.6 (12.3)	3.1 (9.9)	5.2 (13.1)	15.9 (23.5)	10.5 (18.3)	6.2 (14.5)	18.8 (25.7)	12.5 (20.1)
C.A. 10 %	3.1 (10.1)	6.9 (15.3)	5.0 (12.7)	5.8 (13.9)	18.2 (25.3)	12.0 (19.6)	8.9 (17.4)	32.2 (34.5)	20.5 (25.9)
C.A. 20 %	3.0 (10.0)	6.5 (14.8)	4.8 (12.4)	5.6 (13.7)	18.0 (25.1)	11.8 (19.4)	8.6 (17.1)	29.7 (33.0)	19.2 (25.0)
Pongamia 10 %	2.9 (9.9)	5.5 (13.5)	4.2 (11.7)	5.4 (13.5)	17.2 (24.5)	11.3 (19.0)	8.5 (17.0)	28.7 (32.4)	18.6 (24.7)
Pongamia 20 %	2.9 (9.8)	5.3 (13.4)	4.1 (11.6)	5.3 (13.4)	17.6 (24.8)	11.5 (19.1)	8.4 (16.9)	26.2 (30.8)	17.3 (23.8)
Marigold 10 %	3.2 (10.3)	7.7 (16.1)	5.4 (13.2)	6.1 (14.3)	18.9 (25.8)	12.5 (20.0)	9.1 (17.6)	34.3 (35.8)	21.7 (26.7)
Marigold 20 %	3.2 (10.2)	7.6 (16.0)	5.4 (13.1)	6.0 (14.2)	18.7 (25.6)	12.4 (19.9)	9.1 (17.5)	34.2 (35.8)	21.7 (26.6)
Storage cond. mean	2.8 (9.5)	6.4 (14.6)		5.7 (13.8)	18.1 (25.1)		8.3 (16.7)	28.8 (32.3)	
		SE(m)	C.D. 5 %	SE(m)	C.D. 5 %		SE(m)	C.D. 5 %	
Storage condition (A)		0.009	0.027	0.006	0.016		0.011	0.031	
Treatment (B)		0.020	0.058	0.012	0.034		0.023	0.066	
AXB interaction		0.028	0.081	0.017	0.048		0.032	0.093	

[a] Figures in parenthesis are retransformed arc sign values

-Acronyms: *CA* Custard apple, *CS* Cold store, *AT* Ambient temperature

-Each observation is a mean of 3 replicate (r=3)

-Cool store (13 C; 85 % RH), ambient condition (average temperature 36 C; 75.8 % RH)

Table 2 Effect of plant extracts and storage conditions on the spoilage (%) of mango fruits cv. Dashehari

Treatments	Storage period(days)					
	8			12		
	C.S.	A.T.	Mean	C.S.	A.T.	Mean
Control	28.9 (23.8)	46.3 (52.4)	37.6 (38.1)	32.3 (28.6)	67.7 (85.7)	50.0 (57.1)
Neem 10 %	0.0 (0.0)	22.2 (14.3)	11.1 (7.1)	0.0 (0.0)	51.9 (61.8)	25.9 (30.9)
Neem 20 %	0.0 (0.0)	22.2 (14.3)	11.1 (7.1)	0.0 (0.0)	46.3 (52.3)	23.2 (26.2)
C.A. 10 %	14.8 (9.5)	38.0 (38.1)	26.4 (23.8)	25.5 (19.0)	61.0 (76.1)	43.3 (47.6)
C.A. 20 %	7.4 (4.8)	35.1 (33.3)	21.3 (19.1)	25.5 (19.1)	58.1 (71.4)	41.8 (45.2)
Pongamia 10 %	0.0 (0.0)	28.9 (23.8)	14.5 (11.9)	22.2 (14.3)	54.8 (66.6)	38.5 (40.5)
Pongamia 20 %	0.0 (0.0)	25.6 (19.0)	12.8 (9.5)	14.8 (9.5)	51.9 (61.9)	33.4 (35.7)
Marigold 10 %	28.9 (28.6)	46.3 (52.3)	37.6 (40.5)	35.1 (23.8)	67.7 (85.7)	51.5 (54.8)
Marigold 20 %	25.6 (19.0)	46.3 (52.3)	35.9 (35.7)	28.9 (23.8)	64.4 (80.9)	46.7 (52.4)
Storage cond. mean	11.7 (9.5)	34.57 (33.3)		20.5 (15.3)	58.2 (71.4)	
	SE(m)	C.D. 5 %		SE(m)	C.D. 5 %	
Storage condition (A)	1.125	3.239		1.057	3.043	
Treatment (B)	2.386	6.871		2.242	6.455	
AXB interaction	3.374	NS		3.170	9.129	

-No spoilage was observed up to 4 days of storage

*Figures in parenthesis are retransformed arc sign values

-Acronyms: *CA* Custard apple, *CS* Cold store, *AT* Ambient temperature

-Each observation is a mean of 3 replicate (r=3)

-Cool store (13 C; 85 % RH), ambient condition (average temperature 36 C; 75.8 % RH)

the reduction in PLW by reducing the moisture loss through decrease in respiration rate and transpiration. These results are in line with the observations as reported by Doreyappy and Huddar (2001) in mature green Alphanso.

Spoilage The spoilage was mainly brought about by rotting caused by pathogens. On the 12th day of storage no spoilage was observed in fruits treated with 20 % *neem* leaf extract stored at cool storage while untreated fruits at ambient condition exhibited 85.7 % spoilage. Reduction in spoilage with the use of *neem* leaf extract may be attributed to the presence of principle compound azadiractin which has the ability to check the growth of pathogenic microorganisms that are responsible for rotting (Chai et al. 1991; Gakhukar 1996) as well as less contamination and infection under low temperature conditions prevailing in cool storage as compared to ambient condition (Narayana et al. 1996). It can be seen that the inhibitory action of *neem* leaf extract was more at cool store as compared to ambient temperature. Similar findings were reported by Baswa et al. (2001).

Organoleptic score In general, initially the organoleptic score of the fruits increased with reference to score at zero days of storage (6.14), and thereafter decreased gradually, irrespective of the treatments and storage condition. This could be due to occurrence of ripening process in the fruits followed by senescence. However, within treatment the fruits treated with 20 % *neem* leaf extract slow down the changes responsible for alteration in organoleptic score as compared to control. These findings are in conformity with the findings of Bhardwaj et al. (2010). At the end of the storage, the maximum organoleptic score was observed in fruits treated with 20 % *neem* leaf extract. Whereas in control, the fruits had lowest score (Table 3) due to faster degradative changes in carbohydrate, acids, phenolic compounds and spoilage which accounted for loss of colour and flavour of the fruits (Malundo et al. 1997).

Similarly, changes in the overall organoleptic score were slower in cool stored fruits as compared to those under ambient condition (Table 3). This might be due to slower rate of metabolic changes and associated ripening and senescence under low temperature conditions of cool storage.

TSS Initially, the total soluble solids content of fruits increased which may be due to the hydrolysis of insoluble polysaccharide into simple sugars. Afterwards it declined gradually may be due to decline in the amount of carbohydrates and pectin, partial hydrolysis of protein and decomposition of glycosides into sub-units during respiration. At the end of the storage study, the highest TSS content were recorded in fruits treated with 20 % *neem* leaf extract (Table 4), which might be because of reduced respiration rate and delayed ripening in this treatment whereas, the lowest was in control, probably due to higher respiratory

Table 3 Effect of plant extracts and storage conditions on organoleptic score (out of 10) of mango fruits cv. Dashehari

Treatments	Storage period (days)								
	4			8			12		
	C.S.	A.T.	Mean	C.S.	A.T.	Mean	C.S.	A.T.	Mean
Control	6.9	9.0	7.9	8.7	4.2	6.4	5.2	0.5	2.9
Neem 10 %	6.2	8.1	7.1	7.2	4.7	5.9	7.7	1.3	4.5
Neem 20 %	6.1	8.0	7.1	7.1	4.8	6.0	7.9	1.4	4.6
C.A. 10 %	6.3	8.8	7.5	8.2	4.4	6.3	6.2	0.9	3.6
C.A. 20 %	6.2	8.5	7.4	8.1	4.5	6.3	6.3	1.0	3.7
Pongamia 10 %	6.5	8.3	7.4	7.5	4.6	6.1	7.1	1.1	4.1
Pongamia 20 %	6.6	8.2	7.4	7.4	4.7	6.1	7.3	1.1	4.2
Marigold 10 %	6.8	8.9	7.9	8.5	4.3	6.4	5.3	0.5	2.9
Marigold 20 %	6.7	8.9	7.8	8.5	4.3	6.4	5.2	0.6	2.9
Storage cond. mean	6.5	8.5		7.9	4.5		6.5	0.9	
	SE(m)	C.D. 5 %		SE(m)	C.D. 5 %		SE(m)	C.D. 5 %	
Storage condition (A)	0.005	0.015		0.005	0.015		0.005	0.015	
Treatment (B)	0.011	0.032		0.011	0.033		0.011	0.032	
AXB interaction	0.016	0.045		0.016	0.046		0.016	0.046	

-Acronyms: *CA* Custard apple, *CS* Cold store, *AT* Ambient temperature

-Each observation is a mean of 3 replicate (r=3)

-Cool store (13 C; 85 % RH), ambient condition (average temperature 36 C; 75.8 % RH)

Table 4 Effect of plant extracts treatment and storage conditions on total soluble solids (°Brix) of mango fruits cv. Dashehari

Treatments	Storage period(days)								
	4			8			12		
	C.S.	A.T.	Mean	C.S.	A.T.	Mean	C.S.	A.T.	Mean
Control	18.6	21.5	20.0	21.2	19.5	20.4	20.2	15.3	17.1
Neem 10 %	18.2	21.1	19.7	21.4	19.8	20.6	20.6	15.4	18.0
Neem 20 %	18.1	21.1	19.6	21.4	19.9	20.6	20.7	15.4	18.1
C.A. 10 %	18.4	21.4	19.9	21.3	19.6	20.5	20.3	15.2	17.7
C.A. 20 %	18.3	21.3	19.8	21.3	19.7	20.5	20.3	15.2	17.7
Pongamia 10 %	18.3	21.3	19.8	21.3	19.7	20.5	20.3	15.3	17.8
Pongamia 20 %	18.2	21.2	19.7	21.4	19.7	20.6	20.3	15.3	17.8
Marigold 10 %	18.5	21.4	20.0	21.2	19.5	20.4	20.2	15.2	17.7
Marigold 20 %	18.4	21.4	19.9	21.2	19.5	20.4	20.1	15.2	17.6
Storage cond. mean	18.3	21.3		21.3	19.7		20.3	15.3	
	SE(m)	C.D. 5 %		SE(m)	C.D. 5 %		SE(m)	C.D. 5 %	
Storage condition (A)	0.005	0.014		0.005	0.016		0.006	0.017	
Treatment (B)	0.010	0.030		0.012	0.033		0.012	0.035	
AXB interaction	0.015	0.042		0.016	0.047		0.017	0.050	

-Acronyms: *CA* Custard apple, *CS* Cold store, *AT* Ambient temperature

-Each observation is a mean of 3 replicate (r=3)

-Cool store (13 C; 85 % RH), ambient condition (average temperature 36 C; 75.8 % RH)

losses in these fruits as there was no barrier to restrict the movement of gases in the fruit (Singh et al. 2000).

The rate of increase in TSS was found to be faster in fruits stored at room temperature as compared to cool stored fruits. It could be due to high temperature and low relative humidity at room temperature resulted in conversion of starch and other insoluble carbohydrates in soluble sugars. The TSS and sugars were further utilized for respiration thus showing the lower content in fruit tissues. Prolonged storage of mango fruits at low temperature with high humidity in cool storage might be impeded the ripening process resulting in lower values of TSS. The observations are in line with the findings, reported by Joshi and Roy (1985) at room temperature storage and Kapse et al. (1985) and Krishnamurthy and Joshi (1989) in cool storage condition of mango fruits.

Total acids The acidity of the fruit was the highest at zero days of storage and it decreased with the advancement of storage period. It may be due to rapid utilization of acid of the fruit pulp in respiration process and degradation of citric acid which in turn might have influence on reduction in acidity due to their conversion into sugars and further utilization in metabolic process in the fruit.

The different plant extract treatments had significant effect in slowing down ripening processes. Fruits treated with *neem* leaf extract showed higher retention of acidity during storage (Table 5). This could be due to the influence of treatments in delaying physiological ageing and alteration in metabolism, which might owed to higher retention of acidity. Similar results were observed by Bhardwaj and Sen (2003), Mitra et al. (1996), Gautam and Chundawat (1989).

The rate of decrease in acidity was found to be faster in room temperature stored fruits as compared to cool stored fruits. This might be due to influencing of high temperature and low humidity at ambient storage which may be resulted in faster degradation of organic acids into sugars and utilization of acids during respiration. On the contrary, prolonged storage of mango fruits at low temperature and high humidity in cool storage impeded the degradation of organic acids. Similar results were also reported by Joshi and Roy (1985) and Sahani and Khurdia (1989) at ambient storage and Krishnamurthy and Joshi (1989) in cool storage condition of mango fruits. These results also coincided with Doreyappy and Huddar (2001), Ghaouth et al. (1991) Garcia et al. (1998) and Srinivasa et al. (2002).

Ascorbic acid In general, a gradual decline in vitamin 'C' content of the fruits was observed during storage in all the treatments. The rate of decrease in vitamin C was significantly higher in untreated control fruits as compared to treated fruits. This might be due to rapid loss through oxidation because of greater availability of oxygen. The loss

Table 5 Effect of plant extracts and storage conditions on acidity content (%) of mango fruit pulp cv. Dashehari

Treatments	Storage period (days)								
	4			8			12		
	C.S.	A.T.	Mean	C.S.	A.T.	Mean	C.S.	A.T.	Mean
Control	0.31	0.26	0.28	0.21	0.12	0.16	0.18	0.03	0.10
Neem 10 %	0.36	0.29	0.33	0.22	0.16	0.19	0.19	0.05	0.12
Neem 20 %	0.38	0.29	0.34	0.22	0.16	0.19	0.19	0.05	0.12
C.A. 10 %	0.32	0.27	0.29	0.21	0.14	0.18	0.18	0.03	0.11
C.A. 20 %	0.32	0.28	0.30	0.22	0.14	0.18	0.17	0.03	0.11
Pongamia 10 %	0.32	0.29	0.31	0.22	0.14	0.18	0.18	0.04	0.11
Pongamia 20 %	0.34	0.29	0.32	0.22	0.15	0.18	0.19	0.04	0.12
Marigold 10 %	0.31	0.25	0.28	0.21	0.12	0.16	0.18	0.02	0.10
Marigold 20 %	0.32	0.26	0.29	0.21	0.12	0.16	0.18	0.02	0.10
Storage cond. mean	0.33	0.28		0.21	0.14		0.18	0.03	
	S.Em±	C.D. 5 %		S.Em±	C.D. 5 %		S.Em±	C.D. 5 %	
Storage condition (A)	0.001	0.002		0.001	0.002		0.000	0.001	
Treatment (B)	0.001	0.003		0.001	0.004		0.001	0.002	
AXB interaction	0.002	0.005		0.002	0.005		0.001	0.003	

-Acronyms: *CA* Custard apple, *CS* Cold store, *AT* Ambient temperature

-Each observation is a mean of 3 replicate (*r*=3)

-Cool store (13 C; 85 % RH), ambient condition (average temperature 36 C; 75.8 % RH)

in ascorbic acid during storage might be due to rapid conversion of L-ascorbic acid into dehydro-ascorbic acid in the presence of enzyme ascorbinase. Mapson (1970). The maximum retention of ascorbic acid (24.29 mg /100 g pulp of

Table 6 Effect of plant extracts treatment and storage conditions on ascorbic acid content (mg/100 g of pulp) of mango fruits cv. Dashehari

Treatments	Storage period (days)								
	4			8			12		
	C.S.	A.T.	Mean	C.S.	A.T.	Mean	C.S.	A.T.	Mean
Control	42.1	40.5	41.3	36.3	25.1	30.7	28.5	14.7	21.6
Neem 10 %	43.8	41.3	42.5	37.8	27.4	32.6	29.9	18.4	24.1
Neem 20 %	43.8	41.6	42.7	37.9	27.9	32.9	30.0	18.5	24.3
C.A. 10 %	42.5	40.2	41.3	37.1	25.4	31.3	29.1	16.3	22.7
C.A. 20 %	42.6	40.3	41.5	37.4	26.2	31.8	29.2	16.8	23.0
Pongamia 10 %	43.1	40.5	41.8	37.7	26.4	32.1	29.5	18.1	23.8
Pongamia 20 %	43.2	40.6	41.9	37.3	27.5	32.4	29.7	18.3	24.0
Marigold 10 %	42.2	40.1	41.2	36.4	26.2	31.3	28.4	15.0	21.7
Marigold 20 %	42.1	40.1	41.1	36.1	25.5	30.8	28.4	15.0	21.7
Storage cond. mean	42.8	40.6		37.1	26.4		29.2	16.8	
	S.Em±	C.D. 5 %		S.Em±	C.D. 5 %		S.Em±	C.D. 5 %	
Storage condition (A)	0.006	0.017		0.008	0.024		0.011	0.031	
Treatment (B)	0.012	0.036		0.018	0.052		0.023	0.066	
AXB interaction	0.018	0.051		0.025	0.073		0.032	0.093	

-Acronyms: *CA* Custard apple, *CS* Cold store, *AT* Ambient temperature

-Each observation is a mean of 3 replicate (*r*=3)

-Cool store (13 C; 85 % RH), ambient condition (average temperature 36 C; 75.8 % RH)

Table 7 Effect of plant extracts and storage conditions on total sugar content (%) of mango fruit pulp cv. Dashehari

Treatments	Storage period (days)								
	4			8			12		
	C.S.	A.T.	Mean	C.S.	A.T.	Mean	C.S.	A.T.	Mean
Control	11.8	12.8	12.3	12.4	10.1	11.2	11.9	5.8	8.9
Neem 10 %	11.6	12.4	12.0	12.8	10.3	11.5	12.4	5.9	9.1
Neem 20 %	11.5	12.3	11.9	12.9	10.3	11.6	12.5	5.9	9.2
C.A. 10 %	11.7	12.6	12.2	12.6	10.1	11.4	12.2	5.7	9.0
C.A. 20 %	11.7	12.6	12.1	12.6	10.2	11.4	12.2	5.8	9.0
Pongamia 10 %	11.6	12.6	12.1	12.7	10.2	11.5	12.3	5.8	9.1
Pongamia 20 %	11.6	12.5	12.0	12.8	10.3	11.5	12.4	5.9	9.1
Marigold 10 %	11.7	12.7	12.2	12.5	10.1	11.3	11.9	5.7	8.8
Marigold 20 %	11.7	12.8	12.2	12.5	10.1	11.3	12.0	5.7	8.8
Storage cond. mean	11.7	12.6		12.6	10.2		12.2	5.8	
	SE(m)	C.D. 5 %		SE(m)	C.D. 5 %		SE(m)	C.D. 5 %	
Storage condition (A)	0.004	0.013		0.005	0.014		0.006	0.017	
Treatment (B)	0.009	0.027		0.011	NS		0.012	0.036	
AXB interaction	0.013	0.038		0.015	0.043		0.018	0.051	

-Acronyms: *CA* Custard apple, *CS* Cold store, *AT* Ambient temperature

-Each observation is a mean of 3 replicate (*r*=3)

-Cool store (13 C; 85 % RH), ambient condition (average temperature 36 C; 75.8 % RH)

the fruit) with 20 % *neem* leaf extracts treatment (Table 6) which might be due to influence of the *neem* leaf extract on reducing respiration as well as oxidation in the fruits.

Table 8 Effect of plant extracts and storage conditions on reducing sugar content of mango fruits cv. Dashehari

Treatments	Storage period (days)								
	4			8			12		
	C.S.	A.T.	Mean	C.S.	A.T.	Mean	C.S.	A.T.	Mean
Control	3.3	3.9	3.6	3.6	2.9	3.3	3.3	2.4	2.9
Neem 10 %	3.1	3.7	3.4	4.2	3.2	3.7	4.0	2.5	3.3
Neem 20 %	3.1	3.6	3.4	4.3	3.3	3.8	4.1	2.6	3.3
C.A. 10 %	3.3	3.9	3.6	3.7	3.0	3.3	3.6	2.4	3.0
C.A. 20 %	3.2	3.8	3.5	3.7	3.0	3.3	3.6	2.4	3.0
Pongamia 10 %	3.2	3.7	3.5	3.8	3.1	3.4	3.7	2.5	3.1
Pongamia 20 %	3.2	3.7	3.5	3.9	3.1	3.5	3.8	2.5	3.2
Marigold 10 %	3.3	3.9	3.6	3.7	2.8	3.2	3.4	2.4	2.9
Marigold 20 %	3.3	3.9	3.6	3.6	2.8	3.2	3.3	2.4	2.9
Storage cond. mean	3.2	3.8		3.8	3.0		3.7	2.5	
	SE(m)	C.D. 5 %		SE(m)	C.D. 5 %		SE(m)	C.D. 5 %	
Storage condition (A)	0.005	0.015		0.005	0.016		0.005	0.014	
Treatment (B)	0.011	0.032		0.012	0.033		0.011	0.031	
AXB interaction	0.016	0.046		0.016	0.047		0.015	0.043	

-Acronyms: *CA* Custard apple, *CS* Cold store, *AT* Ambient temperature

-Each observation is a mean of 3 replicate (*r*=3)

-Cool store (13 C; 85 % RH), ambient condition (average temperature 36 C; 75.8 % RH)

The best retention of ascorbic acid in cool storage as compared to ambient temperature storage could be attributed to prevalence of low temperature and high relative humidity. The finding is in conformity to the observations as reported by Keleny et al. (2010) during cool chamber storage of mango fruits.

Total and reducing sugars Storage condition influenced the effectiveness of treatments on the total and reducing sugars content of mango fruits during storage, It was found to be higher in mango fruits stored at ambient temperature on the 4th day of storage, compared to the mango fruits stored in cool storage, however, the latter had higher levels of sugars on the day 8th and 12th (Tables 7 and 8). It might be due to the fact that high temperature and low relative humidity at room temperature resulted in conversion of starch and other insoluble carbohydrates in soluble sugars . The sugars were further utilized for respiration thus showing the lower content of sugars at the later period of storage. The low temperature in cool storage reduces fruit metabolism, particularly respiratory activity, delaying the ripening process and increasing fruit shelf life up to two weeks (Koksal 1989). The observations are in line with the findings, reported by Joshi and Roy (1985) at room temperature storage and Kapse et al. (1985) and Krishnamurthy and Joshi (1989) in cool storage condition of mango fruits.

The fruits treated with *neem* leaf extract showed slow increase in sugars content because of the slower metabolic rates and low respiration rate as compared to control ones.

The results obtained from the experiment indicated that the use of plant extracts especially *neem* leaf extract in combination with cool storage showed a greater degree of spoilage inhibition and slowed down the associated changes in the mango fruits cv. Dashehri. during storage. To the best of our knowledge, this is the first report on the use of plant extracts from neem, custard apple, Pongamia leaves and marigold flowers for post harvest treatment of mango fruits cv. Dashehri. Further studies are in progress to examine the efficacy of plant extracts of other higher plants on the post harvest spoilage of mango and citrus fruits.

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