Response of different leaf cushioning on post harvest behaviour of mango (*Mangifera indica* L.) cv. Dashehari

VANDANA DHAMI and C. P. SINGH

Department of Horticulture, College of Agriculture, G. B. Pant University of Agriculture and Technology, Pantnagar-263145 (U. S. Nagar, Uttarakhand),

ABSTRACT: The experiment was conducted during 2010-11 and 2011-12 with the objective of determining suitable cushioning treatment for better shelf life and quality of mango (*Mangifera indica*) fruits. The experiment was laid out in factorial completely Randomized Design with six treatments and four replications. Fresh leaves of plants known to possess anti- microbial properties were collected during the fruiting season 2010-11 and 2011-12. Cushioning treatments with fresh leaves reduced the physiological loss in weight significantly as compared to control with lowest significant mean value of PLW (8.43%) observed in T_2 (Mentha leaves) followed by T_1, neem leaves (8.44%) and T_3, Eucalyptus leaves (8.82%) which were at par to each other and were significantly lower to other treatments. Minimum spoilage (21.24%) was recorded in treatment T_1 (Neem leaves) which was found significantly lower than other treatment mean values including control, while, maximum spoilage (34.76 %) was noticed in T_6 (control). The longest shelf life (12.03 days) was observed with the treatment T_1 (Neem leaves) followed by fruits under T_2 (11.47 days), T_3 (10.94 days) and T_4 (10.56 days). Maximum TSS content (18.21 ºB) was recorded in the treatment T_1 (Neem leaves) and T_2 (Mentha leaves) which was significantly higher than other treatment means, while, the minimum TSS content (16.58 ºB) was observed in T_6 (control) which was significantly lower than other treatments. Maximum titratable acidity (1.163%) was found in treatment T_6 on 0 day of storage which was at par with T_4 (1.159%), T_5 (1.158%) and T_3 (1.148%) on same day. Therefore, neem leaves followed by mentha leaves can be recommended to enhance the shelf life and quality characters of mango fruits under ambient storage conditions.

Key words : Leaf cushioning, mango, shelf life

Mango has become a popular fruit in the world and is praised due to its delicious taste, unique and attractive flavour with high nutritive, diuretic and therapeutic values. Mango is well established as an item of international trade because of its superb quality. Mango production has become an important industry in India with a production of about 18421.3 thousand MT from an area of 2516 thousand ha (Anonymous, 2014). The export market for mango has become highly lucrative.

Mango fruit is vulnerable to post harvest losses due to its high perishable nature and susceptibility to varieties of disorders during post harvest handling and storage. The trade of mango has been significantly limited due to their short shelf life and highly perishable nature (Gil *et al*., 2000). Considerable postharvest losses of fruit are brought about by decay caused by fungal plant pathogens and hence inhibiting the growth of fungi has great significance in post harvest management of fruit. But in recent years, the use of synthetic fungicides and chemicals has increased consumer concern and (but) their use is becoming more restrictive due to carcinogenic effects, residual toxicity problems, environmental pollution, occurrence of microbial resistance and high inputs (Rial Otero *et al*., 2005). There are more than 150 species of plants, herbs and shrubs having medicinal as well as anti-microbial properties which have been successfully used in the postharvest handling of horticultural and agricultural crops (Ahmed and Grainage, 1986). One such practice consists of using fresh botanical leaves such as neem, melia, mentha, walnut, banana, basooti, etc. as cushioning material within package during transportation and storage of fruits and vegetable. Apart from providing cushioning effect these leaves can release certain volatiles in to the vicinity of fruits which might be useful in retaining quality and reducing spoilage.

MATERIALS AND METHODS

The present investigation was carried out in the Department of Horticulture, Govind Ballabh Pant University of Agriculture and Technology, Pantnagar, district Udham Singh Nagar (Uttarakhand), India during two consecutive years in 2011 and 2012. Fruits for experiments pertaining to postharvest treatments were procured from orchards of Horticulture research centre, Patharchatta which was 500 m away from laboratory where treatments were given. All the trees from which fruits were taken were maintained under a strictly uniform schedule of cultural operations. Fresh leaves of plants known to possess anti- microbial properties were collected during the fruiting season 2010-11 and 2011-12. Approximately 25 gm of fresh leaves were placed in CFB cartons of 3.5 kg capacity along with the fruit and kept under ambient storage (temperature 31±1 °C and humidity 60± 5%)) and for physico chemical analysis at 2 days interval during the storage period. The experiment consisted of six treatments viz., T_1- Neem leaves (25 g/ 3.5 kg mango fruits, T_2-Mentha leaves (25 g/ 3.5 kg mango fruits), T_3-Eucalyptus leaves (25 g/ 3.5 kg mango fruits), T_4- Bael leaves (25 g/ 3.5 kg mango fruits), T_5-Marigold leaves (25 g/ 3.5 kg mango fruits) and T_6-control (no cushioning). The experimental data were analysed statistically as per method designed by Snedecor and Cochran (1968) for factorial complete Randomized Design. Mango fruits were stored in a clean, hygienic and well ventilated room at ambient condition (temperature 31±1 °C and humidity 60± 5%) in different lots consisting of 20 fruits per treatment per replication. The containers were placed on the laboratory tables. The storage was terminated on the 14th day of storage, when the fruits became uneconomical. Physiological loss in fruit weight (PLW) and spoilage were recorded at every 2 days interval, while, chemical attributes were recorded at 3 days interval. The T.S.S. of fruit was recorded at room temperature using digital refractometer (Model no. A630355) and it was expressed in °Brix and chemical quality attributes were determined as per standard procedure described in AOAC (1980).

RESULTS AND DISCUSSION

Pooled data of the years 2011 and 2012 (Table-1) revealed that cushioning treatments with fresh leaves reduced the physiological loss in weight significantly as compared to control. The lowest significant mean value of PLW (8.43%) was observed in T_2 (Mentha leaves) followed by T_1, Neem leaves (8.44%) and T_3, Eucalyptus leaves (8.82%) which were at par to each other and were significantly lower to other treatments. Maximum physiological loss in weight (12.83%) was recorded in control. Storage periods also affected PLW significantly. Maximum mean PLW (15.16 %) was found on 14th day and minimum (2.36 %) on 2nd day of harvesting. Thus, significant increase in PLW with increasing storage periods was observed. However, the rate of loss in weight was faster on earlier days of storage, which gradually slowed down as the trial proceeded till the 14th day of storage. Significant interactions among storage periods and treatments were recorded. Data showed that with the increasing storage period, the physiological loss in weight of fruits under all the treatments and control increased significantly. Maximum PLW (20.93%) was observed in control on last day (14th day of storage), while, minimum PLW (1.42%) was found in T_1 (Neem leaves) on 2nd day of storage. Reduction in weight loss due to these treatments might be due to their effect on slowing down of physiological processes responsible for weight loss. Favourable effects of fresh leaves on lowering down the water vapour losses in fruits have also been reported by Samanta and Prasad (1996). Similar results were obtained by Ramesh and Pal, (2006) in litchi fruits cushioned with sisoo leaves in CFB boxes which was due to development of high humidity environment provided by sisoo leaves during storage.

Pooled data of 2011 & 2012 on spoilage (%) (Table 1) revealed that among all treatment means, minimum spoilage (21.24 %) was recorded in treatment T_1 (Neem leaves) which was found significantly lower than other treatment mean values including control, while, maximum spoilage (34.76 %) was noticed in T_6 (control). Storage periods significantly affected the fruit spoilage with maximum spoilage (86.26%) on 14th day i.e. last day of storage which was significantly higher than all the storage days, while, minimum (0.17%) was found on 2nd day. Fruit spoilage showed significant increase with the increasing storage period. Interactions among treatments & storage periods showed that maximum spoilage (100.00%) was found in control on last day of storage while, minimum spoilage was recorded in T_1 (0.00%) on 4th day of storage which was significantly at par with T_2 (0.42%) on same day. On 0 and 2nd day of storage all fruits were healthy with 0 % spoilage except control (1.00%) on 2nd day. All the leaf cushioning treatments significantly reduced the spoilage in mango fruits as compared to control. However, cushioning with neem leaves was found to be the most effective treatment in reducing spoilage during storage. Volatiles generated by these botanicals are reported to destroy incipient infection on fruit, which may cause rotting during storage (Saxena *et al*., 1981). Similar observations have also been reported by Gakhukar (1996), Singh *et al*. (2000) and Bhardwaj and Sen (2003). The active substances in these botanicals are important agents against pathogens in fruit and vegetable storage has been reported by various workers (Isman, 1996 and Pawar, 2001). Ramesh and Pal (2006) also reported minimum browning and spoilage in litchi fruits cushioned with sisoo leaves. Similarly, Chauhan *et al.* (2012) observed minimum spoilage in apple fruits cushioned with camphor leaves.

Pooled data for the years 2011 (Table 1) revealed that the effect of leaf cushioning on shelf life was found significant. The longest shelf life (12.03 days) was observed with the treatment T_1 (Neem leaves) followed by fruits under T_2 (11.47 days), T_3 (10.94 days) and T_4 (10.56 days). However, T_1 was found significantly higher than other treatments. Minimum shelf life of fruits (7.75

Table.1. Response of fresh leaves as cushioning material on physiological loss in weight, spoilage and shelf life of mango (*Mangifera indica* L.) cv. Dashehari

Treatments*	Pooled Physiological loss in weight (%) Storage period (days)								Pooled Spoilage % Storage interval in days									Pooled shelf life (Days)
	2nd	4th	6th	8th	10th	12th	14th	Mean	2nd	4th	6th	8th	10th	12th	14th	2nd	Mean	
T_1	1.42	5.99	9.12	11.45	12.67	13.23	13.67	8.44	0.00	0.00	0.00	3.63	15.02	31.92	47.71	71.66	21.24	12.03
	(6.82)	(14.16)	(17.56)	(19.76)	(20.84)	(21.32)	(21.69)	(15.27)	(0.00)	(0.00)	(0.00)	(10.97)	(22.80)	(34.39)	(43.69)	(57.88)	(21.21)	
T_2	2.32	6.27	9.33	11.36	12.29	12.79	13.07	8.43	0.00	0.00	0.42	4.77	16.43	34.17	52.02	76.29	23.01	11.47
	(8.74)	(14.49)	(17.77)	(19.69)	(20.51)	(20.94)	(21.18)	(15.42)	(0.00)	(0.00)	(1.86)	(12.61)	(23.90)	(35.73)	(46.16)	(60.88)	(22.64)	
T_3	1.71	6.96	9.83	12.40	13.21	13.09	13.37	8.82	0.00	0.00	4.79	6.40	24.87	41.73	59.88	84.87	27.82	10.94
	(7.51)	(15.29)	(18.27)	(20.91)	(21.29)	(21.20)	(21.44)	(15.70)	(0.00)	(0.00)	(12.64)	(14.64)	(29.91)	(40.20)	(50.70)	(67.12)	(26.90)	
T_4	2.51	7.18	10.17	12.67	13.15	13.74	14.12	9.19	0.00	0.00	5.21	7.16	24.08	42.55	60.58	86.88	28.31	10.56
	(9.08)	(15.53)	(18.59)	(20.85)	(21.26)	(21.75)	(22.07)	(16.14)	(0.00)	(0.00)	(13.16)	(15.52)	(29.36)	(40.71)	(51.11)	(68.84)	(27.34)	
T_5	2.85	7.96	11.50	13.66	14.98	15.44	15.82	10.28	0.00	0.00	5.42	8.33	27.01	41.42	80.40	97.88	32.56	8.50
	(9.71)	(16.38)	(19.82)	(21.69)	(22.77)	(23.14)	(23.43)	(17.12)	(0.00)	(0.00)	(13.45)	(16.77)	(31.31)	(40.05)	(63.73)	(83.03)	(31.04)	
T_6	3.36	9.96	14.25	16.33	17.95	19.90	20.93	12.83	0.00	0.00	14.17	30.00	69.17	79.27	96.00	100	48.58	7.75
	(10.57)	(18.39)	(22.17)	(23.83)	(25.07)	(26.48)	(27.21)	(19.21)	(0.00)	(0.00)	(22.06)	(33.21)	(56.28)	(62.92)	(78.52)	(90.00)	(42.87)	
GM	2.36	7.39	10.70	12.98	14.04	14.70	15.16	9.67	0.00	0.17	3.81	6.59	23.09	40.09	63.59	86.26	27.95	10.21
	(8.74)	(15.71)	(19.03)	(21.07)	(21.96)	(22.47)	(22.84)	(16.48)	(0.00)	(0.63)	(9.41)	(14.68)	(28.52)	(39.22)	(53.27)	(71.29)	(27.13)	

	Days	Treatment	Days X Treatment	Days	Treatment	Days XTreatment	
S.Em.±1	0.15 (0.13)	0.13(0.11)	0.36(0.32)	0.46 (0.38)	0.40 (0.33)	1.13 (0.94)	0.17
CD at 5%	0.41 (0.36)	0.36 (0.32)	1.01 (0.89)	1.29 (1.07)	1.12 (0.93)	3.16 (2.63)	0.52

*T_1: Neemleaves ,T_2: Mentha leaves, T_3: Eucalyptus leaves, T_4: Bael leaves , T_5: Marigold leaves, T_6: Control (No leaves)

days) was found in T_6 (control). The increase in shelf life might be due to reduced amount of weight loss, spoilage, shrivelling and enhanced fruit firmness, which provide improved fruit colour, better appearance, glossiness and enhanced market acceptability (Choudhury *et al.* (2003). Moreuil (1973) and Singh (1957) used *Revenala madagascariensis* leaves in litchi and Shisam leaves for different fruits that extended the storage life of fruits for 5 to 6 days under ambient condition. Rajendran and Chayakumari (2003) showed beneficial effect of fresh leaves of neem, eucalyptus, mentha and walnut against storage pathogens as well as the quality determining factors in stored sorghum.

Pooled data of year 2011 & 2012 showed that there was significant effect of fresh leaf cushioning on TSS content of fruits (Table 2.). Maximum TSS content (18.21 ºB) was recorded in the treatment T_1 (Neem leaves) and T_2 (Mentha leaves) which was significantly higher than other treatment means, while, the minimum TSS content (16.58 ºB) was observed in T6 (control) which was significantly lower than other treatments. TSS content increased significantly from 0 day i.e. Day of harvesting to 12^{th} day of storage and after reaching peak value on 12^{th} day the TSS content decreased significantly to 15^{th} day. However, maximum TSS content (20.45 ºB) was recorded on 12^{th} day of storage and the minimum TSS content (8.60 ºB) was observed on 0 day. Pooled data on interactions among storage periods & treatments showed that maximum TSS content (22.49 ºB) was recorded in the treatment T_1 (Neem leaves) on 12^{th} day of storage which was found at par with T_2 (22.41 ºB) on same day. The initial increase might be due to the fact that during storage starch get hydrolyzed into mono and disaccharides which leads to an increase in TSS and sugar content (Aly *et al*., 1981) and after complete hydrolysis of starch no further increase in these constituents occur but subsequently a decline due to utilization as primary substrates for respiration. The slower decline in these constituents might be due to the ability of the volatiles generated by the cushioning materials to slow down the rate of metabolism of fruits and hence utilize the respirable substrates at a slower rate. Similar findings have also been reported with cushioning of litchi fruit with fresh leaves of traveller tree (Samanta and Prasad, 1996).

Pooled data of year 2011 and 2012 showed that effect of cushioning leaves on titratable acidity content of fruits was found significant (Table 2.). Treatment mean values showed that maximum titratable acidity content (0.640 %) was recorded in T_6 (control), while, the minimum acidity (0.609 %) was found in treatment T_1 which was at par with T_2 (0.614 %).While, all other treatments showed significantly higher acidity content as compared to T_1

(Neem leaves). Storage periods significantly affected the acidity content of fruits. The titratable acidity content significantly decreased with increasing storage period. Maximum acidity (1.146 %) was recorded on 0 day of storage, while, the minimum acidity content (0.355 %) was observed on last day of storage. Significant effect of interaction between leaf cushioning treatments and storage periods were noticed on the titratable acidity. Maximum titratable acidity (1.163 %) was found in treatment T_6 on 0 day of storage which was at par with T_4 (1.159 %), T_5 (1.158 %) and T_3 (1.148 %) on same day. On the last day of storage maximum value of acidity (0.450%) was found in control, while, the minimum acidity was noted in T_1 (0.305 %) which was significantly at par with T_4 (0.308%), T_2 (0.313%) and T_3 (0.319%). While, it may be noted that maximum reduction in acidity content was recorded between 0 & 3rd day. This might be due to starch reserves in treated fruits are hydrolysed into glucose units at slower rate as result of which such fruits had high sugar and low acidity (Delvin, 1967) or due to conversion of acids into salts and sugar by the enzymes, particularly invertase or due to utilization of organic acids in respiratory process and other biodegradable reactions. The decrease in acidity might be due to the general catabolisation of organic acids and their conversion into sugars (Silva and Menezes, 2001).

Pooled analysis of data of both years revealed that maximum total sugar content (13.23%) was recorded in T_1 (Neem leaves) which was at par with T_2 (13.19%), while, minimum total sugar content (12.89 %) was found in T_5 (marigold leaves) and T_3 (Eucalyptus leaves). Storage intervals affected total sugar content significantly with maximum total sugar content (16.14%) was found on 9th day of storage and minimum (7.13%) was on 0 day i.e on day of harvesting. The values showed increasing trend from 0 to 9th day and then significant decrease from 9th to 15th day of storage. Significant interactions among treatments and storage periods were observed. On last day of storage, maximum total sugar content (16.17%) was observed in T_1 which was found at par with T_2 (16.16%), while, minimum value (14.72 %) was found in control. The increase in total sugar might be due to breakdown of complex polymers to simple substances by hydrolytic enzymes. This increase in sugar might also be due to conversion of certain cell wall material such as pectin and hemicelluloses into reducing substance during prolonged storage (Silva and Menezes, 2000). The initial increase might be due to the fact that during storage starch get hydrolyzed into mono and disaccharides which leads to an increase in TSS and sugar content (Aly *et al*., 1981) and after complete hydrolysis of starch no further increase in these constituents occur but subsequently a decline due to utilization as primary substrates for respiration. Singh *et al*. (2000) also

Table. 2: Response of fresh leaves as cushioning material on physiological loss in weight, spoilage and shelf life of mango (*Mangifera indica* L.) cv. Dashehari

Treatments*	Pooled TSS (B) Storage period (days)							Pooled Acidity % Storage interval in days							Pooled Total sugar						
	0	3	6	9	12	14	Mean	0	3	6	9	12	14	Mean	0	3	6	9	12	14	Mean
T_1	8.56	16.87	18.45	20.89	22.49	21.99	18.21	1.122	0.921	0.668	0.331	0.307	0.305	0.609	7.13	8.72	13.55	17.13	16.68	16.17	13.23
T_2	8.62	16.74	18.61	21.03	22.41	21.83	18.21	1.127	0.915	0.683	0.331	0.316	0.313	0.614	7.16	8.82	13.48	16.94	16.58	16.16	13.19
T_3	8.58	17.29	18.98	20.38	20.99	19.86	17.68	1.148	0.940	0.676	0.344	0.321	0.319	0.625	7.14	9.02	15.40	15.57	15.25	14.99	12.89
T_4	8.59	17.82	19.40	20.94	19.65	18.49	17.48	1.159	0.895	0.739	0.331	0.310	0.308	0.624	7.13	8.79	13.36	16.65	16.13	15.63	12.95
T_5	8.66	17.73	19.53	20.01	19.24	18.40	17.26	1.158	0.813	0.520	0.455	0.440	0.437	0.637	7.14	9.24	15.89	15.29	15.02	14.79	12.89
T_6	8.59	17.89	19.72	19.19	17.94	16.19	16.58	1.163	0.804	0.520	0.454	0.452	0.450	0.640	7.10	9.37	15.97	15.27	14.95	14.72	12.90
GM	8.60	17.39	19.12	20.41	20.45	19.46	17.57	1.146	0.881	0.634	0.374	0.357	0.355	0.625	7.13	8.99	14.61	16.14	15.77	15.41	13.01

	TSS: Days	TSS: Treatment	TSS: Days X Treatment	Acidity: Days	Acidity: Treatment	Acidity: Days X Treatment	Total sugar: Days	Total sugar: Treatment	Total sugar: Days X Treatment
S.Em.±1	0.077	0.769	0.188	0.003	0.003	0.007	0.024	0.024	0.058
CD at 5%	0.22	0.22	0.53	0.007	0.007	0.018	0.067	0.067	0.164

*T_1: Neemleaves, T_2: Mentha leaves, T_3: Eucalyptus leaves, T_4: Bael leaves, T_5: Marigold leaves, T_6: Control (No leaves)

reported higher total solids, acid and total sugar contents in mango cv. Langra when the fruits were packed with fresh and dry leaves of neem. The slower decline in these constituents might be due to the ability of the volatiles generated by the cushioning materials to slow down the rate of metabolism of fruits and hence utilize the respirable substrates at a slower rate. Similar findings have also been reported with cushioning of litchi fruit with fresh leaves of traveller tree (Samanta and Prasad, 1996).

Pooled data presented in Table 3 also showed significant effect of postharvest cushioning treatments on organoleptic score of fruits. However, maximum organoleptic score (7.84) was recorded in the treatment T_1 (Neem leaves) which was significantly higher than other treatments, while, the minimum organoleptic score (6.31) was observed under control. Pooled data regarding effect of storage periods on organoleptic rating showed that maximum organoleptic score (8.20) was recorded on 6^{th} day of storage and the minimum organoleptic score (5.60) was observed on 14^{th} day which was significantly lower than other treatments. Pooled data on significant interactions among storage periods and treatments showed that maximum organoleptic score (8.46) was recorded in the treatment T_1 (Neem leaves) followed by T_3 (8.33) and T2 (8.25) on the same day, while, the minimum organoleptic score (4.01) was observed under control on 14^{th} day. The observations on colour, taste, appearance and overall acceptability recorded during the storage period revealed marked differences between the treated and untreated fruits. The highest acceptability might be due to balanced ratio of sugar and acid content in the treated fruits. All other treatments exhibited maximum acceptability till 9^{th} day of storage at room temperature. Retention of better quality in fruits cushioned with fresh leaves might be due to reduction in spoilage, moisture loss and respiratory losses of fruits under these treatments, as these processes are primarily responsible for deterioration in quality. Lower acceptability might be due to the early onset of senescence of tissue, resulting in decreased firmness, more incidences of fungal diseases and dull appearance of the fruits as reported by Khader (1992). Slow development of yellow colour might be due to retardation of chlorophyll decomposition and subsequent inhibition of ripening process (Singh *et al*., 1998). In control fruits, this might be due to increased activity of chlorophyllase enzyme which is responsible for the breakdown of chlorophyll and enhanced β-carotene content of fruits. Also, lower TSS and increased tissue senescence might lead to unpleasant taste and off flavour as noticed during the study. The results are in conformation with the studies of Bhardwaj and Sen (2003), Singh *et al*. (2000) who also found that postharvest application of botanical leaves have a significant effect on the sensory attributes of citrus and mango fruit.

Results of the present investigation revealed that the various post harvest cushioning treatments exhibited significant effect on improvement in fruit quality along with extended shelf life. Thus, on the basis of above results it can be concluded that post harvest cushioning with neem leaves proved effective treatment for increased shelf life as well as maintained quality of mango cv. Dashehari.

REFERENCES

A.O.A.C. (1980). Official Methods of Analysis.11th Edn. Association of Official Analytical chemists, Washington, D.C.

Ahmed, S. and Grainge, M. (1986).Potential of neem tree for pest control and rural development. *Economic Botany*. 40 (2): 201-209

Table 3: Response of fresh leaves as cushioning material organoleptic rating of mango *(Mangifera indica L.)* cv. Dashehari

Treatments	Pooled Organoleptic rating					
	3^{rd} day	6^{th} day	9^{th} day	12^{th} day	14^{th} day	Mean
T_1	7.90	8.46	7.98	7.54	7.29	7.84
T_2	7.68	8.25	7.81	6.46	5.31	7.10
T_3	7.55	8.33	7.85	6.98	6.16	7.37
T_4	7.60	8.13	7.74	6.73	6.16	7.27
T_5	7.83	8.09	7.42	6.24	4.65	6.85
T_6	8.12	7.93	6.69	4.79	4.01	6.31
G.M	7.78	8.20	7.58	6.46	5.60	7.12

	Day	Treatment	Day X Treatment
S.Em.±	0.087	0.096	0.214
CD at 5%	0.245	0.269	0.603

T_1: Neemleaves ,**T_2**: Mentha leaves, **T_3**: Eucalyptus leaves, **T_4**: Bael leaves , **T_5**: Marigold leaves, **T_6**: Control (No leaves)

Aly, M.M, El Gamy, Z A. and Biggs, R H. (1981). Ethylene production and firmness of peach and nectarine fruits as related to storage. Proceedings of florida state Horticulture Society. 94: 291-294

Anonymous. (2014). National Horticulture Board. Gurgaon, Haryana.

Bhardwaj, R. L. and Sen, N. Z. (2003). Zero energy coolchamber storage of Mandarin (*Citrus reticulate* cv. Nagpur Santra). *Journal of Food Science and Technology*. 40 (6): 669-672

Chauhan, S.K., Thakur, K.S., Jawa, N.K. and Thakur, K. (2012). Botanical formulation and extracts based on plant leaves and flower, a substitute for toxic chemical and waxes for shelf life extension and quality retention of apple cv. Starking Delicious in India, *Journal of Horticulture and Forestry*, 4(12): 190-200.

Choudhury, S., Ray, D.P., Das, B.K. and Sahu, G.S. (2003). Effect of pre and post-harvest chemical treatments on ripening, quality and storage life of sapota (*Manilkara achras* (Mill.) Forberg) cv. Pala. *Orissa Journal of Horticulture*, 31 (2): 54-57.

Devlin, R.M. (1967). Plant Physiology. Reinhold Pub. Corps, New York, Amsterdam, London.

Gakhukar, R.T. (1996). Commercial and industrial aspects of neem based pesticide. *Pestology.* 22(10): 15-32.

Gil, A., Duarte, I., Delgadillo, I., Colquhoun, I., Casuscelli, F., Humpfer, E. and Spraul, M. (2000). Study of the compositional changes of mango during ripening by use of nuclear magnetic resonance spectroscopy. *Journal of Agricultural Food Chemistry*, 48: 1524-1536.

Isman, M.B. (1996).Some target and non-target effects of neem insecticide. Neem newsletter, 13(2):9-10.

Khader, S. (1992).Effect of Gibberellic acid and vapor-gard on ripening, amylase and peroxides activities and quality of mango fruit during storage. *Journal of Horticultural Science,* 67 (6): 855-860.

Moreuil, C.(1973). Some observations and experiments on the litchi. *Fruits*, 28: 637-640.

Pawar, A. D. (2001). Registration of biopesticides for use in agriculture and public health, *Pesticide Information.*3: 29-37.

Rajendran, S and Chayakumari. (2003). Insect infestation and control in stored sorghum and millets. *Journal of Food Science and Technology*. 40 (5): 51-57.

Ramesh, C. and Pal, R.K. (2006). Influence of active cushioning materials in packaging on shelf life of litchi fruits. *Indian Journal of Horticulture*. 63 (1): 31-35

Rial Otero, R., Arias-Estévez, M., López-Periago, E.; Cancho Grande, B. and Simal Gándara, J. (2005).Variation in concentrations of the fungicides tebuconazole and dichlofluanid following successive applications to greenhouse- grown lettuces. *Journal of Agriculture Food Chem*istry, 53: 4471-4475.

Samanta, R.K. and Prasad M.V. (1996). Indegenous post harvest technology, National Research Centre on pices at Culcutta, India.

Saxena, R C., Liquido, N J. and Justo H. B. (1981). National pesticides from the neem tree (*Azadirachta indica*). Proceeding of International Neem Conference Rattach Engem, Germany.

Silva, A.V.C. and Menezes, J.B. (2001).Physical and chemical characteristics of mangoes cv. Tommy Atkins given pre-harvest application of calcium chloride and stored under refrigeration.Scientia-Agricola. 58 (1): 67-72.

Singh, J N., Acharya, P. and Singh, B B. (2000). Effect of GA_3 and plant extracts on storage behaviour of mango (*Mangifera indica*) cv. Langra. *Haryana Journal Horticulture Science*, 29: 3- 4.

Singh, R. (1957). Improvement of packing and storage of litchi at room temperature. *Indian Phytopathology*, 28: 531-532.

Singh, S., Brahmachari, V.S. and Jha, K.K (1998). Effect of Calcium and polythene wrapping on storage life of mango. *Indian Journal of Horticulture*, 55(3): 218-222.

Singh, Dinesh., Thakur, R.K. and Singh D. (2003). Effect of pre-harvest sprays of fungicides and calcium nitrate on post-harvest rot of Kinnow in low temperature storage. *Plant Disease Research*. 18(1): 9-11.

Snedecor, G.W. and Cochran, W.G. (1968). Statistical Methods, 6th ed., Iowa State University Press, Ames, IA.

Received: February 5, 2014
Accepted: Jul 8, 2016