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INFLUENCE OF HOT WATER TREATMENT AND WAX COATING ON QUALITY AND STORAGE LIFE OF MANGO (*MANGIFERA INDICA* L.) FRUITS CV. AMRAPALI UNDER AMBIENT CONDITION

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ABSTRACT

The experiment was conducted to study the effect of post harvest hot water treatment (at 52 ± 2°C for 5 minutes) and wax coating (6% wax emulsion) on quality and storage life of Amrapali mango fruits under ambient condition. Results revealed that the fruits treated with the combination of HWT+ wax coating showed the slower rate of chemical changes and retain the highest TSS (20.18 and 20.48%), acidity (0.15 and 0.14%) and ascorbic acid (47.37 and 47.05 mg/100g) upto 18 days of storage during both years, respectively. Similarly, the separate treatment of wax coating was also found superior to retain the highest sugars (15.95 and 16.30%), β-carotene (5056 and 5080 μg/100g) and TSS acid ratio (144.14 and 156.46). The shelf life of fruits was effectively extended by both the treatments upto 15th day of storage, although fruits treated with the combination treatment of HWT+ wax coating showed the minimum PLW (12.96 and 12.28%). Fruits treated with wax coating and combination of HWT+ wax coating were also found organoleptically acceptable upto 15 days of storage. In conclusion, the post harvest treatment with wax coating and combination of HWT+ wax coating were found to be effective for maintaining the quality of Amrapali mango fruits with the extended storage life and acceptability upto 15 days under ambient conditions.

KEY WORDS
Mango fruits
Amrapali
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INTRODUCTION

Mango (*Mangifera indica* L.) is the most important fruit of India. It is considered as the king of fruits due to its attractive colour, aroma and jelly pulp packed with vitamin A, but it is highly perishable in nature. Only a few varieties *viz*. Alphanso, Kesar *etc*. are available with better storage life and hence better suited for export. But the productivity of these cultivars is very limited.

Among the promising mango hybrid, Amrapali is one of the most suitable varieties for inter as well as overseas markets and processing industries. It possesses quality par excellence with very high pulp percentage and TSS. The fresh fruit poses deep orange red colour and contains about 2.5-3.0 times more β-carotene content than other commercial varieties. The only bottleneck associated with this variety is its shorter shelf life. Being a climacteric fruits, it is perishable in nature and possesses a short shelf life about one week under ambient condition. After harvest, various physiological and biochemical changes occur in fruits which causes decline in quality and limits its shelf life. Other factors like improper harvesting, mishandling, inadequate transportation and storage have also added to post harvest losses. In mango, post harvest losses lie in the range 25-40 per cent from harvesting to consumption stage (Tahir *et al.*, 2002). It is not only a serious problem of Amrapali growers and traders in India, but present time improvement in the shelf life and reduction in the post harvest losses of mango fruit is an international issue.

Mango fruit has unconvinced storage quality and technologies for long term storage such as controlled or modified atmospheric storage and storage at low temperature have not been applied successfully to the mango fruit. Fruits stored in modified atmosphere often show undesirable characteristics, *i.e.* poor colour, poor eating quality and presence of undesirable flavors. Storage at low temperature also has limitations as the mango fruit is susceptible to chilling injury. So, to prolong the storability and minimize the post harvest losses of this particular variety at ambient condition by the help of various post harvest aids, other than refrigeration and modified storage system, is needed for its commercialization.

Edible wax coating is being used on fruits to extend the shelf life and improve appearance. Semi permeable wax coating can create a modified atmosphere similar to controlled atmospheric storage. Wax coating also reduces moisture loss, retard ripening, impart gloss and minimize physico-chemical changes and decay loss during storage at ambient temperature (Drake and Nelson, 1990). The beneficial effects of wax coating were also studied by (Figueroa *et al.*, 2011) in Ataulfo mango. Hot water treatment has been accepted worldwide as an ideal disease and insect control treatment in mango fruits since it is environmentally safe and non-chemical. It maintains the fruit quality, appearance, prolongs the storage life, develops tolerance to chilling injury and kills the pathogens and eggs

of fruit fly. Hot water treatment also increased the storage period of mango by extending fruit shelf life through the regulation of a myriad of metabolic parameters, including patterns of antioxidant and cell wall hydrolase genes and protein expression during storage at low and ambient temperatures (Yimyong *et al.,* 2011). Netravati, *et al.* (2015) reported that the post harvest hot water and chitosan treatments were found effective in maintaining the pulp color, indicating the reduced ripening process and extended storage life of mango cv. Alphonso fruits. The beneficial effects of pre-storage hot water treatments were also studied by many workers including in ber (Shalini *et al.*, 2014). These treatments are also easy to applicability and cost effective. Hence, the present investigation was formulated with post harvest hot water treatment and wax coating to minimize the post harvest losses in quality and to extend the storage life of Amrapali mango fruits under ambient conditions.

MATERIALS AND METHODS

Plant Material and Treatment Methodology

The present experiment was conducted at PHT Laboratory of Department of Horticulture, N.D. University of Agriculture and Technology, Kumarganj, Faizabad (U.P) during the two successive seasons of 2010-11 and 2011-12. Fruits were harvested at green mature stage by hand with 1.0 cm stalk to escape any damage of fruit in morning hours. Fruits of uniform size and maturity, free from pest and disease, injuries, bruises and blemishes were selected for the experiment. Fruits were washed in running tap water and cleaned with muslin cloth. Fruits were equally divided in four lots and undergone with four post harvest treatments *viz*. Hot Water Treatment at 52 $\pm$2ºC for 5 minutes (T_1), Wax coating of 6% wax emulsion (T_2), Hot Water Treatment at 52 $\pm$2ºC for 5 minutes +Wax coating of 6% wax emulsion (T_3) and Control (T_4) with three replications. First and third lots were treated with hot water treatment at 52 $\pm$2ºC temperature for 5 minutes in water bath. Second lot and third lot (treated with HWT) were treated with the 'NIPRO-FRESH, Mango' brand 6 % wax emulsion. Fourth lot was dip in water only and taken as control. Treated fruits were packed in corrugated fiber board boxes with the use of news paper as liner. All boxes were tagged as per treatments and stored under ambient condition (normal temperature).

Fruit Quality Analysis

Three fruits per treatment were evaluated for quality analysis just after harvesting and at 3 days intervals during storage until 18 days by the following methods.

Physiological loss in Weight (PLW%): Weight of fruits was recorded with the help of physical balance and weight loss per cent was calculated by using the following standard procedure mentioned in AOAC (2000).

$$PLW\ \% = \frac{\text{Initial fruit weight - Weght of fruit on observation day}}{\text{Initial fruit weight}} \times 100$$

Total soluble solids (TSS %)

Total soluble solid were determined with the help of hand refractometer of 0-32 per cent range. The reading was corrected to 20ºC with the help of reference table (Ranganna, 1986) and the mean value was expressed as per cent total soluble solids in fruit pulp.

Acidity (%), Ascorbic acid (mg/100g) and β-carotene (µg/100g)

Acidity (%), ascorbic acid (mg/100g) and β-carotene (µg/100g) were determined by the procedures of Ranganna (1986).

Total sugars (%)

Total sugars content was determined by Fehling's solution method given by (Lane and Eynon, 1923).

TSS acid ratio

TSS acid ratio was calculated by dividing the TSS (%) to the acidity (%) of fruits.

Organoleptic Evaluation

The organoleptic evaluation for assessing sensory attributes such as peel colour, flesh colour, texture, taste and flavor of the stored fruits were made by using 9 point Hedonic Rating Scale by a panel of eight judges as described by Larmond (1977).

Shelf Life

The shelf life (days) was determined upto the weight loss of fruits reached at the level of 10 percent during the storage. The shelf life of fruits was accounted from the date of harvesting to the shelf life expiration date during storage.

Statistical Analysis

The data were collected in three replications and analyzed using Completely Randomized Design (CRD) to test statistical significance at ($p \leq 0.05$) (Panse and Sukhatme, 1985).

RESULTS AND DISCUSSION

Physiological loss in Weight (PLW %)

The PLW per cent of mango fruits was significantly increased with the advancement of storage period (Table 1). Physiological loss in weight of fruits is mainly due to evaporation of water, respiration and degradation processes occurring during the post harvest handling of fruits (Haard and Salunkhe, 1975). Fruits treated with HWT +wax coating showed the minimum PLW (12.96 and 12.28%) followed by wax coating treatment (13.40 and 13.08%) upto 18 days of storage. Hoa *et al.* (2002) reported that the wax forms a thin layer around the fruits that create permeability barriers to moisture migration and possibly for the some gasses like ethylene, oxygen, CO_2. Thus wax coating appeared to reduce the PLW by reducing the transpiration and respiration of fruits. The heat treatments also inhibit the biochemical pathways involved in ripening and other processes in many fruit (Paull and Chen, 2000). Similar results to the present finding have also been reported by Figueroa *et al.* (2011) in Ataulfo mango.

Total soluble solids (TSS%)

The TSS content of mango fruits was significantly increased with storage period, reached its peak, and then declined (Table 2). The fruits treated with wax coating and combination of HWT +Wax coating showed the slower rate of change in TSS content and reached at its increasing peak on 15th day of storage and then declined, but other treatment including control showed its increasing trend up to 12th days only and then declined till the end of storage period. Treatment of HWT

Table 1: Effect of wax coating on physiological loss in weight (PLW %) of mango fruits cv. Amrapali during ambient storage

Treatments	Days of storage 2010-11							2011-12						
	3	6	9	12	15	18	Mean	3	6	9	12	15	18	Mean
T_1 (HWT)	2.42	4.85	8.4	13.23	17.01	20.51	11.07	2.19	4.57	8.35	12.71	16.81	20.08	10.79
T_2 (WC)	1.39	2.98	5.52	7.79	9.84	13.40	6.82	1.15	2.69	5.25	7.28	9.26	13.08	6.45
T_3 (HWT + WC)	1.24	2.88	5.41	7.53	9.43	12.96	6.58	1.01	2.49	5.04	7.01	8.98	12.28	6.14
T_4 (control)	2.56	5.03	8.85	13.72	17.51	20.77	11.41	2.34	4.80	8.80	13.18	17.12	20.43	11.11
Mean	1.90	3.94	7.04	10.57	13.46	16.91	8.97	1.67	3.62	6.75	10.05	13.04	16.47	8.60

	2010-11			2011-12		
	T	D	T × D	T	D	T × D
S.Em. ±	0.06	0.06	0.13	0.13	0.05	0.13
p< 0.05	0.17	0.18	0.37	0.39	0.16	0.37

Table 2: Effect of wax coating on total soluble solids (TSS %) of mango fruits cv. Amrapali during ambient

Treatments	Days of storage 2010-11								2011-12							
	0	3	6	9	12	15	18	Mean	0	3	6	9	12	15	18	Mean
T_1 (HWT)	9.42	13.81	18.60	20.82	21.90	21.28	20.82	18.09	9.63	14.08	18.72	20.94	22.09	21.36	20.95	18.26
T_2 (WC)	9.42	12.25	14.61	16.87	19.25	20.48	20.04	16.15	9.63	12.50	14.74	16.96	19.48	20.63	20.34	16.32
T_3 (HWT + WC)	9.42	11.33	13.75	15.98	18.50	20.32	20.18	15.62	9.63	11.63	13.90	16.11	18.67	20.47	20.48	15.84
T_4 (control)	9.42	15.58	20.31	21.53	22.41	21.66	21.32	18.89	9.63	15.77	20.44	21.66	22.57	21.57	21.46	19.01
Mean	9.42	13.24	16.81	18.80	20.52	20.93	20.59	17.19	9.63	13.52	16.95	18.92	20.70	21.01	20.81	17.37

	2010-11			2011-12		
	T	D	T × D	T	D	T × D
S.Em. ±	0.08	0.09	0.18	0.06	0.09	0.18
p< 0.05	0.24	0.24	0.50	0.18	0.25	0.50

Table 3: Effect of wax coating on total acidity (%) of mango fruits cv. Amrapali during ambient storage

Treatments	Days of storage 2010-11								2011-12							
	0	3	6	9	12	15	18	Mean	0	3	6	9	12	15	18	Mean
T_1 (HWT)	0.37	0.32	0.27	0.25	0.20	0.16	0.11	0.24	0.37	0.31	0.26	0.23	0.18	0.13	0.10	0.23
T_2 (WC)	0.37	0.34	0.30	0.28	0.23	0.18	0.14	0.26	0.37	0.33	0.29	0.26	0.21	0.17	0.13	0.25
T_3(HWT + WC)	0.37	0.35	0.31	0.29	0.24	0.20	0.15	0.27	0.37	0.34	0.30	0.27	0.22	0.18	0.14	0.26
T_4 (control)	0.37	0.31	0.25	0.21	0.17	0.12	0.09	0.22	0.37	0.30	0.24	0.20	0.15	0.10	0.08	0.21
Mean	0.37	0.33	0.28	0.26	0.21	0.17	0.12	0.25	0.37	0.32	0.26	0.24	0.18	0.14	0.11	0.24

	2010-11			2011-12		
	T	D	T × D	T	D	T × D
S.Em. ±	0.002	0.002	0.005	0.002	0.002	0.005
p< 0.05	0.006	0.007	0.014	0.005	0.007	0.014

Table 4: Effect of wax coating on ascorbic acid (mg/100g) of mango fruits cv. Amrapali during ambient storage.

Treatments	Days of storage 2010-11								2011-12							
	0	3	6	9	12	15	18	Mean	0	3	6	9	12	15	18	Mean
T_1 (HWT)	57.14	52.63	51.54	50.28	49.62	47.79	45.94	50.70	56.77	52.31	51.21	50.04	48.91	47.43	45.80	50.34
T_2 (WC)	57.14	53.05	52.07	50.93	49.93	48.54	46.64	51.19	56.77	52.75	51.76	50.61	49.61	48.19	46.33	50.86
T_3(HWT + WC)	57.14	53.55	52.65	51.66	50.52	49.40	47.37	51.75	56.77	53.18	52.36	51.40	50.22	49.11	47.05	51.45
T_4 (control)	57.14	52.32	50.92	49.35	48.19	46.67	44.75	49.90	56.77	52.03	50.62	49.04	47.89	46.38	44.43	49.59
Mean	57.14	52.89	51.79	50.54	49.47	48.10	46.21	50.88	56.77	52.58	51.49	50.36	49.20	47.98	46.03	50.63

	2010-11			2011-12		
	T	D	T × D	T	D	T × D
S.Em. ±	0.17	0.17	0.37	0.20	0.26	0.52
p< 0.05	0.50	0.49	NS	0.58	0.73	NS

Table 5: Effect of HWT and wax coating on total sugars (%) of mango fruits cv. Amrapali during ambient storage

Treatments	Days of storage															
	2010-11								2011-12							
	0	3	6	9	12	15	18	Mean	0	3	6	9	12	15	18	Mean
T_1 (HWT)	6.81	10.06	13.43	16.01	16.72	16.75	16.09	13.69	7.17	10.43	13.79	16.36	17.08	17.13	16.44	14.06
T_2 (WC)	6.81	9.94	13.25	15.89	16.57	16.56	15.94	13.56	7.17	10.31	13.50	16.23	17.01	17.14	16.30	13.95
T_3(HWT+WC)	6.81	9.78	13.01	15.72	16.34	16.40	15.84	13.42	7.17	10.14	13.25	15.94	16.72	16.87	16.09	13.74
T_4 (control)	6.81	10.26	13.56	16.15	16.84	16.87	16.19	13.81	7.17	10.62	13.92	16.52	17.20	17.28	16.56	14.17
Mean	6.81	10.01	13.34	15.94	16.64	16.67	16.01	13.63	7.17	10.39	13.61	16.26	17.00	17.11	16.35	14.00

	2010-11			2011-12		
	T	D	T×D	T	D	T×D
S.Em. ±	0.03	0.04	0.08	0.04	0.06	0.11
p< 0.05	0.09	0.11	NS	0.12	0.16	NS

Table 6: Effect of HWT and wax coating on β-carotene (*μ*g/100g) of mango fruits cv. Amrapali during ambient storage

Treatments	Days of storage															
	2010-11								2011-12							
	0	3	6	9	12	15	18	Mean	0	3	6	9	12	15	18	Mean
T_1 (HWT)	1204	2292	3244	3834	4225	4822	5101	3532	1217	2311	3289	3847	4239	4838	5132	3553
T_2 (WC)	1204	2199	2650	3424	4156	4761	5056	3351	1217	2221	2687	3437	4173	4776	5080	3369
T_3(HWT+WC)	1204	2183	2642	3273	3948	4725	5014	3285	1217	2209	2675	3287	3963	4723	5026	3300
T_4 (control)	1204	2399	3355	3941	4292	4888	5108	3597	1217	2413	3394	3952	4308	4895	5145	3619
Mean	1204	2272	2974	3618	4155	4799	5067	3441	1217	2288	3012	3631	4171	4808	5096	3460

	2010-11			2011-12		
	T	D	T×D	T	D	T×D
S.Em. ±	12.72	15.79	31.89	12.51	16.14	32.40
p< 0.05	36.16	43.92	88.99	35.58	44.88	90.41

Table 7: Effect of HWT and wax coating on TSS acid ratio of mango fruits cv. Amrapali during ambient storage

Treatments	Days of storage															
	2010-11								2011-12							
	0	3	6	9	12	15	18	Mean	0	3	6	9	12	15	18	Mean
T_1 (HWT)	25.81	43.16	68.89	83.28	109.50	133.00	189.27	93.22	26.38	45.42	72.00	91.04	122.70	164.31	209.50	104.4
T_2 (WC)	25.81	36.03	48.70	60.25	83.70	113.78	144.14	73.15	26.38	37.88	50.83	65.23	92.76	121.35	156.46	78.74
T_3 (HWT +WC)	25.81	32.37	44.35	55.10	77.08	101.60	133.60	67.18	26.38	34.21	46.33	59.67	84.86	113.72	146.29	73.12
T_4 (control)	25.81	50.26	81.24	102.50	131.80	180.50	236.89	115.60	26.38	52.57	85.17	108.30	150.50	215.70	268.25	129.5
Mean	25.81	40.45	60.80	75.29	100.50	132.22	175.98	87.29	26.38	42.52	63.58	81.06	112.70	153.77	195.12	96.45

	2010-11			2011-12		
	T	D	T×D	T	D	T×D
S.Em. ±	0.61	0.78	1.56	0.63	0.76	1.61
p< 0.05	1.73	2.16	4.35	1.74	2.15	4.68

+Wax coating also retained the highest TSS (20.18 and 20.48%) followed by wax coating treatment upto 18 days of storage. The slower rate of increase in TSS content of HWT +Wax coated fruits might be due to their effect on delayed degradation process of carbohydrates and also reduced transpiration from the fruits. The finding is in accordance with Ansari and Feridoon (2008) and Zambrano *et al.* (2011).

Acidity (%)

The acidity content of fruits was continuously decreased during the entire period of storage (Table 3). Such loss of acidity with the advancement of storage might be due to use of organic acids in the respiratory process (Ulrich, 1974). Fruits treated with HWT+ wax coating showed the slower rate of loss in acidity content. This treatment retained the highest acidity (0.15 and 0.14%) followed by wax coating treatment upto 18 days of storage. The slower rate of loss in acidity might be due to lower rate of respiration during storage resulted less oxidation of organic acids (Garg *et al.,* 2009). The above result is fall in line with the earlier reports of Paull and Chen (2000) and Anwar and Malik (2007).

Ascorbic Acid (mg/100g)

The ascorbic acid content of fruits was significantly decreased with the advancement of storage period (Table 4). The fruits treated with HWT +Wax coating showed the slower rate of

Table 8: Effect of HWT and wax coating on organoleptic quality of mango fruits cv. Amrapali during ambient storage

Treatments	Days of storage															
	2010-11								2011-12							
	0	3	6	9	12	15	18	Mean	0	3	6	9	12	15	18	Mean
T_1 (HWT)	7.36	7.92	8.12	8.32	7.91	7.03	5.13	7.39	7.48	7.86	8.24	8.39	7.99	7.05	5.17	7.45
T_2 (WC)	7.36	8.07	8.61	8.82	8.43	7.58	5.88	7.82	7.48	8.38	8.74	8.88	8.51	7.66	5.92	7.94
T_3 (HWT + WC)	7.36	8.13	8.87	9.08	8.79	7.96	6.36	8.08	7.48	8.67	8.99	9.14	8.88	8.05	6.40	8.23
T_4 (control)	7.36	7.87	7.91	8.10	7.53	6.60	4.24	7.09	7.48	7.67	8.03	8.16	7.61	6.68	4.28	7.13
Mean	7.36	8.07	8.38	8.58	8.17	7.28	5.40	7.61	7.48	8.15	8.49	8.66	8.25	7.36	5.44	7.69

	2010-11			2011-12		
	T	D	T × D	T	D	T × D
S.Em. ±	0.02	0.05	0.13	0.04	0.06	0.16
p< 0.05	0.07	0.13	0.36	0.12	0.16	0.45

HWT- Hot Water Treatment, **WC-** Wax coating

decrease in ascorbic acid content of mango fruits. This treatment also retained the highest ascorbic acid (47.37 and 47.05 mg/100g) followed by wax coating treatment upto 18 days of storage. The possible reason may be that wax coatings slowdown the oxidation of ascorbic acid by regulating O_2 permeability into fruits resulting in slower reduction in ascorbic acid content during storage. The above result is very close to the findings of Anwar and Malik (2007) and Jhagolkar and Reddy (2007).

Total sugars (%)

The total sugar content in all the treatments was initially increased up to 15th days of storage and then decreased (Table 5). Fruits treated with wax coating showed slower changes in total sugars content. This treatment also retained the highest total sugar (15.95 and 16.30%) followed by the combination of HWT + wax coating upto 18 days of storage. The slower rate of increase in sugars content in wax coated fruits might be due to the delayed degradation processes and less conversion of starch in to simple sugars. The above result corroborates the findings of Jhagolkar and Reddy (2007) in mango.

β-carotene (μg/100g)

The β-carotene content of fruits was significantly increased with the advancement of storage period (Table 6). Fruits treated with wax coating showed the lesser rate of increase in β-carotene content of mango fruits. This treatment also retained the highest β-carotene (5056 and 5080 μg/100g) followed by the combination of HWT + wax coating upto 18 days of storage. This slower rate of loss in β-carotene content of fruits might be due to the physical barrier of wax coating that slowed down the enzyme activities and other metabolic processes in fruits. The results are in line with the findings of (Anwar and Malik, 2007) in mango fruits.

TSS acid ratio

Fruits treated with wax coating showed the lesser increase in TSS acid ratio of mango fruits over all the treatments (Table 7). This treatment also showed the highest TSS acid ratio (144.14 and 156.46) followed by the combination of HWT + wax coating upto 18 days of storage. Lesser increase in the ratio of TSS acid in treated fruits might be due to the slower changes in TSS and acidity content of fruits during the storage. The above results substantiate to the earlier reports of Ansari and Feridoon (2008).

Organoleptic Evaluation

All the treated fruits were found acceptable upto 15th day of storage against 12th days of control (Table 8). However, the maximum organoleptic score was obtained by fruits treated by HWT + Wax coating followed by wax coating treatment during the entire period of storage. Parallel results to the present findings were also previously reported by Anwar and Malik (2007) in mango and Sindhu *et al.* (2009) in pear fruits. They reported that the coating of wax and HWT improves the organoleptic quality, appearance and acceptability of fruits during the prolonged storage.

Storage Life

Fruits treated with wax coating and combination of HWT + wax coating showed the maximum storage life upto 15th day of ambient storage, although fruits treated with HWT + wax coating showed the minimum PLW (9.43 and 8.98%) on that day (Table 1). The wax coating treatment was also found the second to extend the shelf life with PLW (9.84 and 9.84%) on 15th day of storage. Analogous observations to these findings have also been earlier reported by Figueroa *et al.* (2011), Shalini *et al.* (2014) and Netravati, *et al.* (2015).

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