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Effect of physico-chemical treatments on ripening behavior and post-harvest quality of Amrapali mango (*Mangifera indica* L.) during storage

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Abstract

An experiment was done to assess the effect of various physico-chemical treatments on ripening behavior and post harvest quality of mango cv. Amrapali. The experiment was planned under completely randomized design (CRD) with three replications. The treatment units was five fruits per replication. Total 14 treatments were applied. Out of these, ethrel 750 ppm treated fruits showed better results in respect of specific gravity (0.88), moisture loss (8.45%), decay (2.5%), total soluble solids (TSS, 20.7° brix), sugar content (14.39%) and acidity content (0.32) followed by ethrel 500 ppm; specific gravity (0.90), moisture loss (8.82%), decay (3.5%), TSS (20.7° brix), sugar content (13.99%) and acidity content (0.36%). The pedicellate fruits and ethrel+bavistin (750+1000 ppm) were also found to be significantly superior over control in respect of specific gravity (0.88 and 0.86), moisture loss (9.10 and 9.33%), decay (4.0 and 5.33%), TSS (20.1 and 20.4° brix), sugar content (12.70 and 12.80%) and acidity content (0.42 and 0.38%), respectively. Based on results of this study, it can be concluded that ethrel 750 ppm was found to be the most suitable treatment in improving physico-chemical traits *i.e.* ripening, storage, quality and shelf-life for commercial purpose in mango.

Key words

Physical and chemical treatments, Ripening behavior, Post-harvest quality, Amrapali mango

Introduction

Mango (*Mangifera indica* L.) is a "National fruit of India" because of its delicious taste, excellent flavor/ aroma, attractive colour a amount of vitamin A and C. India contributes 12% of total fruit production of the world. Out of these, India contributes 39.5% share of mango in world production (Anonymous, 2008). The state Uttar Pradesh has 0.265 m ha area under mango cultivation with 23.6% share in total mango production of India. The average productivity of mango in India is about 6.3 m ha^{-1} (Anonymous, 2006). Mango is also a good source of income generation as 45.35 thousand tons of mango worth 127.41 crore rupees has been exported to the different countries of the world (Anonymous, 2008). Mango has rich diversity in cultivated varieties and out of these; Amrapali is a well known regular bearing dwarf hybrid, fruit is oblong and oblique in shape. The pulp percentage is not so high, excellent in taste, good for table purpose and has better keeping quality at room temperature approximately one week (Chattopadhaya, 1996). The flesh of Amrapali is deep red in colour which may be used for preparing colourful mango nectar and juice. Due to dwarfness of cultivar, it is recommended for kitchen garden and high density planting (HDP). Ray (1999). The fruit of Amarpali are rich source of

β-carotenoids than its parents *i.e.* Dashehari and Neelum, Sharma *et al*. (1981).

Post harvest losses have been estimated in developed countries from 5-25%, while in developing countries it is near to 20-50% (Kader, 1992). The lost after harvesting of fruits are more due to mismanagement and losses due to various unfavorable factors *i.e.* physiological, biological and environmental of produce. Therefore, it is essential to overcome the problems associated with the produce by proper handling and care after harvesting of fruits. Keeping these in view, the present investigation was carried out to minimize the post harvest losses, and to improve keeping quality of fruit during the storage with the application of different physico-chemical treatments.

Materials and Methods

Experimental site: This experiment was carried out in Post-Harvest Technology Laboratory, Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut, Uttar Pradesh (India) during 2006-2007. The maximum temperature of experimental site was 42°C in summer and minimum temperature was 7-8°C in winter and average rainfall was 300 mm. Meerut is situated between 29.01°N latitude and 77.75°E longitude of 297 m above mean sea level.

Experimental design and treatments: Total 14 treatments (three physical, ten chemical and one control) were applied to assess the ripening behavior and post-harvest quality of mango during storage. The experiment was planned under completely randomized block design (CRD) with three replications. The treatment unit was five fruits per replication. The treatments namely, ethrel 500 ppm (mol. wt. 144.49, 40% aqueous solution, make SRL India), ethrel 750 ppm, ethrel 1000 ppm, $CaNO_3$ 1.5%,$CaNO_3$ 2.0%, $CaNO_3$ 2.5%, bavistin (50 WP, make Bayer India Limited) 500 ppm, bavistin 1000 ppm, bavistin 1500 ppm , pedicellate fruits with 15 mm pedicel, fruit covered with non-perforated polyethylene sheet 200 gauge, fruit covered with perforated polythene sheet 200 gauge, ethrel 500 ppm + bavistin 1000 ppm and control. The treated fruits were wrapped in butter paper and packed in light weighed corrugated card board box for ripenining purposes at ambient storage conditions. Data were recorded after 6, 8 and 10 days of storage. During the experimentation, average maximum and minimum room temperature was 34.68 and 24.4°C with average relative humidity 70.20%. Mature fruits of Amarpali according to maturity indices were harvested in July at specific gravity of 1.00 and immediately brought to laboratory for further study.

Physical qualitative characters *i.e.* fruit skin colour (surface colour of ripened fruit was recorded visually at ripening stage matching with the Royal Horticultural Society, colour chart, 1969), flavour and aroma, organoleptic taste, and marketability were recorded with opinion of panel of 5 judges who scored according to hedonic scale suggested by Amerine *et. al.* (1965), and chemical analysis specific gravity, moisture loss percentage, decay percentage, TSS, sugar content and acidity percentage were also recorded by using standard analytical methods. Statistical analyses were carried out as suggested by Gomez and Gomez (1996).

Results and Discussion

Effect on ripening behavior: Data presented in Table 1 shows that with increase in ethrel concentration from 500 up to 1000 ppm, there was significant change in skin colour *i.e.* greenish to deep yellow on 6-10th day, while yellow colour was recorded on 8th day of storage with 750 ppm ethrel. The colour development was better due to rapid degradation of chlorophyll and higher synthesis of carotenoids and other pigments in applied treatments. The findings of the present study confirm with the findings of Singh and Janes (2001). Fruit skin colour as affected by $CaNO_3$ treatment increased up to 1.5 - 2.5%. Change in skin colour from green to yellowish-green was observed on 6 - 8th day, while yellow colour was developed on 10th day with 1.5% $CaNO_3$. However, light green, greenish-yellow and yellowish-green colour was obtained with 2.0 and 2.5% $CaNO_3$ on 6th, 8th and 10th days. Relevant findings were also reported by Gautam *et al*., (2003), Singh and Mandal, (2000). Bavistin treated fruits showed better skin colour. Bavistin 500 ppm treated fruits had skin colour greenish-yellow on 6th and yellowish-green on 8th and 10th day of storage. Similarly, greenish yellow colour was observed on 6th and 8th day of storage with 1000 ppm bavistin, while yellow colour was noticed on 10th day of storage with 1000 ppm. Bavistin treated fruits by 1000 ppm showed greenish-yellow colour which was noticed after 10th day of storage. Bavistin 1500 ppm showed greenish- yellow colour on 6th day and yellow colour on 8th and 10th day of storage. This may be due to rapid degradation of chlorophyll content, higher synthesis of caratenoids and other pigments. These findings are in conformity with the findings of Dhemre and Waskar, (2003). Pedicellate fruit (15 mm length) developed greenish -yellow colour on 6th and 8th day and yellowish-colour on 10th day of storage. These results are in conformity with the results of Prakash *et al*., (1996). The fruits covered with polythene (200 gauges) gave non-significant change in fruit skin colour at all the days of storage and the colour almost remained light green. This may be due to high moisture content around the fruit skin by respiration process; temperature of polythene bag is not so high in the presence of water vapour and the metabolic activities inside of fruit was poor. Therefore, there was no change in the colour of fruit skin. However, fruit covered with perforated polythene sheet (200 gauges) showed slight change in skin colour on 8th and 10th day of storage like greenish-yellow and yellowish-green, while light green on 6th day of storage. The changes in colour with perforated polyethylene sheet due to delayed ripening were also reported by (Singh and Janes, 2001). The ethrel 750 ppm + bavistin 1000 ppm treatment gave significant improvement in skin colour (yellow) on 6th and 8th day of storage, while deep yellow colour was recorded on 10th day of storage. In control treatment, slight change in skin colour from greenish-yellow on 6th day, yellowish-green on 8th days to yellow colour on 10th day was also observed. Therefore, all the physical and chemical treatments were significantly effective in improving the skin colour except fruit covered with polythene

Table - 1: Physiological attributing characters of mango cv. Amarpali as influenced by physico-chemical treatments

Treatments	Days of storage (at room temperature)											
	Fruit skin colour			Flavour/Aroma			Organoleptic taste			Marketability		
	6th	8th	10th	6th	8th	10th	6th	8th	10th	6th	8th	10th
Ethrel 500 ppm	Greenish yellow	Yellow	Deep yellow	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Acceptable	Acceptable	Acceptable
Ethrel 750 ppm	Greenish yellow	Yellow	Deep yellow	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Acceptable	Acceptable	Acceptable
Ethrel 1000 ppm	Greenish yellow	Yellow	Deep yellow	Excellent	Good	Good	Excellent	Good	Fair	Acceptable	Acceptable	Acceptable
$CaNO_3$ 1.5%	Light green	Yellowish green	Yellow	Good	Good	Good	Good	Good	Fair	Acceptable	Acceptable	Non-acceptable
$CaNO_3$ 2.0%	Light green	Greenish yellow	Yellowish green	Good	Good	Fair	Good	Fair	Fair	Acceptable	Acceptable	Non-acceptable
$CaNO_3$ 2.5%	Light green	Greenish yellow	Yellowish green	Good	Good	Fair	Good	Fair	Fair	Acceptable	Acceptable	Non-acceptable
Bavistin 500 ppm	Greenish yellow	Yellowish green	Yellowish green	Good	Good	Fair	Fair	Fair	Fair	Acceptable	Acceptable	Non-acceptable
Bavistin 1000 ppm	Greenish yellow	Yellowish green	Yellow	Good	Good	Fair	Fair	Fair	Fair	Acceptable	Acceptable	Non-acceptable
Bavistin 1500 ppm	Greenish yellow	Yellow	Yellow	Good	Good	Fair	Good	Good	Fair	Acceptable	Acceptable	Non-acceptable
Pedicellate fruit (15 mm)	Greenish yellow	Greenish yellow	Yellowish green	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Acceptable	Acceptable	Acceptable
Fruit covered in polythene sheet (200 gauges)	Light green	Light green	Light green	Fair	Fair	Fair	Fair	Fair	Fair	Non-acceptable	Non-acceptable	Non-acceptable
Fruit covered in perforated polythene sheet (200 gauges)	Light green	Greenish yellow	Yellowish green	Good	Good	Fair	Good	Good	Fair	Non-acceptable	Acceptable	Non-acceptable
Ethrel+Bavistin (750+1000 ppm)	Yellow	Yellow	Deep yellow	Excellent	Excellent	Good	Excellent	Excellent	Good	Acceptable	Acceptable	Acceptable
Control	Greenish yellow	Yellowish green	Yellow	Good	Good	Fair	Good	Good	Fair	Acceptable	Acceptable	Non-acceptable

Table- 2: Physiological attributing characters of mango cv. Amarpali as influenced by physico-chemical treatments

Treatments	Days of storage (room temperature)																	
	Specific gravity			Moisture loss (%)			Decay (%)			TSS (^{0}Brix)			Sugar content (%)			Acidity content (%)		
	6th	8th	10th	6th	8th	10th	6th	8th	10th	6th	8th	10th	6th	8th	10th	6th	8th	10th
Ethrel 500 ppm	0.99	0.87	0.84	5.31	8.90	12.25	0.00	0.00	3.50	18.0	22.5	21.6	11.49	15.97	14.51	0.63	0.28	0.19
Ethrel 750 ppm	0.91	0.88	0.85	5.11	8.71	11.54	0.00	0.00	2.50	17.0	23.3	21.8	11.84	16.75	14.59	0.57	0.23	0.17
Ethrel 1000 ppm	0.89	0.86	0.84	5.45	9.25	13.24	0.00	0.33	6.00	17.6	20.9	20.5	10.77	14.29	13.89	0.52	0.30	0.21
$CaNO_3$ 1.5%	0.88	0.86	0.83	5.80	9.41	14.13	0.00	0.50	7.00	17.3	20.7	20.4	10.75	13.85	12.95	0.61	0.27	0.19
$CaNO_3$ 2.0%	0.88	0.84	0.83	5.97	9.25	13.15	0.00	0.33	6.00	17.8	21.2	21.1	10.12	13.76	12.91	0.63	0.24	0.18
$CaNO_3$ 2.5%	0.90	0.85	0.80	6.04	9.78	14.45	0.00	0.67	8.00	17.3	20.4	20.2	9.86	13.37	12.76	0.67	0.22	0.18
Bavistin 500 ppm	0.88	0.86	0.81	5.68	9.18	13.28	0.00	0.83	6.50	17.5	21.7	20.6	10.03	13.88	12.27	0.61	0.25	0.20
Bavistin 1000 ppm	0.89	0.85	0.83	6.25	10.25	14.67	0.00	0.83	9.00	17.1	21.3	20.7	10.83	13.53	12.21	0.60	0.22	0.19
Bavistin 1500 ppm	0.88	0.86	0.82	6.17	10.28	15.05	0.00	0.67	10.0	17.0	20.7	20.2	11.18	13.92	12.15	0.58	0.21	0.17
Pedicellate fruit (15 mm)	0.93	0.88	0.84	5.29	8.93	13.08	0.00	0.00	4.00	18.1	22.4	19.7	9.79	14.79	13.55	0.67	0.33	0.26
Fruit covered in polythene sheet (200 gauges)	0.99	0.94	0.90	2.27	5.86	7.45	0.00	1.00	15.0	12.2	14.4	13.1	7.68	14.49	10.15	0.91	0.42	0.39
Fruit covered in perforated polythene sheet (200 gauges)	0.95	0.85	0.82	4.68	8.23	14.73	0.00	0.33	10.0	14.6	20.3	19.8	9.86	13.61	12.09	0.84	0.31	0.18
Ethrel+Bavistin (750+1000 ppm)	0.90	0.87	0.81	5.71	9.18	13.10	0.00	0.00	5.33	17.9	22.2	21.0	10.61	14.14	13.91	0.62	0.34	0.19
Control	0.88	0.84	0.79	6.45	11.73	15.02	0.00	1.50	12.00	18.1	20.8	20.1	10.04	13.73	12.04	0.53	0.22	0.19
SEM ±	**0.024**	**0.02**	**0.022**	**0.07**	**0.111**	**0.093**	**-**	**0.271**	**1.31**	**0.61**	**0.391**	**0.342**	**0.395**	**0.374**	**0.262**	**0.03**	**0.022**	**0.019**
CD at 5%	**NS**	**NS**	**NS**	**0.21**	**0.324**	**0.273**	**-**	**0.789**	**3.82**	**1.80**	**1.138**	**0.996**	**1.15**	**1.090**	**0.763**	**0.08**	**0.064**	**0.056**

sheet as compared to control. The findings of the present investigation are in support with findings of Yah *et al*., (1998).

The excellent flavor and aroma of fruits were observed with the fruits treated with ethrel 500 and 750 ppm on 6th, 8th and 10th day of storage, while ethrel 1000 ppm gave excellent flavor only upto 6th day of storage, similar trend was recorded with physical treatments on pedicellate fruits (15 mm length) over control. However, outstanding flavor was also found in ethrel 750 ppm + bavistin 1000 ppm in treated fruits on 6th and 8th day of storage, while good flavor was recorded on 10th day of storage as compared to control and other treatments at all the stages of storage. The present findings are also reported earlier by Hiwale and Singh, (2003). Data pertaining to organoleptic taste was found excellent with treatments like ethrel 500 and 750 ppm and pedicellate fruits on 6th, 8th and 10th day of storage, while ethrel 1000 ppm gave the excellent taste only on 6th day of storage. Similarly, ethrel 750 + bavistin 1000 ppm gave excellent taste upto 6th and 8th day. However, $CaNO_3$ 1.5% and control treatment were superior in respect of taste on 6th and 8th day of storage. Change in flavor and taste may be due to the ripening which was affected by carbon-di-oxide and lowered rate of oxygen in fruit affect the ethylene concentration. Similar results were also reported by Gouburdhan, (1994); Singh and Mandal, (2000). Data presented in Table 1 revealed that the effects of various physical and chemical treatments on marketability of mango fruits were significant as compared to control. ethrel 500 and 750 ppm were significantly superior in improving the marketability of fruit with excellent acceptability at all the days of storage, while ethrel 1000 ppm was found with good acceptability on 6th and 8th day of storage but poor acceptability was noticed on 10th day. All the concentrations of $CaNO_3$ gave good marketability upto 6th and 8th day, while non acceptable on 10th day of storage in all treatments of $CaNO_3$. The marketability of fruits depend upon the appropriate production of ethylene inside fruits, optimum concentration of ethrel responsible for uniform ripening of fruit surface. If the concentration of ethrel was higher it caused rapid metabolic activities, resulting in over ripening. These findings are in close conformity with the earlier results reported by Dhemre and Waskar, (2003); Madhvi *et al*., (2005). Similar results were also found with bavistin treatments. However, pedicellate fruits had good acceptability for marketing at all the stage of storage. It was also reported by Prakash *et al*., (1996) that pedicellate fruits had good acceptability (71.14 and 37.83%) than non-pedicellate fruits. Acceptable fruits were found with fruit covered with polyethylene sheet (200 gauge) treatment at all the phases of storage, while acceptable fruits were found in perforated polyethylene sheet (200 gauge) on 8th day of storage and non-acceptable on 6th and 10th day of storage. Similar results were also reported earlier by Hiwale and Singh, (2003).

Effect on post harvest quality: Data presented in Table 2 showed that the specific gravity of fruits under different treatments was found statistically non-significant during all stages of observations. The maximum specific gravity of 0.99 was recorded on 6th day with treatment of fruits covered with polyethylene sheet (200 gauges), while minimum (0.79) was recorded on 10th day in control. The significant differences were recorded among all the treatments in respect of moisture loss % of fruit during storage. The minimum (2.27, 5.86 and 7.45%) moisture loss was noticed on 6th, 8th and 10th day of storage, respectively under fruit covered with polyethylene sheet (200 gauges), while maximum loss of moisture percent (6.45, 11.73 and 15.02%) was noticed under control. It might be due to significant influence on reducing the respiration by modifying the atmosphere inside the bag. The findings are collaborative with the findings of Hiwale and Singh (2003). Treatments like ethrel 500 and 1000 ppm gave higher moisture loss percent as compared to ethrel 750 ppm on 6th, 8th and 10th day of storage. Similar trends were also noticed with the treatment $CaNO_3$ 1.5, 2.0 and 2.5% application at all the days of storage. It might be due to moisture loss percent gradually increased with advanced period of storage (Kulkarni *et al*., 2004). The fruit covered with perforated polythene sheet (200 gauges) gave significant better performance in respect of moisture loss percent on 6th and 8th day of storage, while on 10th day of storage it was found at par with bavistin 1000 and 1500 ppm. The pedicellate fruits were found significantly superior over ethrel + bavistin (750 + 1000 ppm) on 6th, 8th and 10th day of storage in respect of moisture loss. Similar results were also reported by Prakash *et al*., (1996). The data indicated that no decay percent was recorded on 6th day of storage, while all treatments were found significantly better than control. No decay was noticed in fruits treated with ethrel 500 and 750 ppm, pedicillate fruits on 8th day of storage, while maximum decay was observed in control on 8th day of storage. On 10th day of storage, maximum decay (15%) was recorded with treatment of fruit covered with polyethylene sheet (200 gauge) followed by control (12%) and other treatments, while minimum decay (2.5 and 3.5%) was found in ethrel 750 ppm on 10th day of storage. The maximum decay might be due to fruit covered with polyethylene sheet, the high moisture content found inside the polybag, resulted in maximum fungal attack on fruit surface and minimum due to other treatments (Ahmd and Singh, 1999).

It was observed that the data presented in Table 2 showed increased in storage period from 6-8th day, there was gradual increase in TSS and thereafter it declined significantly. The minimum (12.2°Brix) and maximum TSS (18.1°Brix) was recorded on the 6th day of storage in both pedicellate fruit and control. Similarly, ethrel 500 and1000 ppm and ethrel 750 + bavistin 1000 ppm , Ca NO_3 2.0%, bavistin 500 ppm were found significant on 8th day of storage. The TSS level increased and reached maximum (23.3°Brix) in the fruits treated with ethrel 750 ppm. It was found at par (22.5°Brix) with ethrel 500 ppm, pedicellate fruits (22.4) and ethrel 750 + bavistin 1000 ppm, (22.2°Brix), respectively.These finding are in accordance with Kumar *et al*., (2005); Madhvi *et al*., (2005); Prakash *et al*.,(1996). It was also observed that TSS decreased gradually on 10th days of storage in all the treatments. The minimum TSS of 13.1° Brix was noticed when the fruit covered with polyethylene sheet (200 gauges) upto 10th day and maximum of 21.80 Brix was recorded with 750 ppm ethrel. Narayan *et al*.,

(1991) also reported that TSS and carotenoids were found to increase at faster rate in control, while in fruit packed in polyethylene sheet, had low TSS.

Data indicates that the sugar content gradually increased upto 8th day of storage and further declined. The maximum sugar content (11.84%) was recorded with ethrel 750 ppm and it was minimum (7.68%) in fruit covered with polyethylene sheet (200 gauge) at 6th day of storage. This trend was observed at par with 1500 ppm bavistin on 6th day storage. The control treatment was found at par with treatment like ethrel 1000 ppm, $CaNO_3$(1.5%),$CaNO_3$ (2.0%), bavistin 500 ppm, bavistin 1000 ppm and ethrel 750 ppm + bavistin 1000 ppm, respectively on 6th day of storage. These findings are in close conformity with earlier workers reported by Nair and Singh, (2003); Madhvi *et al.*, (2005). The maximum sugar content (16.75%) was recorded on the 8th day of storage with ethrel 750 ppm and proved to be significantly better treatment. However, minimum sugar content (11.49%) was observed on 8th day storage in fruits covered with polyethylene sheet (200 gauges). After 8th day of storage sugar content markedly decreased in all the treatments on last day of storage. Polyethylene packing delayed breakdown of starch and slowed down the formation of reducing and total sugar (Hiwale and Singh, 2003). The result indicates that the acidity content declined significantly with the increase in days of storage. The more acidity content was recorded in all treatments on 6th day of storage, while it decreased markedly on 8th and 10th day of storage respectively. The maximum acidity (0.91, 0.42 and 0.39%) was recorded with fruit covered with polythene sheet (200 gause) at all the stages of storage period, while minimum acidity (0.17%) was found with bavistin (500 and 750 ppm) on 10th day of storage. It was due to slow rate of degradation in acidity in fruits covered with polyethylene bags reduced physiological losses in weight and enzymatic activity, thereby slowing the rate of ripening (Hiwale and Singh, 2003). In other treatments, it was due to faster rate of respiration and formation of sugar content with oxidation of carbohydrate. These results are in agreement with earlier workers (Prakash *et al.,* 1996; Singh and Sharma, 1996). Based on experimental results it is concluded that ethrel 750 ppm was found to be the best suitable treatment for ripenning, storage and quality in Amrapali mango.

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