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Effect of pre harvest treatments on shelf life and quality of mango CV. Amrapali

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Abstract
An experiment was conducted to investigate the effect of pre-harvest treatments on shelf-life and quality of mango cv. Amrapali fruits during storage at ambient conditions (25 ± 5°C; 65 ± 5% RH). Mango trees were sprayed with 0.5, 1.0 and 1.5 % $CaCl_2$ and 25, 50 and 75 ppm GA_3 at 20 and 10 days before harvest (DBH) with the objective of extending the shelf-life of fruits and delay the ripening process. Fruits trees sprayed with 75 ppm GA_3 at 20 DBH (T_3) and 1.50% $CaCl_2$ at 20 DBH(T_6) took more number of days for ripening (16.3 and 16.0 days) while it was least in control (8.3 days). Fruits sprayed with GA_3 @75ppm at 20 DBH showed shelf life upto 21.0 days followed by 1.50% $CaCl_2$ at 20 DBH (20.8days) as against 11.3 days of control trees.
Spray of 75 ppm GA_3 at 20 DBH and spray of 1.50% $CaCl_2$ at 20DBH significantly improved the physico-chemical parameters and organoleptic evaluation of mango fruits compared to control.

Keywords: pre-harvest, shelf-life, Mango trees

Introduction
Mango (*Mangifera indica* L.) is one of the most important commercial fruit crops, being referred to as the 'King of fruits'. Mango is cultivated in an area of 2.5 million hectares with a production of 18.3 million tones and a productivity of 7.3 MT/ha. As per NHB 2014 data base, mango occupies 34.9% of total fruit area, 20.7% of total fruit production.
Mango has rich diversity with many cultivated varieties and hybrids. Among them, Amrapali is a well known as a regular bearing dwarf hybrid. The fruit is oblong in shape. It is excellent in taste and is regarded as a good table variety. The fruit quality of Amrapali is favorably superior over its parent, Dashehari. The flesh is deep orange red and has about 2.5 to 3.0 times more ß carotene content indicating higher vitamin A content. Besides, being attractive flesh colour, this variety is more suitable for export and processing industry for preparing colored mango nectar and juice. Due to dwarf nature the cultivar is recommended for high density planting and kitchen gardens (Ray, 1999) [9].
Gibberellins as a pre-harvest spray was reported as an efficient growth regulator in enhancing fruit storability and marketability through its action on cell juvenility and retardation of senescence, fruit coloration and softness (Macleod and Millar, 1962) [4]. Pre harvest spray of calcium increases the productivity of mango due to reduction of abscission and it enhances the fruit quality by increasing the fruit firmness and by maintaining the turgidity of middle lamella cells (Kumar *et al*., 2006) [3]. Fruits storability was also improved by $CaCl_2$ under cold storage (Wahdan *et al*., 2011) [13]. Low fruit calcium levels have been associated with reduced post-harvest life and physiological disorders. Hence the present study was taken to investigate the effect of pre-harvest spray of 0.5, 1.0 and 1.5 % $CaCl_2$ and 25, 50 and 75 ppm GA_3 at 20 and 10 days before harvest (DBH) in a leading mango cv. Amrapali with the objective of extending the shelf-life of fruits and delay the ripening process.

Materials and Methods
The present experiment was carried out on 9 year old mango trees cv. Amrapali at Central Research Institute for Dry land Agriculture, Hyderabad during the year 2014-2015. A randomized block design was used with thirteen treatments and three replications, considering three trees per replication. Trees of mango cv.Amrapali were sprayed with 0.5, 1.0 and 1.5% Calcium Chloride ($CaCl_2$) and 25, 50 and 75 ppm Gibberllic acid (GA_3) at 20 and 10 days before harvest. Control trees were spray with water. Harvested fruits were sorted for uniformity in size, maturity and free from defects and washed with water. An average of 10 fruits per tree was considered for calculating the fruit weight, pulp weight, peel weight, stone

weight after harvesting and expressed in grams.

Ripening (%)
Immediately after the harvest of the fruits, stalk was removed and fruits were washed with clean water and liquid soap and the days from the harvesting till the ripening were accounted. Mango fruits with more than 50 percent yellowing of skin colour were counted at specific intervals of storage was considered ripened. Such ripened fruits out of total fruits stored in each replication was computed and expressed in percentage.

Shelf life (in days)
The shelf-life of fruit was accounted from the date of harvesting to the shelf- life expiration date. The shelf life of fruits was determined by recording the number of days the fruits remained in good condition during storage without spoilage. When the spoilage of fruits exceeded 50% it was considered as the end of shelf (Padmalatha, 1995) [7].

Length, breadth, thickness and volume of fruit
The length of the fruit from stalk end to the apex of the fruit was determined at harvest stage with the help of vernier caliper and expressed in centimeters. The breadth of fruit was determined as the maximum linear distance between two shoulders of the fruit with the help of vernier caliper and expressed in centimeters. The thickness of the fruit was measured at the linear distance between the two checks of the fruit with the help of vernier caliper and expressed in centimeters. The volume of the fruit was measured by the conventional water displacement method and expressed in milliliter.

Weight of fruit, peel, pulp and stone
Immediately after the harvest of the fruit, stalk was removed and the weight of the raw fruit was recorded in grams. The ripened fruits were peeled off using a knife and weight of the peel was recorded in grams. The mango pulp from the ripe fruits was separated from the peel and the stone and the weight was expressed in grams. The stone weight of fruits separated from the pulp was recorded in grams.

Fruit volume
The volume of the fruit was measured by the conventional water displacement method and expressed in milliliters.

Pulp/peel and pulp / stone ratio
The pulp/peel ratio of the fruit at the end of storage was determined by dividing the weight of pulp by weight of peel. The pulp / stone ratio of the fruit at the end of storage was determined by dividing the weight of pulp by the weight of stone.

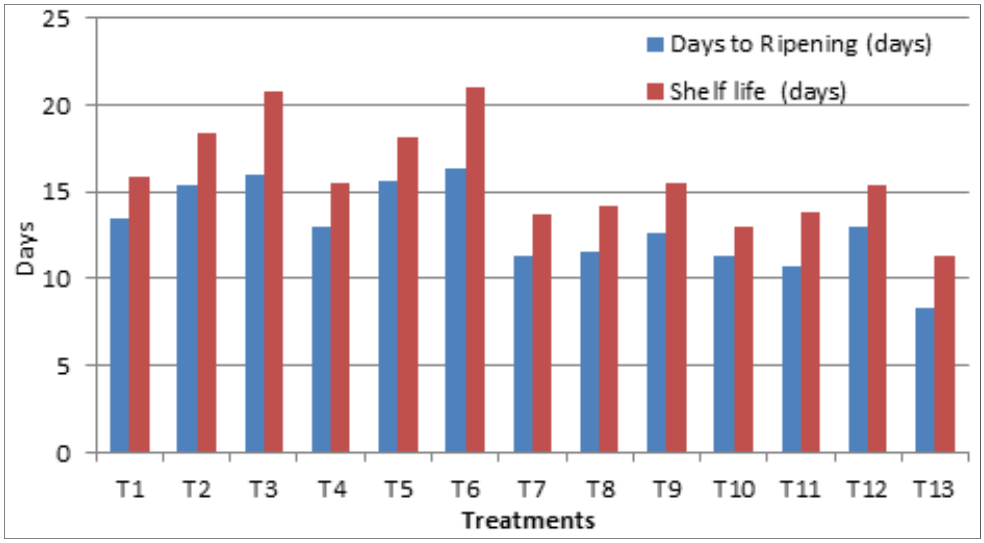
For organoleptic evaluation
The various treatments were evaluated by a panel consisting of five trained panelists and evaluated the sample on the basis of peel colour, pulp color, texture, flavor, taste and points were given as per hedonic scale procedure (score of 9-1) (Amerine *et al*., 1965) [1]. The average of all the score for above characters was calculated and expressed as overall acceptance or palatability rating. Higher scoring was treated as more acceptable from the attraction point of view.

Total sugars, reducing, non reducing sugars, total soluble solids and acidity
Total sugars and reducing sugars present in the mango pulp samples were determined by the method of Lane and Eynon (AOAC, 1990) [2]. The non-reducing sugar was calculated by deducting the reducing sugar from total sugar and subsequently multiplying with the necessary factor (0.95). The amount of non-reducing sugar estimated, was expressed in g/100 g of juice. Total Soluble Solids (TSS) was determined by using ERMA hand refractometer and expressed in °Brix (Ranganna, 1986) [8]. The acidity was calculated and expressed as per cent malic acid (Ranganna, 1986) [8]. Brix acid ratio was calculated by dividing the T.S.S value with the acid value (Titratable Acidity).

Statistical analysis
The data obtained in this study was subjected to Analysis of Variance (ANOVA) for a Randomized Block Design as per the procedure outlined by Panse and Sukhatme (1985) [8]. The data were processed at Computer Centre, PJTS Agricultural University, Hyderabad using well established statistical methods.

Results
Number of days taken for ripening of fruits
There was significant difference between the treatments for number of days taken for ripening of fruits. Significant delay of ripening of fruits was found when trees were sprayed with 75 ppm GA_3 at 20 days before harvest (16.33 days) and 1.50% $CaCl_2$ at 20 DBH (16.0). The reason might be that pre-harvest applications of gibberellic acid decreasing the tissue permeability there by reducing the rate of water loss leading to delayed fruit ripening (Wills *et al*., 1998) [14] and it showed the inhibitory effect on ethylene biosynthesis and retarded the activity of enzymes responsible for ripening and through creation of resistance to pathogen entry, hence cell degradation was prevented which in turn facilitated the reduced moisture loss and lesser respiratory gas exchange, results in delay of ripening. The delay of ripening by $CaCl_2$ may be attributed to higher fruit calcium levels that lead to the reduction of respiration and ethylene production rates (Singh *et al*., 2003) [11].

Shelf-life of fruits
Significantly long shelf-life of fruit was recorded in Cv. Amrapali when trees were sprayed with 75 ppm GA_3 at 20 days before harvest (21.0 days) and 1.5% $CaCl_2$ at 20 DBH (20.8 days) (Fig.1). The shelf-life of fruits was minimum (11.3 days) in control trees. in general, the shelf life fruits increased with increase in concentration of GA_3, $CaCl_2$.The current study demonstrates that application of GA_3 has merit in extending the shelf life might be due to delay in conversion of starch to sugars there by reducing the peroxidase activity and ethylene. The extended shelf life in $CaCl_2$ treatment may be due to the fact that calcium enhances fruit firmness relative to control which leads to slower hastening and extends the shelf-life.

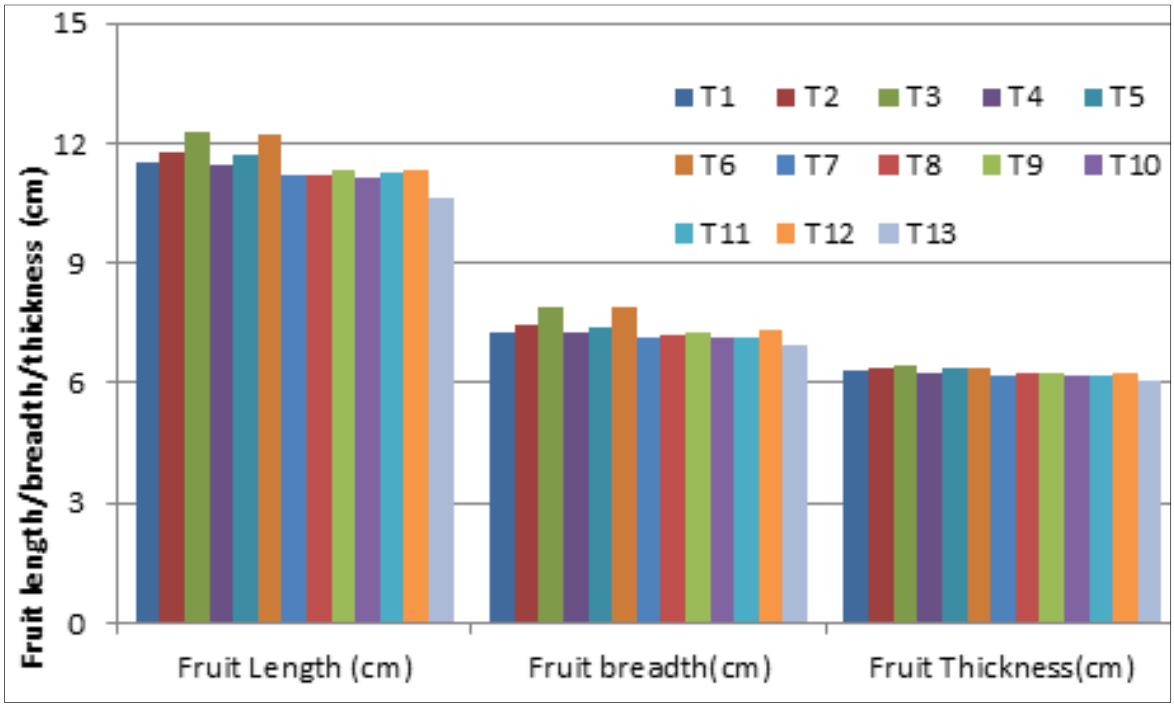


CD (5%): days to ripening: 0.816; Shelf life: 1.05

Fig 1: Effect of pre harvest treatments on days to ripening and shelf life of mango cv. Amrapali

Physical parameters of fruits

Higher fruit length (12.30 cm), breadth (7.93 cm), thickness (6.43cm) was recorded in treatment of 1.5% $CaCl_2$ at 20 days before harvest where as volume (322.66 ml), weight of fruit (341 g) and pulp weight of fruit (218.23 g) was maximum when trees were sprayed with 75 ppm GA_3 at 20 days before harvest (Fig. 2 & 3) when compared with other treatments. Richard (2006) reported that gibberellic acid promoted growth by increasing plasticity of the cell wall followed by the hydrolysis of starch into sugars which reduces the cell water potential, resulting in the entry of water into the cell and causing elongation. The improvement observed in the fruit quality due to calcium chloride could be attributed to its effects in influencing formation and changes of carbohydrates and carbohydrate enzymes, others reasons might be the reduction of abscission and the calcium influence in maintaining the middle lamella cells Wahdan *et al*. (2011) [13].



CD (5%): Fruit length : NS, Fruit breadth: NS; Fruit thickness: 0.03

T_1: 0.5% $CaCl_2$ spray at 20DBH, T_2: 1.0% $CaCl_2$ spray at 20DBH,T_3: 1.5% $CaCl_2$ spray at 20DBH

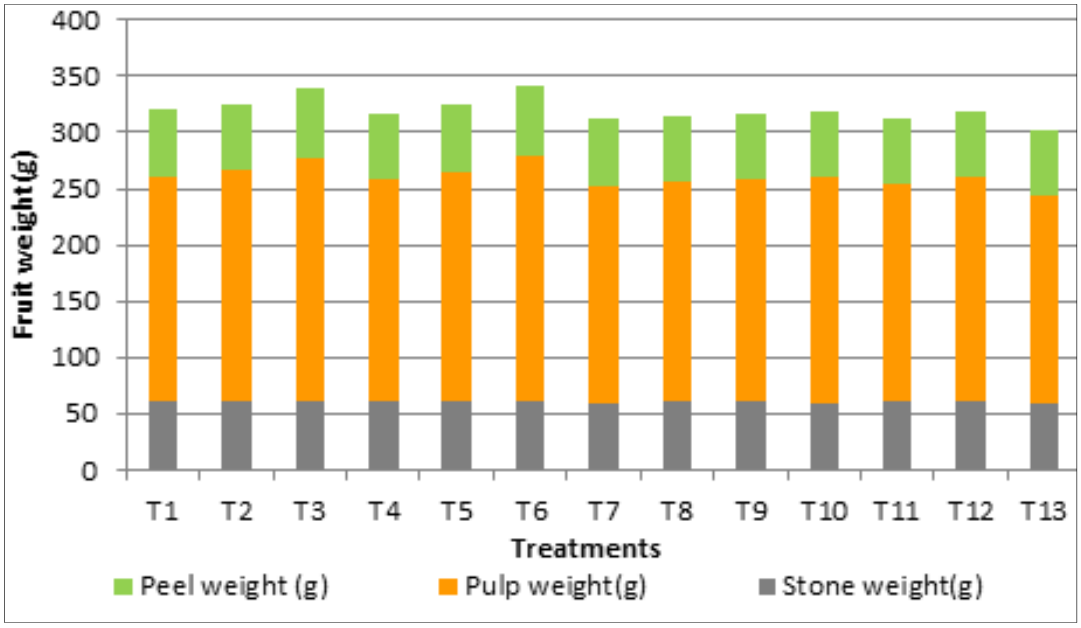
T_4: 25 ppm GA_3 spray at 20DBH, T_5: 50 ppm GA_3 spray at 20DBH, T_6: 75 ppm GA_3 spray at 20DBH

T_7: 0.5% $CaCl_2$ spray at 10DBH, T_8: 1.0% $CaCl_2$ spray at 10DBH, T_9: 1.5% $CaCl_2$ spray at 10DBH

T_{10}: 25 ppm GA3 spray at 10DBH, T_{11}: 50 ppm GA_3 spray at 10DBH, T_{12}: 75 ppm GA_3 spray at 10DBH

T_{13}: Control (water spray) DBH: Days before harvest

Fig 2: Effect of pre harvest treatments on physical parameters of mango cv. Amprapali

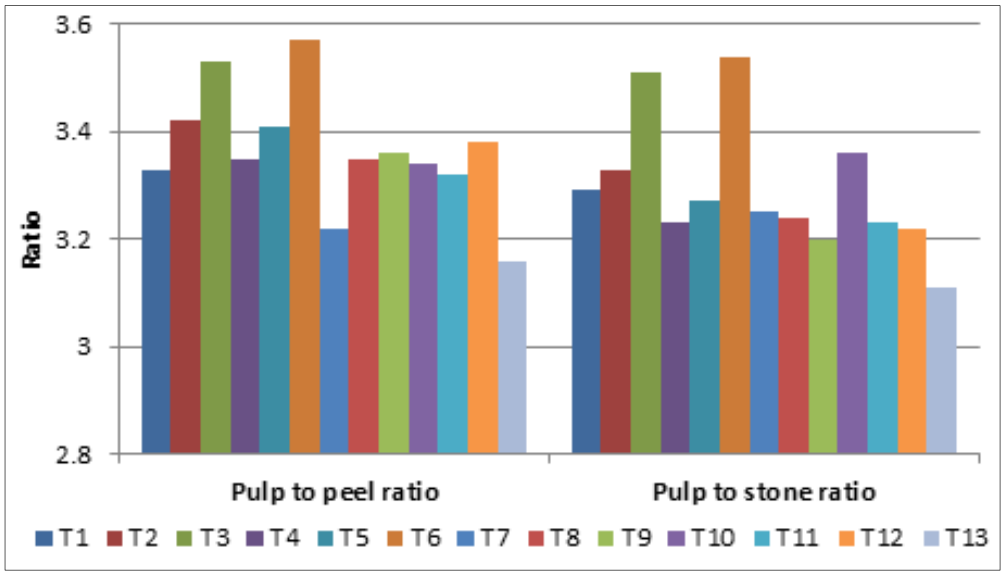


CD (5%): Fruit weight: 3.32; Peel wt.: 0.347; Pulp wt.: 3.61; Stone wt.: 0.527

Fig 3: Effect of pre harvest treatments on fruit weight parameters of mango cv. Amprapali

Pulp/peel and pulp / stone ratio

Significantly maximum pulp to peel (3.57), pulp to stone (3.54) ratio of fruit was recorded in Cv. Amrapali when trees were sprayed with 75 ppm GA_3 at 20 days before harvest (Fig.4).



CD (5%):Pulp to peel ratio: 0.06; Pulp to stone ratio: 0.07

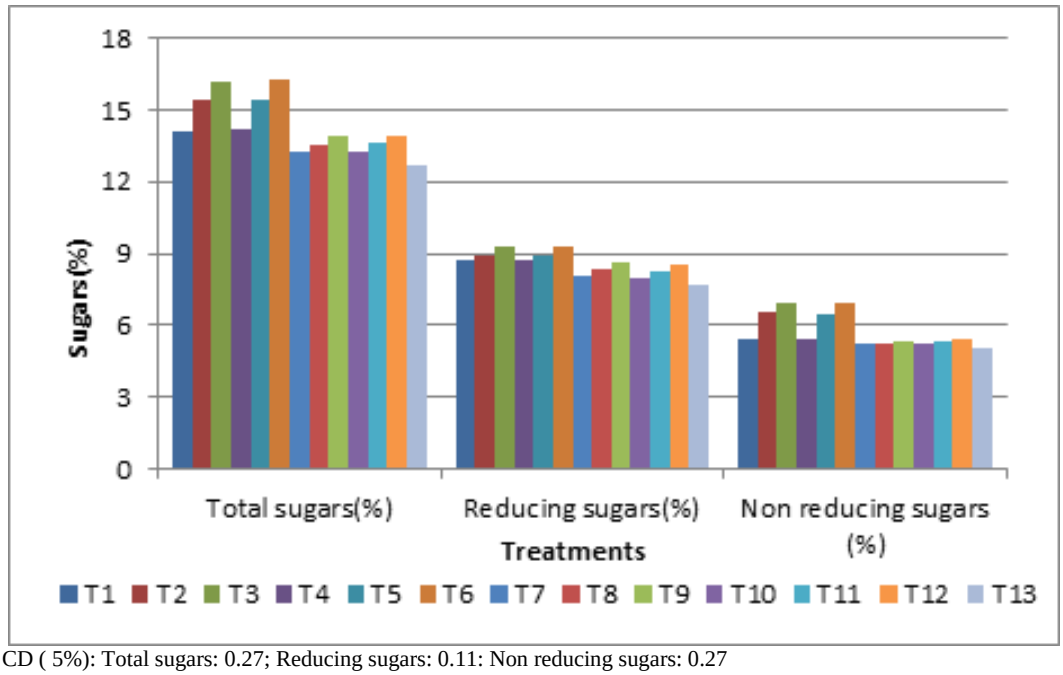
Fig 4: Effect of pre harvest treatments pulp to peel ratio and pulp to stone ratio of mango cv. Amprapali

Chemical parameters of fruits

Significantly higher TSS of fruit (21.66^{0}Brix), significantly higher percentage of total sugars (16.24 %), and reducing sugar (9.26 %) and minimum percentage of titratable acidity (0.14%) was observed when trees were sprayed with 75 ppm GA_3 at 20 days before harvest (Fig.5 & 6). The increase of TSS during storage periods might be the because of transformation of organic matter of fruits to soluble solids under enzymatic activities. The general increase of TSS of fruits has been recorded by Wahdan *et al*. (2011) [13]. Among the different treatments minimum acidity recorded in GA_3 75 ppm 20 DBH. This reduction of acidity content might be due to the change of acid into sugars under enzyme invertase influence during storage period. GA3 induced reduction in acidity, may be linked with hormonal stimulation of assimilates translocation. Similar changes have been reported by Monica *et al.*, (2013) [5] in litchi cv. Dehradun

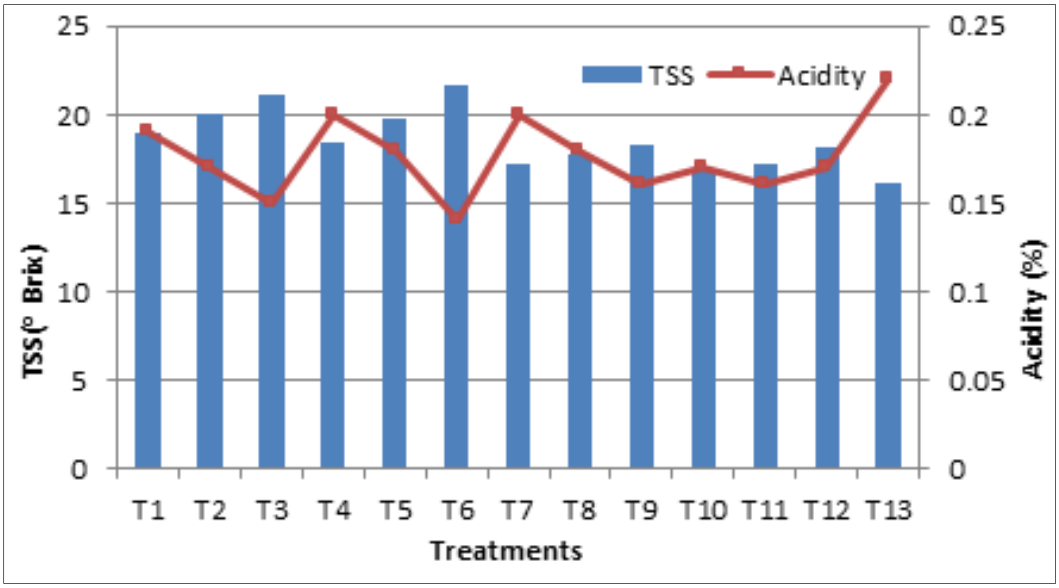
The increase in sugars content of mango fruits could be due to normal ripening process that leads to senescence and to the transformation of some carbohydrates components as starch to sugars by the enzymatic activities. $CaCl_2$ and GA_3 treatments significantly increased total sugars during storage of mango fruits. The increase in the sugars of fruits has been recorded by Wahdan *et al*. (2011) [13]. Reduction of acidity

content may be due to the change of acid into sugars under enzyme invertase influence during storage period. The observed decreasing in the fruitacidity could be due to that acids partially are a respiratory substrate and its consumption in respiratory increase with the progresses of storage periods and this may be responsible for the observed decreasing in acidity during the storage. The findings obtained in the present investigation can be compared to those obtained by Mahajan *et al*. (2011)



CD (5%): Total sugars: 0.27; Reducing sugars: 0.11: Non reducing sugars: 0.27

Fig 5: Effect of pre harvest treatments on Chemical parameter of mango cv. Amrapali



CD(5%):TSS: 0.64; Acidity: 0.02

Fig 6: Effect of pre harvest treatments on TSS (° Brix) and acidity (%) of mango cv. Amrapali

Organoleptic qualities of fruits

Results pertaining to the shelf-life of fruits are presented in Table.1. Organoleptic qualities of mango fruits Cv. Amrapali when trees were sprayed with different concentrations of 75 ppm GA_3 at 20 DBH (8.23) and 1.5% $CaCl_2$ at 20 DBH (8.21) showed a good quality of fruit when compared to control trees (6.79 points). Singh *et al.* (1993) [12] also studied the changes in post-harvest quality of mangoes affected by pre-harvest application of calcium chloride and they observed that there were no significant changes on skin green colour when fruits were ripened. Partially green colour of peel in treated fruits by calcium components treatment showed that there is a relationship of its components with physiological phenomenon occurred in colour development 75 ppm GA_3 at 20 days before harvest showed maximum score of pulp colour and pulp texture of fruits. However, the score was minimum in fruits from water sprayed trees (control).

Table 1: Effect of pre harvest treatments on organoleptic qualities on mango cv. Amrapali

No.	Treatments	Peel Color	Pulp color	Pulp Texture	Pulp Flavor	Pulp Taste	Average score
T_1	0.5% $CaCl_2$ spray at 20DBH	7.99	7.76	7.83	7.84	7.50	7.78
T_2	1.0% $CaCl_2$ spray at 20DBH	8.06	7.85	8.16	7.78	8.03	7.97
T_3	1.5% $CaCl_2$ spray at 20DBH	8.16	8.05	8.33	8.00	8.54	8.21
T_4	25 ppm GA_3 spray at 20DBH	7.98	7.70	7.93	7.91	7.46	7.79
T_5	50 ppm GA_3 spray at 20DBH	8.05	7.81	8.10	7.89	7.93	7.95
T_6	75 ppm GA_3 spray at 20DBH	8.14	8.11	8.36	8.01	8.56	8.23
T_7	0.5% $CaCl_2$ spray at 10DBH	7.90	7.51	7.70	7.93	7.30	7.66
T_8	1.0% $CaCl_2$ spray at 10DBH	7.95	7.62	7.80	7.82	7.93	7.82
T_9	1.5% $CaCl_2$ spray at 10DBH	7.96	7.66	8.13	7.83	8.20	7.95
T_{10}	0.5% GA_3 spray at 10DBH	7.91	7.48	7.76	7.94	7.46	7.71
T_{11}	1.0% GA_3 spray at 10DBH	7.93	7.61	7.93	7.87	7.96	7.86
T_{12}	1.5% GA_3 spray at 10DBH	7.97	7.65	8.10	7.97	8.16	7.97
T_{13}	Control (water spray)	7.27	7.23	6.06	7.78	6.56	6.98
	SE(m)	0.315	0.308	0.053	0.066	0.099	
	CD at 5%	NS	NS	0.155	NS	0.029	

DBH: Days before harvest

Conclusion

The present study showed that the ripening, shelf-life, physico-chemical parameters and organoleptic evaluation of mango fruits Cv. Amrapali were improved when sprayed with 75 ppm GA_3 at 20 days before harvest and 1.5% $CaCl_2$ at 20 DBH. Hence both can be used depending on their availability.

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