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ASSESSING THE EFFECTIVENESS OF VARIOUS PHYSICO-CHEMICAL TREATMENTS ON THE NUTRITIONAL QUALITY AND PROLONG SHELF LIFE OF MANGO (*MANGIFERA INDICA* L.) CV. RATAUL

Arbaj Ali[1]*, Sanjay Kumar Tripathi[1], Arvind Kumar[1], Satya Prakash[2], Suresh Chandra[3], Amit Kumar[4], Uday Raj Gaurav[1], Amit Kumar[1] and Tripti Singh[1]

[1]Department of Fruit Science, College of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250110, Uttar Pradesh, India

[2]Department of Vegetable Science, College of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250110, Uttar Pradesh, India

[3]Department of Agricultural Engineering, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut-250110, Uttar Pradesh, India

[4]Department of Fruit Science, College of Horticulture, Chandra Shekhar Azad University of Agriculture & Technology, Kanpur-208002, Uttar Pradesh, India

*Corresponding author E-mail: aliarbaj162@gmail.com

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ABSTRACT

This study was conducted at Post-Harvest Laboratory, Department of Horticulture, Sardar Vallabhbhai Patel University of Agriculture and Technology, Meerut (U.P.). The objective was to evaluate the effects of various post-harvest treatments on the ripening dynamics and shelf life of mango fruits during storage under ambient conditions. Among the different treatments evaluated, Ethrel at 750 ppm emerged as the most effective across multiple parameters. Physiologically, Ethrel 750 ppm-treated fruits demonstrated the lowest physiological loss in weight with 2.15%, 4.75% and 5.85% on the 5th, 10th and 15th day, respectively and decay percentage of 0%, 1.12% and 4.15%, indicating better storability. Firmness retention was significantly higher in the same treatment at 45.13 N, 24.46 N and 15.89 N on the 5th, 10th and 15th day, respectively, outperforming all other treatments. Fruit skin colour received sensory scores of 8.26, 8.45 and 7.83, while flavour/aroma scored 7.83, 8.26 and 7.95 on the 5th, 10th and 15th day, respectively, signifying superior consumer appeal. In terms of marketability and freshness, Ethrel 750 ppm-treated fruits achieved the highest sensory evaluation scores of 7.26, 8.76, and 7.22 for marketability and 8.45, 8.36 and 7.89 for freshness on the 5th, 10th and 15th day, respectively. Specific gravity decreased during storage, with values of 0.938, 0.928 and 0.812 for Ethrel 750 ppm on the 5th, 10th and 15th day, respectively, correlating with advanced ripening stages. Bio-chemically, Ethrel 750 ppm treatment significantly increased total soluble solids with 18.58°Brix, 20.55°Brix and 20.65°Brix; reducing sugars content with 3.81%, 4.25%, and 4.36% and total sugars content with 14.95%, 15.82% and 15.85% on the 5th, 10th and 15th day, respectively. Furthermore, it maintained lower titratable acidity at 0.24%, 0.22% and 0.17% and favourable pH values of 3.25, 5.12 and 6.78 across the three respective intervals, indicating balanced ripening. Non-reducing sugars in Ethrel 750 ppm was recorded at 11.82%, 11.57% and 11.49% on the 5th, 10th and 15th day, respectively. Overall, Ethrel 750 ppm proved to be the best treatment for enhancing ripening characteristics, improving sensory attributes and prolonging post-harvest shelf life of mango cv. Rataul. Ethrel 500 ppm also performed well, although slightly less effectively. The results strongly support the application of Ethrel at 750 ppm as a promising post-harvest management strategy for improving mango fruit quality during storage.

***Key words*:** Ethrel 750 ppm, Post-harvest treatment, Ripening, Shelf life, Mango (cv. Rataul), Sensory evaluation

Introduction

Mango (*Mangifera indica* L.) originated in north-eastern India, along the Indo-Myanmar border, and in Bangladesh, where it may still be found as a wild tree

with very tiny fruits. It is also reported to exist near Nepal, Bhutan, and Sikkim in the lower Himalayan region (Dinesh *et al.*, 2016). Mango is a diploid fruit tree with 2n = 40 chromosomes (Kuhn *et al.*, 2017). According to Mukherjee (1953), mango has been cultivated for at least 4000 years, with over 1000 kinds grown throughout this time. Mangoes are grown well both in tropical as well as sub-tropical regions at about 1200–1400 m above mean sea level (Kostermans & Bompard,1993). Nutritionally, it offers a balance of macronutrients and micronutrients, containing approximately 0.8 g of protein, 15 g of carbohydrates, 0.4 g of fat, 1.6 g of fibre, and 14 g of sugars per 100 g. It also provides important minerals such as calcium (6 mg), iron (0.16 mg), magnesium (10 mg), phosphorus (14 mg), potassium (168 mg), and sodium (1 mg). Additionally, it is a good source of vitamins, including vitamin C (36.4 mg), thiamine (0.028 mg), riboflavin (0.038 mg), and niacin (0.669 mg) per 100 g (USDA, 2018).

India is the largest producer of mango in the world with an annual production of 22.39 MMT from an area of 2.39 M ha (NHB, 2023-24). Major mango producing states include Uttar Pradesh, Maharashtra, Bihar, and Karnataka.

The Rataul mango is characterized by a medium-sized tree with an erect trunk and an irregular to spreading crown, typically reaching an average diameter of 10 meters. The tree exhibits a predominantly spreading growth habit. Flowering initiates in early March, with fruit maturity occurring from early to mid-July. The ripened fruit is small, oval, and exhibits a prominent sloping ventral shoulder, typically elevated relative to the dorsal side. The fruit skin is medium in thickness, greenish-yellow in colour, and the flesh exhibits medium firmness with scanty fibre near the skin.

Finally taking account the mango is climacteric fruit that continue the ripening process after detachment from the parent plant, attributed to the increase in the rate of respiration and ethylene production (Tharanathan *et al*., 2006), several post-harvest handling process can reduce their post-harvest life and also the fruit composition, leading to losses in term quality and quantity, which can be considerable reduce by applying adequate and improve strategies and technologies to prolong the self-life of mango fruit in India and other tropical countries, the commercial fruit crop is mostly traded in ambient condition and reported to have faster ripening and high post-harvest losses (Singh *et al*., 2013). Conducting this study under various physico-chemical treatments required strict standardization and randomization of mango samples to ensure consistency and minimize bias. A key challenge was maintaining uniformity in fruit size and maturity, which was addressed through careful selection and random allocation. Application of treatments such as Ethrel, Calcium nitrate $Ca(NO_3)_2$, and Chitosan demanded precise formulation and consistent monitoring to avoid variability in results. The ripening process and post-harvest evaluation involved regular and labour-intensive assessments of quality parameters including firmness, colour, weight loss, and total soluble solids. Environmental variables like temperature and humidity were carefully controlled, as fluctuations could influence outcomes. Limitations in sample size and replication due to resource constraints may have affected statistical robustness. Despite these challenges, understanding the ripening behaviour and post-harvest physiology of mangoes remains critical for enhancing fruit quality, shelf life, and market value. Therefore, the present study was undertaken to evaluate the post-harvest quality of *Mangifera indica* L. cv. Rataul under different physico-chemical treatments.

Material and Methods

The present investigation was carried out during 2024 at the Post-harvest Laboratory, College of Horticulture, and Agro Processing Centre (CoPHT&FP), Sardar Vallabhbhai Patel University of Agriculture & Technology, Meerut, Uttar Pradesh, India. The experimental site is geographically located at 29º04 N latitude and 77°42 E longitude, with an elevation of 237.75 meters above mean sea level. The fruit were obtained from 6 to 8 years old orchard of mango cv. Rataul planted at a distance of 8×8 m. The study aimed to evaluate the post-harvest ripening behaviour and shelf life of mango cv. Rataul by examining various physico-chemical and sensory parameters during storage. The parameters assessed included Physiological Loss in Weight (%), decay percentage, fruit firmness (N), sensory attributes (score), Total Soluble Solids (° Brix), pulp pH, total titratable acidity (%), total sugars (%), reducing sugars (%), sugars/acidity ratio and non-reducing sugars (%).

The experiment was laid out in a Completely Randomized Design (CRD) comprising 12 treatments *i.e.* are Control (T_1), $CaNO_3$ 1.5% (T_2), $CaNO_3$ 2.0% (T_3), $CaNO_3$ 2.5% (T_4), Chitosan 1.0% (T_5), Chitosan 1.5% (T_6), Chitosan 2.0% (T_7), {Pedicellate Fruits 12 cm in length (T_8)}, CaNO3 1.5% + Chitosan 1.5% (T_9), Ethrel 500 ppm (T_{10}), Ethrel 750 ppm (T_{11}) and Ethrel 1000 ppm (T_{12}) each replicated thrice. Observations were recorded at three intervals: the 5th, 10th and 15th days of storage room temperature. PLW (%) was calculated manually following the method described by Srivastava

Table 1: Observations of PLW, Decay percent, Firmness and Sensory of mango cv. Rataul.

Treatments	Day of storage (at ambient room temperature)											
	Physiological loss in weight (%)			Decay (%)			Fruit firmness (N)			Sensory evaluation test		
	5th	10th	15th	5th	10th	15th	5th	10th	15th	5th	10th	15th
Control	6.23	11.23	15.85	0.00	6.64	15.58	39.12	16.61	12.89	6.35	6.72	6.45
$CaNO_3$ 1.5%	5.26	7.36	9.58	0.00	5.87	8.47	42.41	20.18	13.49	6.25	7.57	7.25
$CaNO_3$ 2.0%	5.35	7.43	10.36	0.00	5.71	8.72	41.23	19.76	11.35	6.5	7.25	6.62
$CaNO_3$ 2.5%	4.58	7.65	10.78	0.00	5.75	8.91	40.38	18.46	12.59	6.28	7.35	7
Chitosan1.0%	5.58	9.11	12.48	0.00	5.42	8.12	25.46	21.33	13.25	6.75	7.55	7.38
Chitosan1.5%	5.31	8.33	14.36	0.00	5.34	8.39	23.88	22.67	13.18	6.55	7.7	7.28
Chitosan2.0%	5.03	7.56	13.25	0.00	5.77	8.41	31.72	29.21	11.12	6.44	7.45	7.14
Pedicellate Fruits	4.45	6.38	9.89	0.00	1.23	5.12	42.76	21.49	14.13	7.45	8	7.65
$CaNO_3$ 1.5% + Chitosan1.5%	4.78	7.34	11.92	0.00	5.44	8.34	39.11	20.92	11.31	6.4	7.63	7.26
Ethrel 500 ppm	3.93	6.26	8.23	0.00	1.15	6.15	43.56	22.23	13.23	7.25	8.25	8
Ethrel 750 ppm	2.15	4.75	5.85	0.00	1.12	4.15	45.13	24.46	15.89	7.84	8.35	8.15
Ethrel 1000 ppm	7.15	12.41	16.95	0.00	4.73	11.34	38.16	19.42	12.15	7.15	7	6.95
Mean	**4.983**	**7.984**	**11.625**	0.00	**4.514**	**8.475**	**37.743**	**21.395**	**12.882**			
SE(m)±	0.064	0.078	0.138		0.057	0.178	0.497	0.306	0.225			
C.D.at5%	0.187	0.228	0.402		0.168	0.52	1.452	0.893	0.656			
C.V.(%)	2.227	1.692	2.052		2.206	3.64	2.282	2.476	3.023			

and Tandon (1968). Decay percentage was determined based on the incidence of visible spoilage symptoms, expressed as the proportion of unmarketable fruits. Fruit firmness was measured using a penetrometer and expressed in Newtons (N). Sensory evaluation, based on taste, flavour, aroma, fruit freshness, and overall marketability, was conducted using the Hedonic scale (1-9) Amerine *et al*., (1965). A panel of five trained judges, aged between 21 and 60 years, assessed the samples.

The biochemical analysis conducted by following standard protocols. Titratable acidity (%), reducing sugars (%) and non-reducing sugars was determined by method described in A.O.A.C. (2000). The TSS content of mango pulp was determined using a hand refractometer (range 0-32° Brix) (A.O.A.C. 2000). Freshly extracted juice was used for determining the pulp pH using a digital pH meter. Total sugar were estimated as suggested by Ranganna (1999). sugars/acidity ratio was calculated by Venkatesan & Tamilmani (2014).

Statistical analysis of the data was performed as per the procedures outlined by Gomez and Gomez (1996). The findings from this study are expected to contribute valuable insights into optimizing storage practices, minimizing post-harvest losses, and extending the marketability of mango cv. Rataul.

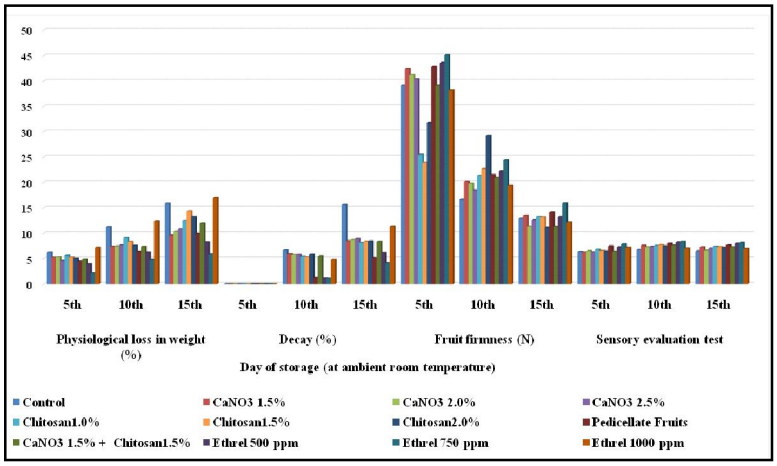

Fig. 1: Observations of PLW, Decay percent, Firmness and Sensory of mango cv. Rataul.

Results and Discussion

Effect on Physiological loss in weight

The present mango data in Table 1 showed that the physiological loss in weight (PLW) of stored at room temperature. The fruits treated with Ethrel 750 ppm was found statistically superior over rest of the treatment with minimum percent physiological loss in weight during 5th, 10th, and 15th days of the storage of room temperature (2.15, 4.75, 5.85) respectively followed by Ethrel 500 ppm (3.93, 6.26, 8.23) and Pedicellate fruits (4.45, 6.38, 9.89). A similar trend was also observed by Sakhale *et al*. (2006), Kulkarni *et al.*, (2004) in mango Cv. Alphonso, Mahajan *et al.*, (2010). Continuous processes of respiration and transpiration have resulted in weight loss of mango. Siddiqui and Dhua (2009).

Table 2: Observations of TSS, pH, Titrability acidity and Reducing sugars of mango cv. Rataul.

Treatments	Day of storage (at ambient room temperature)											
	TSS (°Brix)			pH of Mango Fruits			Titrability Acidity (%)			Reducing Sugars of (%)		
	5th	10th	15th	5th	10th	15th	5th	10th	15th	5th	10th	15th
Control	18.23	18.35	19.63	3.88	6.12	6.24	0.35	0.28	0.21	3.22	3.58	3.68
$CaNO_3$ 1.5%	18.15	18.68	18.77	3.58	5.78	5.92	0.3	0.26	0.18	3.43	3.62	3.96
$CaNO_3$ 2.0%	17.45	19.25	19.35	3.47	5.88	6.34	0.32	0.25	0.19	3.58	3.65	3.78
$CaNO_3$ 2.5%	18.25	19.35	19.25	3.44	5.98	5.88	0.34	0.27	0.18	3.65	3.83	3.88
Chitosan1.0%	17.54	18.35	19.23	3.95	5.25	5.35	0.32	0.25	0.21	3.68	3.85	3.92
Chitosan1.5%	18.25	18.95	18.95	3.55	5.36	5.48	0.31	0.26	0.18	3.73	3.76	3.87
Chitosan2.0%	16.35	18.45	18.85	3.28	5.99	6.02	0.33	0.25	0.19	3.55	3.81	3.85
Pedicellate Fruits	18.15	19.44	19.56	3.35	6.23	6.46	0.27	0.24	0.19	3.62	3.74	3.95
$CaNO_3$ 1.5% + Chitosan1.5%	18.35	18.46	19.25	3.65	5.57	5.72	0.31	0.26	0.2	3.71	3.83	3.86
Ethrel 500 ppm	17.35	20.15	19.45	4.28	6.17	6.56	0.26	0.23	0.18	3.78	4.16	4.28
Ethrel 750 ppm	18.58	20.55	20.65	3.25	5.12	6.78	0.24	0.22	0.17	3.81	4.25	4.36
Ethrel 1000 ppm	16.25	18.75	18.95	4.15	6.14	6.39	0.29	0.24	0.2	3.45	3.65	3.76
Mean	**17.742**	**19.061**	**19.324**	**3.652**	**5.799**	**6.095**	**0.303**	**0.251**	**0.19**	**3.601**	**3.811**	**3.929**
SE(m)±	0.216	0.354	0.297	0.051	0.09	0.1	0.005	0.003	0.003	0.061	0.066	0.061
C.D.at5%	0.63	1.032	0.868	0.15	0.262	0.293	0.015	0.01	0.009	0.179	0.192	0.177
C.V.(%)	2.109	3.214	2.664	2.439	2.681	2.848	2.916	2.364	2.826	2.957	2.985	2.68

Effect on decay %

No decay percent was recorded in all the treatments on the 5th day after storage, while on 10th day Ethrel 750 ppm the minimum decay % was recorded in 1.12 %. and pedicellate fruits recorded in 1.23 decay %. On 15th day of storage, the minimum decay percentage was recorded in Ethrel 750 ppm 4.15%. The maximum percent of decay were recorded in control (6.64 and 15.58). Similar trend was also observed by Singh *et al.*, (2012).

Effect on specific gravity

After 5th days of storage, the maximum specific gravity 1.113 was observed in the control treatment. The lowest value was recorded in Ethrel 750 ppm at 0.938. This pattern was consistent at 10 and 15 days as well, where control continued to maintain relatively higher specific gravity values, although declining to 1.103 and 0.937, respectively. By the 10th day, a noticeable decrease was observed in specific gravity across all treatments, with $CaNO_3$ 1.5% at 0.918 and Ethrel 1000 ppm showing the lowest values of 0.883. This trend persisted on the 15th day, where ethrel 750 ppm and 1000 ppm registered the minimum values of 0.812 and 0.816, indicating rapid ripening and associated moisture loss under higher ethrel concentrations. Similar trend was also observed by Singh *et al.*, (2012).

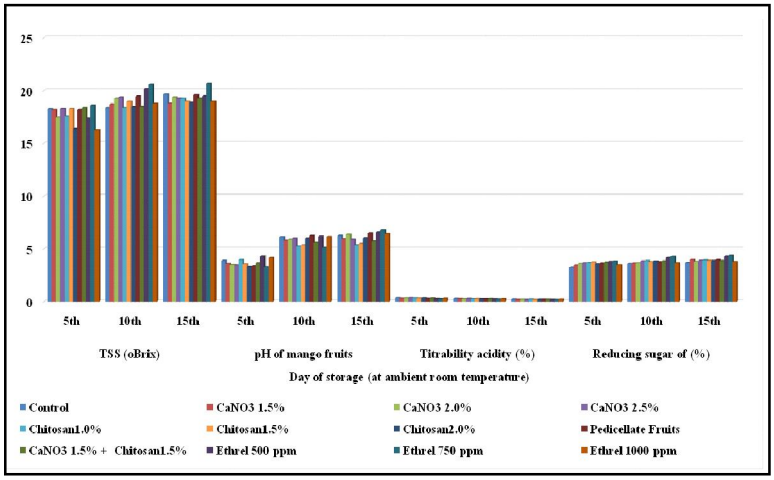

Fig. 2: Observations of TSS, pH, Titrability acidity and Reducing sugars of mango cv. Rataul.

Effect on fruit firmness

The 5th days of ambient room temperature, the treatment with 750 ppm was superior performance in retaining fruit firmness at 45.13 (N), While on 10th days of storage, the most effective treatment for preserving fruits firmness was chitosan 2.0 at 29.21 (N). On the 15th days of storage, the treatment with ethrel 750 ppm, pedicellate fruits 500 ppm and ethrel 500 ppm were effective slow down the decline in fruits firmness of rataul mango (15.89, 14.13 and 13.23) N respectively. In respect of firmness of fruits, the results show that it decreased with the ripening of the fruits. Similar results were also obtained by Yashoda *et al.*, (2006), Ali *et al.*, (2011) and Siddqui and Dhua (2009).

Table 3: Observations of Total sugarsand Specific gravity of mango cv. Rataul.

Treatments	Day of storage (at ambient room temperature)					
	Total Sugar (%)			Specific Gravity		
	5th	10th	15th	5th	10th	15th
Control	14.12	14.36	15.38	1.113	1.103	0.937
$CaNO_3$ 1.5%	14.42	14.75	15.45	0.962	0.918	0.861
$CaNO_3$ 2.0%	14.36	14.56	15.52	1.095	0.966	0.905
$CaNO_3$ 2.5%	14.55	14.78	15.46	0.992	0.949	0.878
Chitosan1.0%	14.38	14.44	15.65	1.102	1.071	1.021
Chitosan1.5%	14.36	14.76	15.44	1.103	1.082	1.011
Chitosan2.0%	14.43	14.68	15.69	1.101	1.078	1.065
Pedicellate Fruits	14.65	15.55	15.78	0.995	0.965	0.935
$CaNO_3$ 1.5% + Chitosan1.5%	14.53	14.67	15.76	1.037	0.998	0.936
Ethrel 500 ppm	14.78	15.75	15.82	0.952	0.926	0.849
Ethrel 750 ppm	14.95	15.82	15.85	0.938	0.928	0.812
Ethrel 1000 ppm	14.42	15.43	15.74	0.948	0.883	0.816
Mean	**14.496**	**14.963**	**15.628**	**1.028**	**0.989**	**0.919**
SE(m)±	0.202	0.207	0.199	0.015	0.057	0.178
C.D.at5%	0.589	0.604	0.581	0.045	0.168	0.52
C.V.(%)	2.413	2.394	2.206	2.60	2.206	3.64

Effect of sensory evaluation

The Sensory evaluation test on the 5th day show the maximum value 7.84 when fruit was treated with Ethrel 750 ppm. while on 10th and 15th day, Sensory evaluation tests were conducted in which Ethrel 750 ppm, best performance Sensory evaluation score at (8.35) and (8.15) respectively. While the minimum sensory score at (6.25) on the 5th day of storage were recorded when fruit treated with $CaNO_3$ 1.5%. On the 10th day of storage lowest sensory evaluation scores at (6.72) was obtained by Control, On the 15th days of storage lowest sensory evaluation scores control at 6.45. The similar trends was followed by Gupta *et al.*, (2015) in their experiment Ethrel 750 ppm and Ethrel 500 ppm found best sensory evaluation scores.

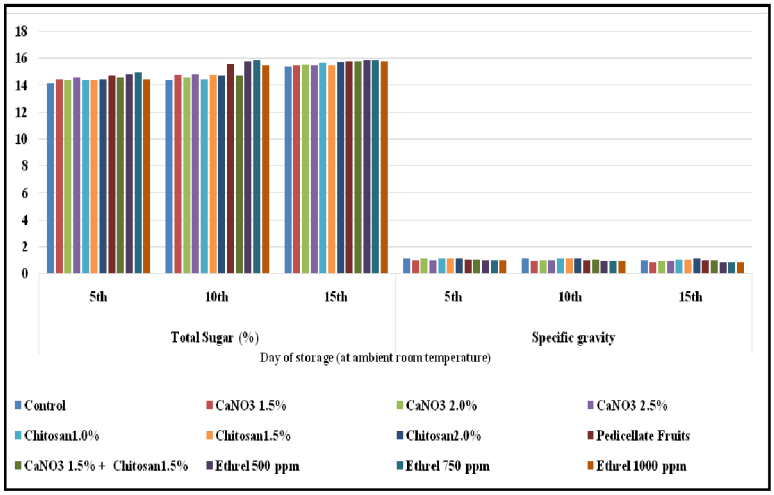

Fig. 3: Observations of Total sugars and Specific gravity of mango cv. Rataul.

Effect of Total Soluble solids (TSS)

At the initial stage, the TSS of mango fruit was found to be 15 °Brix. At the end of 5th, 10th and 15th day of storage, Ethrel 750 ppm recorded maximum TSS (18.58, 20.55 and 20.65) respectively. The minimum TSS value recorded after 5th days of storage, Ethrel 1000 ppm (16.25) in ethylene gas exposure treatment in the ripening chamber. At the end of 10th day of storage, the Control treatment recorded minimum TSS value (18.35) in ethylene gas exposure treatment in the ripening chamber. At the end of 15th days of storage, the minimum TSS value recorded $CaNO_3$ 1.5% (18.77). The TSS might be increased due to hydrolysis of starch, cellulose and pectin substances into simpler substances or might be due to decrease in moisture content. Similar results were also reported by Pandarinathan and Sivakumar (2010), Venkatram and Pandiarajan (2014), Zagade and Relekar (2014), Patel *et al.*, (2015) in mango fruits.

Effect of pH

At the initial stage, the pH of mango fruit was found to be 3.20. After 5th days of storage, the highest pH at 4.28 was observed in fruits treated with Ethrel 500 ppm, The lowest pH at this stage was recorded in Ethrel 750 ppm at 3.25. at 10th days, an increase in pH was noticed Pedicellate fruits at 6.23, while the lowest was noted in Ethrel 750 ppm at 5.12. At the end of the storage period 15th days, Ethrel 750 ppm treatment showed the highest pH value at 6.78

and lowest pH at this stage was noted in chitosan 1.0% at 5.35. Similar results also indicated that the pH increased with increase in storage temperatures during ripening of mango fruits. These observations were attributed to the conversion of citric acid and ascorbic acid into sugar and other products with the ripening process and whose rate of conversion was increased with the temperature Rathore *et al*., (2007) and Gol and Rao (2013).

Effect of Total sugars (%)

The initial stage, the TSS of mango fruit was found to be 7.12 %. At 5th days, the maximum total sugars 14.95% was observed in fruits treated with Ethrel 750 ppm. The lowest sugars content at this stage was noted in the control at 14.12%. At 10th days of storage Ethrel 750 ppm treatment recorded the highest total sugars at 15.82%, The control fruits showed a lower total sugars of 14.36%. At 15th days of storage, Ethrel 750 ppm showed the highest sugars content at 15.85%. The lowest value was noted in the control at 15.38%. The significant increase in the total sugarss content may be due to the carbohydrates accumulate during maturation in the form of starch. As the fruit ripens, starch was broken down into sugarss. These observations are in conformity with research findings of Pandarinathan and Sivakumar (2010), Zagade and Relekar (2014) in mango fruits.

Effect of Titratable acidity (%)

At the initial stage, the TSS of mango fruit was found to be 0.39 %. At 5th days of storage, The highest titratable acidity at 0.35% was observed in the control fruits. The lowest acidity at this stage was recorded in fruits treated with Ethrel 750 ppm at 0.24%. At 10th days of storage, The control still maintained a relatively higher acidity at 0.28%. The lowest acidity was found in Ethrel 750 ppm at 0.22% and Ethrel 500 ppm at 0.23%, showing their role in faster acid decline. At 15th days of storage, the maximum titratable acidity recorded in control and Chitosan 1.0% both treatments 0.21%. The minimum acidity at this stage was noted in Ethrel 750 ppm at 0.17%. This might be due to faster degradation of organic acids into sugarss and utilization of acids during respiration. The results obtained in present study are in conformity with the observations of Deepa and Preetha (2014) in mango fruits.

Reducing Sugars (%)

At the initial stage, the Reducing sugars of mango fruit was found to be 3.05 %. At 5th days of storage, The highest reducing sugars content at 3.81% was recorded in fruits treated with Ethrel 750 ppm. The lowest reducing sugars content was found in the control fruits at 3.22%, indicating slower conversion of starch to sugarss without any treatment. At 10th days Ethrel 750 ppm at 4.25% and Ethrel 500 ppm at 4.16% showed the highest values of reducing sugars content. The control recorded a lower value of 3.58% reducing sugars content of mango. At 15th days Ethrel 750 ppm recorded the highest content at 4.36%. The control treatment showed the lowest reducing sugars at 3.68%, demonstrating the slowest ripening and sugars conversion. It might be due to release of sugarss by hydrolysis of starch reserve during ripening stage. The results are also supported by William, (2009), Pandarinathan and Sivakumar (2010), Bhatt *et al*., (2012) and Patel *et al.,* (2015) in mango fruit.

Conclusion

The present study conclude that post-harvest application of physico-chemical treatments significantly influenced the ripening behaviour and shelf life of mango cv. Rataul. Among all treatments, Ethrel 750 ppm consistently outperformed others across a wide range of physical, chemical and sensory parameters during the 5th, 10th, and 15th day of storage at room temperature. It resulted in minimal physiological weight loss, delayed decay and optimal firmness retention, reflecting its ability to regulate water loss and fruit softening effectively. Furthermore, Ethrel 750 ppm enhanced fruit colour, aroma and taste, as confirmed by high sensory evaluation scores throughout the storage period. Bio-chemically, Ethrel 750 ppm facilitated higher TSS, reducing and total sugars and a favourable sugars/acidity ratio, supporting its role in accelerating starch hydrolysis and acid degradation. While other treatments such as Ethrel 500 ppm and pedicellate fruits showed moderate benefits, control and $CaNO_3$ - treated fruits underperformed, especially in flavour and marketability. Overall, Ethrel 750 ppm was established as the most effective treatment, promoting uniform ripening, superior fruit quality, and extended shelf life. These findings are of practical significance for improving mango marketability and post-harvest handling, offering a reliable strategy for commercial-scale ripening and quality maintenance of mango fruits.

Future Scope

This study offers promising insights with potential to significantly impact the mango sector and its stakeholders. The findings contribute to the scientific basis for improving post-harvest handling and storage strategies, aiming to prolong shelf life and maintain fruit integrity throughout distribution. By fine-tuning the ripening process, it becomes feasible to deliver mangoes with enhanced sensory and nutritional qualities. Furthermore, the results may support the development of sustainable and eco-conscious post-harvest interventions, thereby reduce post-harvest losses

and strengthen supply chain efficiency. These advancements are expected to positively influence industry standards, ultimately benefiting cultivators, exporters, retailers, and consumers through more consistent quality and availability of mangoes.

Disclaimer (Artificial Intelligence)

Author(s) hereby declare that NO generative AI technologies such as Large Language Models (ChatGPT, COPILOT, etc) and text-to-image generators have been used during writing or editing of manuscripts.

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References

A.O.A.C. (2000). Official methods of analysis. 17th Edition. Association of Official Analytical Agricultural Chemists, Gaithersburg, M.D., USA.

Ali, A., Muhammad M.T.M., Sijam K. And Siddiqui Y. (2011). Effect of Chitosan coatings on the physiochemical characteristics of Eksotika II Papaya(*Carica papaya* L.) fruit during cold storage. *Food Chemistry*, **124(2)**, 620-626.

Amerine, M.A., Pangborn R.M. and Rossessler E.B. (1965). Principles of sensory evaluation of *food. Acadamic Press inc*., NewYork USA. 366-374.

Bhatt, A., Mishra N.K., Mishra D.S. and Singh C.P. (2012). Foliar application of potassium, calcium, zinc, and boron enhance yield, quality, and shelf life of mango. *Hortflora res. Spectrum.* **1(4)**, 300-305.

Deepa, J. and Preetha P. (2014). Influence of Exposure Time, Temperature and Ethylene Concentration on The Ripening of Mango Fruits. *Trends in Biosciences* **7(20)**, 3260-3267.

Dinesh, M.R., Ravishankar K.V. and Donald Sangma (2016). Mango breeding in India-past and future. *J.Hortl. Sci.*, **11(1)**, 1-12.

Gol, B. Neeta and Rao Ramana T.V. (2013). Influence of zein and gelatin coatings on the postharvest quality and shelf-life extension of mango (*Mangifera indica* L.) Fruits, *EDP sciences vol*. **69**, 101-115.

Gomez, A.K. and Gomez A.A. (1996). Statistical procedure for agricultural research. *2 John willey and sons pnc*. New York.

Gupta, B.P., Singh M.K., Mukesh K., Malik S., Satya P., Singh K.V. and Sanjeev R. (2015). Ripening and post-harvest quality of Dashehari mango as influenced by different physico-chemical treatments during storage. *Hort Flora Research Spectrum*, **4(3)**, 192-199.

Kostermans, A.J.G.H. and Bompard J.M. (1993). The Mangoes: Their Botany. Nomenclature, Horticulture and Utilization, *International Board for Plant Genetic Resources*, Rome and the Linnean Society Publishers, London.

Kuhn, D.N., Bally I.S.E, Dillon N.L., Innes D., Groh A.M., Rahaman J., Ophir R., Cohen Y. and Sherman A. (2017). Genetic Map of Mango: A Tool for Mango Breeding. *Frontiers in Plant Science*, **8**, 577.

Kulkarni, S.G., Kudachikar V.B., Vasantha M.S., Keshava Prakash M.N., Aravinda Prasad B. and Ramana K.V.R. (2004). Studies on effect of ethrel dip treatment on ripening behaviour of mango (*Mangifera indica* L.) variety Neelum *J Food Sci. Technol*. Mysore. **41(2)**, 216-220.

Mahajan, B.V.C., Tajender K., Gill M.S., Dhaliwal H.S., Ghuman B.S. and Chahil B.S. (2010). Studies on optimization of ripening techniques for banana. *J. F. Sci. and Tech*. **47(3)**, 315-319.

Mukherjee, S.K. (1953). The mango - its botany, cultivation, uses and future improvements, especially as observed in India. *Econ. Bot*., **7**, 130.

National Horticulture Board (2023-24). Indian Horticulture Database 2021. Ministry of Agriculture & Farmers Welfare, Government of India. Retrieved from https://www.pib.gov.in

Pandarinathan, S. and Sivakumar S. (2010). Studies on biochemical changes in mangoes due to artificial ripening. *Int. J. Agri. Sci.* **1**, 347-355.

Patel, U., Varu D.K. and Chaudhari J. (2015). Effect of pre-harvest spray of chemicals on shelf-life and quality of mango cv. Kesar. *Asian J. of Hort*. **10(2)**, 187-193.

Ranganna, S. (1999). Handbook of analysis and quality control for fruit and vegetable products and Ed. Tata *Mc-Graw Hill* publishing company Ltd, New Delhi.

Rathore, H.A., Masud T., Sammi S. and Soomro A.H. (2007). Effect of storage on physico-chemical composition and sensory properties of mango (*Mangifera indica* L.) variety Dosehri. *Pak. J. Nutr.* **6**, 143-8.

Sakhale, B.K., Pawar V.N. and Kapse B.M. (2006). Effect of Ethrel on Hastening of Onset of Ripening in Kesar Mango (*Mangifera indica* L.). In VIII *International Mango Symposium*, **820**, 635-642.

Sakhale, B.K., Pawar V.N. and Kapse B.M. (2006). Effect of Ethrel on Hastening of Onset of Ripening in Kesar Mango (*Mangifera indica* L.). In Proceedings of 8th *International Mango Symposium*, February 2006, **820**, 635-642.

Siddiqui, M.D.W. and Dhua R.S. (2009). Standardization of ethrel treatment for inducing ripening of mango var. 'Himsagar'. In Proceedings of *International Conference on Horticulture*, Bangalore; c2009. 1641-1648.

Singh, P., Singh M.K, Kumar M. and Malik S. (2012). Effect of

physic-chemical treatment on ripening behaviour and post-harvest quality of Amrapali Mango (*Mangifera indica* L.) during storage. *J. Environ. Bio*., **33**, 227-232.

Singh, P., Singh M.K., Kumar V., Kumar M. and Malik S. (2012). Effect of physico-chemical treatments on ripening behaviour and post-harvest quality of Amrapali mango (*Mangifera indica* L.) during storage. *Journal of environmental biology*, **33(2)**, 227-232.

Singh, Z., Singh R.K., Sane V.A. and Nath P. (2013). Mango-post-harvest biology and biotechnology. *Critical Reviews in Plant Sciences*, **32(4)**, 217-236.

Srivastava, M.P. and Tandon R.N. (1968). Changes in ascorbic acid content of Mosambi fruit induced by *Botryodiplodiatheobromae*. *Canadian Journal of Plant Science*, **48(3)**, 337-338.

Tharanathan, R.N., Yashoda H.M. and Prabha T.N. (2006). Mango (Mangifera indica L.), "The king of fruits"—An overview. *Food Reviews International*, **22(2)**, 95-123.

United States Department of Agriculture (USDA), Agricultural Research Service, (2018). USDA National Nutrient Database for Standard Reference, Release 1 April, Nutrient Data Laboratory Home Page, https://ndb.nal.usda.gov/ndb/ (accessed 6 July 2022).

Venkatesan, T. and Tamilmani C. (2014). Effect of ethrel on the starch sugars changes of off-season fruits of mango (*Mangifera indica* L. Var. Neelum) during ripening. *International letters of natural sciences*, **2**, 1-12.

Venkatram, P. and Pandiarajan T. (2014). Optimization of Ethylene Concentration and Exposure Time for the Ripening of Mango var. Alphonso in Farm Level Ripening Chamber. *Trends in Biosciences*, **7(24)**, 4259-4263

William, O.A., Ibok O. and William O.E. (2009). Effect of Ethy-Gen II® ripening concentrate on ripening and sensory properties of mangoes (*Mangifera indica* L.). *Pakistan Journal Nutrition*, **8(10)**, 1641-1644.

Yashoda, H.M., Prabha T.N. and Tharanathan R.N. (2006). Mango ripening: changes in cell wall constituents in relation to textural softening. *Journal of the Science Food and Agriculture*, **86(5)**, 713-721

Zagade, V.V. and Ralekar P.P. (2014). Chemical composition, ripening behavior and organoleptic quality of mango Cv. Alphonso as influenced by period of maturity. *Plant Archives*. **14(2)**, 751-756.