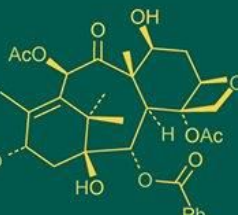
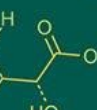
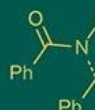


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Impact of pre-harvest calcium and Putrescine sprays on quality parameters of peach cv. Pratap

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Abstract

This study was conducted at the Horticulture Research Centre, Pattharchatta, and the Post-Harvest Laboratory of the Department of Horticulture, College of Agriculture, G.B. Pant University of Agriculture and Technology, Pantnagar, from April to May 2021. The experiment utilized a Factorial Completely Randomized Design (FCRD) with two factors and included twelve treatments: Control (T₁), Calcium Nitrate at 0.5% (T₂), Calcium Nitrate at 1.0% (T₃), Putrescine at 100 ppm (T₄), Putrescine at 200 ppm (T₅), Putrescine at 300 ppm (T₆), Calcium Nitrate at 0.5% combined with Putrescine at 100 ppm (T₇), 200 ppm (T₈), and 300 ppm (T₉), and Calcium Nitrate at 1.0% combined with Putrescine at 100 ppm (T₁₀), 200 ppm (T₁₁), and 300 ppm (T₁₂). These treatments were tested across six storage intervals (0, 6, 12, 18, 24, and 30 days), with 12 treatment combinations replicated three times. After harvesting, the fruits were stored in a refrigerator for further analysis, during which parameters such as fruit weight, fruit diameter, TSS (total soluble solids) to acid ratio, reducing sugars, and non-reducing sugars were evaluated. Among the treatments, T₁₀ (Calcium Nitrate at 1.0% + Putrescine at 100 ppm) was most effective, followed by T₁₁ (Calcium Nitrate at 1.0% + Putrescine at 200 ppm), in minimizing fruit weight and diameter loss while maintaining the TSS to acid ratio and sugar content throughout the storage period.

Keywords: Putrescine, calcium, TSS: acid ratio and quality attributes

Introduction

Peach (*Prunus persica* L. Batsch) belongs to the family Rosaceae, is considered one of the most important stone fruits and has prodigious demands in the international market because of its attractive colour, excellent quality, and superior taste (Cantin *et al.*, 2009, Serra *et al.*, 2020, Chauhan *et al.*, 2021) [2, 18, 3]. It is believed to be originated in China, as reports from reports of de Candolle as early as 2000 BC. From China, it moved to Persia and after that global dissemination occurred (Sharma and Verma, 2014) [22]. The major peach producing countries are Italy, U.S.A., Spain, China, France, Greece, and Japan. Global production of peach in 2019 was 25.73 million metric tons out of which 62% share was contributed by China (Anonymous, 2019) [1]. Introduction of cultivated varieties of peach in India, probably took place in later half of 19th century and now it is cultivated in mostly Himalayan region starting from Jammu and Kashmir and extending up to North-Eastern hills (Das *et al.*, 2011) [4].

Peach is generally categorized as a fruit crop suited to warm temperate regions due to its relatively low chilling requirement of 500-900 hours below 7 °C, compared to other temperate fruits. However, certain low-chilling peach cultivars need fewer than 500 chilling hours at or below 7.2 °C to achieve proper flowering and fruit setting (Nijjar and Khajuria, 1979) [15]. Due to introduction and adaptation of low chilling cultivars of peach, they are also now being grown commercially in certain areas of the north Indian plains. The varieties like Florida Prince, Early Grande, Pratap, Shan-e-Punjab and Sharbati etc., have become very popular and are grown commercially in plains and valley area of Uttarakhand but despite of the good production levels, the subtropical peaches have very low proportion in international and domestic trade due to the high perishability of the fruits after harvest.

The ripening process of peach, like other climacteric fruits, is characterized by rapid increases in the rates of cellular respiration and ethylene production that, in turn, cause substantial losses in the quality (Ligouri *et al.*, 2004) [12].

As a negative consequence for excessive early harvest, the overall peach fruit quality is reduced and does not fulfil the consumer's expectation. Polyamines and ethylene have opposite effects on fruit ripening and senescence. The main polyamines in significant amounts are putrescine, spermidine, and spermine which are crucial for the growth and development of plant and fruit, as well as stress responses (Valero and Serrano, 2010) [24]. Putrescine, a positively charged aliphatic amine synthesized in mitochondria, plays a role in various physiological processes, including growth, flowering, and fruit development (Pandey *et al.*, 2000) [16]. Fruit treated with putrescine can protect against oxidative stress and maintain cell membrane integrity, but the concentration is crucial. Insufficient putrescine can lead to low endogenous polyamine levels, while excessive accumulation can be toxic to the plant (Martinez-Tallez *et al.*, 2008) [14].

In continuation of above, another element calcium, plays a critical role in forming cross-bridges that enhance cell wall strength, serving as the final barrier before cell separation (Fry, 2004) [6]. As an essential plant nutrient, calcium is crucial for reducing fruit softening and delaying senescence, thereby improving overall fruit quality (El Badawy, 2012) [5]. The application of calcium, both pre- and post-harvest, can delay senescence in fruits without negatively affecting consumer acceptance. Exogenously applied calcium not only reinforces the plant cell wall but also shields it from cell wall-degrading enzymes, such as polygalacturonase (PG) and pectin methyl esterase (PME), which are newly synthesized during fruit ripening (Hadfield and Bennett, 1998). Pre-harvest calcium treatments, aimed at increasing the cell wall's calcium content, have proven effective in delaying senescence, resulting in firmer fruits with improved quality (Serrano *et al.*, 2004) [19].

Keeping in view the role of putrescine and calcium in improving storability and quality of fruits, the proposed study entitled was carried out to study the effect of preharvest sprays of calcium, putrescine on quality attributes of peach cv. Pratap.

Materials and Methods

The present investigation was carried out at during the year 2020-21 at Horticulture Research Centre, Pattharchatta and Post Graduate Lab of Department of Horticulture, G.B. Pant University of Agriculture and Technology Pantnagar, District Udham Singh Nagar (Uttarakhand). The experiment was conducted on 15 years old healthy fruit bearing trees of peach cv. Pratap having uniform vigour and size. The experiment was laid down in Factorial Complete Randomized Design (FCRD) with 3 replications and 6 storage intervals i.e. 0, 6, 12, 18, 24 and 30 days after harvesting. The treatments included a control, calcium nitrate at 0.5% and 1.0%, putrescine at 100 ppm, 200 ppm, and 300 ppm, as well as combinations of calcium nitrate (0.5% or 1.0%) with putrescine (100 ppm, 200 ppm, or 300 ppm). The spray solutions of calcium nitrate and putrescine were made by dissolving their requisite quantities in 200 ml of distilled water before making the final volume with tap water. For each treatment, 15 litres of spray solution was made. In order to decrease the surface tension of droplets and to facilitate the absorption, a few drops of Teepol (surfactant) were added to the solution prior to spray. The

fruits were sorted to eliminate bruised, damaged, or infected ones and graded by size. They were pre-cooled at room temperature for 10–15 minutes to remove field heat, cleaned with a muslin cloth, and air-dried under a ceiling fan. Subsequently, the fruits were divided into lots based on treatments, with 20 fruits from each of three replications packed in polyethylene bags. The samples were stored at 4 °C, and physico-chemical analyses were conducted every six days over a 30-day storage period. Fruit weight was recorded by weighing the individual fruits on an electronic Balance and average fruit weight was expressed in grams (g). Fruit width was recorded at the broadest point from two directions (90° to each other) on each fruit with vernier calliper and expressed in millimetres (mm). The TSS: acid ratio was determined by dividing the total soluble solids (TSS) by the titratable acidity. TSS was measured using a hand refractometer (0–32°Brix) with averaged readings from three fruits per replication, while acidity was estimated by titrating a 10 g fruit sample (diluted to 100 ml) with 0.1 N NaOH using phenolphthalein as an indicator. The ratio reflects the balance between sweetness and acidity in the fruit. The reducing sugars were determined following the method described. Twenty-five millilitres of filtered juice were neutralized with 1N NaOH, followed by the addition of 2 ml of lead acetate. After 10 minutes, a few drops of potassium oxalate were added, and the mixture was diluted to a known volume. The prepared sample was titrated against 10 ml of Fehling's solution using methylene blue as an indicator until a brick-red precipitate formed. The reducing sugar percentage was calculated using the formula $\text{Reducing sugar (\%)} = (\text{Mg of invert sugar} \times \text{Dilution} \times 100) / (\text{Titre} \times \text{weight or volume of sample} \times 1000)$. The non-reducing sugars were analysed by subtracting reducing-sugars from total sugars and thereafter correction factor 0.95 was implemented. To determine the effects of putrescine and calcium on post-harvest life of peach fruit, progress of fruit firmness and disease incidence (decay) was also determined over storage interval periods. The experimental data was analysed statistically as per the method suggested for Factorial Complete Randomized Design (Factorial C.R.D.). The significance of variation among the treatments was observed by applying 'F' test, and critical differences (CD) at 5% level of significance was calculated to compare the mean values of the treatments for all the characters.

Results and Discussions

The impact of preharvest sprays of calcium, putrescine, and their combination on peach fruit weight during storage is presented in Table 1. A detailed analysis revealed a significant influence of treatments and storage durations on fruit weight, though their interaction was non-significant. The highest fruit weight (126.12 g) was recorded in treatment T₁₂ (Calcium nitrate @ 1% + Putrescine @ 300 ppm), which was statistically similar to T₈ (125.67 g) and T₇ (125.06 g). Conversely, the lowest fruit weight (89.34 g) was observed in the control (T₁). Additionally, fruit weight declined over the storage period, from 112.60 g on the day of harvest to 104.33 g on the 30th day, irrespective of treatments. The least percentage reduction in weight was noted in T₁₀ (Calcium nitrate @ 1% + Putrescine @ 100 ppm), with a decrease from 116.12 g to 111.59 g, while the control (T₁) showed the highest reduction, from 95.63 g to

81.65 g. The reduced weight loss in calcium and putrescine treatments can be attributed to calcium's role in preserving membrane integrity and functionality, and its ability to lower the activity of enzymes responsible for cellular disintegration, thereby minimizing gaseous exchange (Levy and Poovaiah, 1979) ^[11]. The similar results were found by Kaur and Jawandha (2014) ^[8] in peach and plum.

The data related to response of different pre harvest sprays of putrescine and calcium and their various combinations on fruit diameter during storage was presented in Table 2. It was clearly evident from data that fruit diameter was significantly influenced by different treatments and storage intervals whereas, the effect of interaction was found to be non-significant. Maximum mean diameter (66.65 mm) was observed in T₈ treatment (Calcium nitrate @ 0.5% + Putrescine @ 200 ppm) which was *at par* with T₁₂ (66.29 mm) and T₇ (66.11 mm) treatments while, minimum diameter was recorded in control (54.43 mm). On further examining the data, it was also observed that fruit diameter continuously decreased with advancement of storage intervals in all treatments and ranges from 62.27 mm to 58.65 mm on 30th day of storage. However, the rate of decrease in diameter of fruits was rapid in control as compared to other treated fruits. Loss in diameter of peach fruits during storage occurs mainly due to water loss by transpiration and loss of carbon reserve due to respiration (Vogler and Ernest, 1999) ^[25]. Application of calcium and putrescine helps in reducing the rate of respiration and thus the reduction in width of fruits (lower shrinkage) was at lower rate as compared to untreated fruit. The results are also in accordance with the findings Kumar *et al.* (2017) ^[10] in guava, who found maximum fruit shrinkage in control and the lowest fruit shrinkage under treated fruits.

Total soluble solids (TSS) and titratable acidity (TA) are generally considered as two major quality parameters for the post-harvest life of fruit. For better consumer acceptability, fruits should exhibit a higher TSS-to-acid ratio (Sturm *et al.*, 2003) ^[23]. Freshly harvested fruits generally have a lower TSS-to-acid ratio, which increases during storage due to the conversion of acids into sugars (Shahid and Abbasi, 2011) ^[21]. For TSS: acid content of fruit, the obtained results are depicted in Table 3. It is evident after analysis of data that TSS: acid ratio generally increased with storage time for most treatments, supporting the observation that acid content decreases as it is converted into sugars during storage. Early intervals (0–12 days) showed a relatively modest increase in the ratio, while later intervals (18–30 days) exhibited more pronounced changes, indicating accelerated acid conversion over time. The maintenance of sugar and acid blend over a period of time is considered crucial for high consumer acceptance. T₁ (control) even though show highest increase from the day of harvesting till 30th day after storage but during last interval i.e. 24th – 30th day after storage it showed the decrease in TSS: acid ratio.

T₁₀ and T₁₁ treatments which differ non-significantly with each other were able to maintain the ratio over storage intervals i.e. day of harvesting till 30th day after storage. The previous workers also provided the evidence for maintenance of TSS: acid content by spray of preharvest spray of calcium chloride @ 1.0% (Shah and Sajid, 2017) ^[20]. Liu *et al.* (2018) ^[13] found that putrescine application to peaches not only slowed down the softening process but also helped maintain higher levels of TSS and a more favourable TSS:acid ratio during storage.

The trend on reducing sugars content under various treatments and storage intervals is presented in Table 4. The data clearly revealed that reducing sugar progressively increased from 7.29% on initial day to 8.24% on 24th day of storage and on 30th day it reduces to 8.18%. Maximum reducing sugar content (8.48%) on 30th day was observed in T₁₀ treatment (Calcium nitrate @ 1.0% + Putrescine @ 100 ppm) and minimum (7.53%) in T₁ treatment (control). Interaction effect of both treatment and storage days was also found to have significant effect on reducing sugar content of fruit. The trend observed in case of non-reducing sugars is similar to that observed in case of reducing sugars. Mean maximum non-reducing sugar (2.44%) was observed in T₁ treatment (control) while minimum readings (1.93%) were observed in T₅ treatment (Putrescine @ 200 ppm). The results obtained clearly showed that total sugars content of fruits in all the treatments increased for initial periods and subsequently decreased during later periods except for treatment T₁₀ and T₁₁, where increased in non-reducing sugar content of fruit was observed till 30th day of storage. The mean values for storage intervals showed that non-reducing sugar content generally increased from zero to 24th day of storage i.e., 1.87 to 2.41% after which it is decreased on 30th day of storage and was 2.27%. The production of sugars from the organic acids with increment in the glycolytic enzymes activity is the possible mechanism responsible for the increase in sugars during the storage of fruit (Rapisarda *et al* 2008) ^[17]. Yadav and Shukla (2009) ^[26] reported the reduction in increase in sugar content in aonla during storage as compared to control due to use of 1.0% calcium nitrate and 0.1% Topsin-M when sprayed 20 days before harvest. Kaur and Jawandha (2013) ^[9] reported that, in peaches during storage, higher sugars were found in putrescine treated fruits as compared to control fruit.

The combined effects of pre-harvest sprays of calcium and putrescine on maintaining fruit firmness and reducing fruit decay during storage intervals were evaluated (Fig. 1). Treatments T₁₀ (Calcium Nitrate 1.0% + Putrescine 100 ppm) and T₁₁ (Calcium Nitrate 1.0% + Putrescine 200 ppm) effectively preserved fruit firmness throughout the storage period. These treatments demonstrated minimal impact on the physico-chemical attributes while successfully maintaining peach fruit quality by inhibiting fungal sporulation on the fruits (Fig. 2).

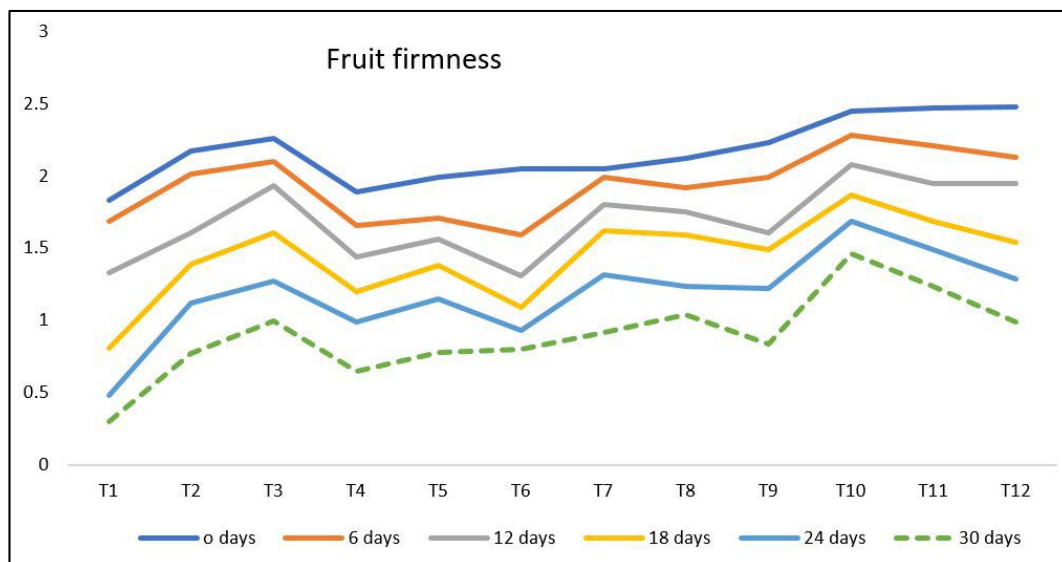


Fig 1: Effect of putrescine and calcium on fruit firmness of peach under storage



Fig 2a: Disease incidence on control fruits.



Fig 2b: Treated Fruits

Fig 2: Effect of putrescine and calcium in preventing fruit decay

Table 1: Effect of preharvest sprays of calcium, putrescine, and their combinations on fruit weight of peach during storage

Treatments	Storage Intervals (Days)						Mean
	0	6	12	18	24	30	
T ₁	95.63	93.87	91.78	88.91	84.23	81.65	89.34
T ₂	109.75	109.15	108.76	108.15	105.66	101.05	107.09
T ₃	111.99	111.32	110.45	109.18	107.99	105.89	109.47
T ₄	97.17	96.55	95.59	94.04	92.25	90.85	94.41
T ₅	98.64	97.67	96.89	94.52	92.27	90.22	95.03
T ₆	108.18	106.96	105.24	100.49	97.96	96.96	102.63
T ₇	127.33	127.01	126.69	125.21	123.65	120.49	125.06
T ₈	128.78	126.83	126.21	125.78	123.87	122.54	125.67
T ₉	111.01	110.05	109.68	108.22	105.21	103.82	108.00
T ₁₀	116.12	115.56	114.70	113.22	112.78	111.59	113.99
T ₁₁	115.14	114.43	113.33	113.01	111.66	109.98	112.92
T ₁₂	131.48	130.48	126.71	124.45	122.99	120.59	126.12
Mean	112.60	111.66	110.50	108.77	106.71	104.64	
	Treatments (T)		Storage Intervals (D)		Interaction (T x D)		
S.Em.±	0.64		0.45		1.57		
C.D (5%)	1.79		1.27		NS		
T ₁ – Control	T ₅ - Putrescine @ 200 ppm				T ₉ - Calcium nitrate @ 0.5 + Putrescine @ 300 ppm		
T ₂ - Calcium Nitrate @ 0.5%	T ₆ -Putrescine @ 300 ppm				T ₁₀ - Calcium nitrate @ 1% + Putrescine @ 100 ppm		
T ₃ - Calcium Nitrate @ 1.0%	T ₇ - Calcium Nitrate @ 0.5% + Putrescine @ 100 ppm				T ₁₁ - Calcium nitrate @ 1% + Putrescine @ 200 ppm		
T ₄ - Putrescine @ 100 ppm	T ₈ - Calcium Nitrate @ 0.5 + Putrescine @ 200 ppm				T ₁₂ - Calcium nitrate @ 1% + Putrescine @ 300 ppm		

Table 2: Effect of preharvest sprays of calcium, putrescine, and their combinations on fruit diameter of peach during storage

	Storage Intervals (Days)						
Treatments	0	6	12	18	24	30	Mean
T ₁	57.43	56.70	55.56	54.26	52.10	50.53	54.43
T ₂	61.64	61.29	61.00	60.51	59.78	57.72	60.32
T ₃	62.55	62.30	61.89	61.58	61.02	59.98	61.55
T ₄	58.14	57.92	57.50	56.59	55.72	54.52	56.73
T ₅	57.31	57.05	56.73	55.77	55.14	53.79	55.96
T ₆	60.80	60.48	59.88	58.21	57.33	56.29	58.83
T ₇	67.32	66.91	66.71	66.15	65.35	64.19	66.11
T ₈	67.84	67.25	66.93	66.68	66.04	65.14	66.65
T ₉	61.11	60.86	60.65	59.85	58.66	58.00	59.86
T ₁₀	62.79	62.52	62.17	61.50	61.21	60.78	61.83
T ₁₁	61.83	61.47	60.96	60.80	60.34	59.34	60.79
T ₁₂	68.52	68.01	66.90	65.76	65.01	63.56	66.29
Mean	62.27	61.90	61.41	60.64	59.81	58.65	
	Treatments (T)		Storage Intervals (D)		Interaction (T x D)		
S.Em.±	0.31		0.22		0.76		
C.D (5%)	0.87		0.61		NS		
T ₁ – Control	T ₅ - Putrescine @ 200 ppm				T ₉ - Calcium nitrate @ 0.5 + Putrescine @ 300 ppm		
T ₂ - Calcium Nitrate @ 0.5%	T ₆ -Putrescine @ 300 ppm				T ₁₀ - Calcium nitrate @ 1% + Putrescine @ 100 ppm		
T ₃ - Calcium Nitrate @ 1.0%	T ₇ - Calcium Nitrate @ 0.5% + Putrescine @ 100 ppm				T ₁₁ - Calcium nitrate @ 1% + Putrescine @ 200 ppm		
T ₄ - Putrescine @ 100 ppm	T ₈ - Calcium Nitrate @ 0.5 + Putrescine @ 200 ppm				T ₁₂ - Calcium nitrate @ 1% + Putrescine @ 300 ppm		

Table 3: Effect of preharvest sprays of calcium, putrescine, and their combinations on TSS-acid ratio (TSS: TA) of peach during storage

Storage Intervals (Days)							
Treatments	0	6	12	18	24	30	Mean
T ₁	18.57	26.36	35.43	37.50	38.33	33.79	31.66
T ₂	16.5	20.94	24.08	26.17	27.27	27.38	23.72
T ₃	16.35	19.48	21.85	24.2	24.47	25.33	21.95
T ₄	15.4	18.28	20.57	23.06	25.11	25.00	21.24
T ₅	14.77	17.17	19.11	20.56	21.54	20.98	19.02
T ₆	14.03	15.97	17.76	19.64	21.51	21.15	18.34
T ₇	14.77	17.00	19.27	22.6	25.53	23.78	20.49
T ₈	15.22	17.58	20.36	21.92	24.47	23.7	20.54
T ₉	14.43	16.25	18.28	20.19	21.35	21.8	18.72
T ₁₀	13.65	15.71	16.87	17.16	18.28	19.03	16.78
T ₁₁	12.76	14.79	16.01	17.03	18.23	19.34	16.36
T ₁₂	12.25	15.52	18.81	21.89	23.14	23.4	19.17
Mean	14.89	17.92	20.70	22.66	24.10	23.72	
Treatments (T)		Storage Intervals (D)			Interaction (T x D)		
S.Em.±		1.052		0.744		2.577	
C.D (5%)		2.098		1.483		5.139	
T ₁ – Control		T ₅ - Putrescine @ 200 ppm			T ₉ - Calcium nitrate @ 0.5 + Putrescine @ 300 ppm		
T ₂ - Calcium Nitrate @ 0.5%		T ₆ -Putrescine @ 300 ppm			T ₁₀ - Calcium nitrate @ 1% + Putrescine @ 100 ppm		
T ₃ - Calcium Nitrate @ 1.0%		T ₇ - Calcium Nitrate @ 0.5% + Putrescine @ 100 ppm			T ₁₁ - Calcium nitrate @ 1% + Putrescine @ 200 ppm		
T ₄ - Putrescine @ 100 ppm		T ₈ - Calcium Nitrate @ 0.5 + Putrescine @ 200 ppm			T ₁₂ - Calcium nitrate @ 1% + Putrescine @ 300 ppm		

Table 4: Effect of preharvest sprays of calcium, putrescine, and their combinations on reducing sugars of peach during storage

Treatments	Storage Intervals (Days)						
	0	6	12	18	24	30	Mean
T ₁	7.70	7.92	8.19	8.06	7.79	7.53	7.86
T ₂	7.35	7.60	7.96	8.15	8.24	7.97	7.88
T ₃	7.62	7.99	8.21	8.46	8.54	8.42	8.21
T ₄	7.41	7.68	7.92	8.12	8.24	8.37	7.96
T ₅	7.39	7.73	7.94	8.25	8.62	8.46	8.07
T ₆	6.96	7.29	7.66	7.93	8.08	7.97	7.65
T ₇	7.51	7.79	7.98	8.17	8.41	8.29	8.03
T ₈	7.22	7.67	7.93	8.20	8.36	8.21	7.93
T ₉	6.91	7.30	7.77	8.21	8.42	8.28	7.82
T ₁₀	7.44	7.50	7.72	7.93	8.16	8.48	7.87
T ₁₁	7.01	7.17	7.64	7.83	8.00	8.29	7.66
T ₁₂	6.91	7.20	7.42	7.66	7.99	7.90	7.51
Mean	7.29	7.57	7.86	8.08	8.24	8.18	
	Treatments (T)		Storage Intervals (D)		Interaction (T x D)		
S.Em.±	0.05		0.03		0.11		
C.D (5%)	0.13		0.09		0.33		
T ₁ – Control	T ₅ - Putrescine @ 200 ppm				T ₉ - Calcium nitrate @ 0.5 + Putrescine @ 300 ppm		
T ₂ - Calcium Nitrate @ 0.5%	T ₆ -Putrescine @ 300 ppm				T ₁₀ - Calcium nitrate @ 1% + Putrescine @ 100 ppm		
T ₃ - Calcium Nitrate @ 1.0%	T ₇ - Calcium Nitrate @ 0.5% + Putrescine @ 100 ppm				T ₁₁ - Calcium nitrate @ 1% + Putrescine @ 200 ppm		
T ₄ - Putrescine @ 100 ppm	T ₈ - Calcium Nitrate @ 0.5 + Putrescine @ 200 ppm				T ₁₂ - Calcium nitrate @ 1% + Putrescine @ 300 ppm		

Table 5: Effect of preharvest sprays of calcium, putrescine, and their combinations on non-reducing sugars of peach during storage

Treatments	Storage Intervals (Days)						
	0	6	12	18	24	30	Mean
T ₁	1.93	2.48	2.80	2.56	2.53	2.35	2.44
T ₂	1.85	2.14	2.41	2.61	2.73	2.05	2.30
T ₃	1.97	2.02	2.27	2.37	2.50	1.99	2.19
T ₄	1.89	2.13	2.23	2.34	2.50	2.64	2.29
T ₅	1.71	1.77	1.86	1.91	2.17	2.15	1.93
T ₆	1.93	2.19	2.31	2.48	1.84	1.81	2.09
T ₇	1.89	2.00	2.15	2.21	2.58	2.50	2.22
T ₈	1.81	1.92	1.96	1.99	2.36	2.00	2.01
T ₉	1.83	1.99	2.02	2.03	2.08	2.02	2.00
T ₁₀	1.87	1.99	2.12	2.35	2.61	2.67	2.27
T ₁₁	1.99	2.11	2.22	2.30	2.63	2.77	2.34
T ₁₂	1.81	1.90	2.27	2.31	2.33	2.32	2.16
Mean	1.87	2.05	2.22	2.29	2.41	2.27	
Treatments (T)		Storage Intervals (D)			Interaction (T x D)		
S.Em.±		0.02			0.01		
C.D (5%)		0.05			0.04		
T ₁ – Control	T ₅ - Putrescine @ 200 ppm		T ₉ - Calcium nitrate @ 0.5 + Putrescine @ 300 ppm				
T ₂ - Calcium Nitrate @ 0.5%	T ₆ -Putrescine @ 300 ppm		T ₁₀ - Calcium nitrate @ 1% + Putrescine @ 100 ppm				
T ₃ - Calcium Nitrate @ 1.0%	T ₇ - Calcium Nitrate @ 0.5% + Putrescine @ 100 ppm		T ₁₁ - Calcium nitrate @ 1% + Putrescine @ 200 ppm				
T ₄ - Putrescine @ 100 ppm	T ₈ - Calcium Nitrate @ 0.5 + Putrescine @ 200 ppm		T ₁₂ - Calcium nitrate @ 1% + Putrescine @ 300 ppm				

Conclusion

Based on the results outlined above, it was evident that preharvest application of putrescine and calcium nitrate significantly improved the quality of peach fruits (cv. Pratap) compared to untreated fruits, primarily by inhibiting ethylene biosynthesis. Moreover, the combined application of calcium nitrate and putrescine proved more effective in enhancing quality parameters than their individual applications. It can be concluded that a preharvest spray of calcium nitrate at 1.0% combined with 100 ppm putrescine, applied 10 days before harvesting, was the most effective treatment for maintaining the quality of peach cv. Pratap for up to one month under low-temperature storage conditions.

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