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Exogenous Application of Polyamines Maintains Physico-Chemical Properties of Mango (*Mangifera indica* L.) cv Alphonso under Aimbient Storage

Binayak Chakraborty, Rajendrakumar P. Bambharolia, Yogesh V. Naghera, Mangaldeep Sarkar

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Abstract Three most commonly known polyamine viz. putrescine (PUT), spermidine (SPD), spermine (SPM) were tested for their suitability to maintain the post harvest physico-chemical properties of mango fruits. For this purpose, mature green mango cv Alphonso were harvested, precooled followed by air dried then dipped in various polyamine solutions at a concentration of 0.1 mM and 0.5 mM for 5 min. before placed in cardboard cartons under ambient storage ($22 \pm 2\,^{0}$C and 80-85% RH) conditions. Observations on various physico-chemical parameters were studied at three days interval right from the day of harvesting up to 18th day of storage. Fruits dipped in 0.5 mM SPM solution registered least changes in physico-chemical properties of mango fruit during the entire storage period. PUT and SPD also maintained the post harvest quality of mango fruits over control (water dipping). The effects of polyamine treatments were more pronounced with the advancement of storage days. The effectiveness of polyamines to maintain the physico-chemical properties of mango were found in the following order SPM > SPD ≥ PUT in most of the studied parameters.

Keywords Mango, Putrescine, Spermidine, Spermine, Ambient storage.

B. Chakraborty*, R. P. Bambharolia, Y. V. Naghera
College of Agriculture

M. Sarkar
Hill Millet Research Station, Navsari Agricultural University, Waghai 394730, The Dangs, Gujarat, India
e-mail: binayak.hort@gmail.com
*Correspondence

Introduction

Mango (*Mangifera indica* L.), the major fruit crop grown in India has gained popularity all over the world due to its mouth watering taste, exemplary matritive values, captivating flavor and attractive color. But heavy postharvest losses mainly because of its climacteric pattern of respiration, it can hardly be stored for a week under room condition [1]. The post harvest losses of mango account about 25-40% at different stages from harvesting to the consumption [2]. Polyamines are low molecular weight, positively charged aliphatic nitrogenous compound found in almost all living organisms and have participated in many physiological processes including after harvesting of horticultural crops [3]. Putrescine (PUT), spermidine (STD) and spermine (SPM) are the three most commonly detected polyamines in plant system.

Polyamine and ethylene production are interrelated and share a common precursor *S*-adenosyl methionine (SAM). There is an inverse relationship existed between polyamines and ethylene production indicating that increased levels of polyamines have been correlated with reduced rate of ethylene synthesis that may ultimately delay the process of ripening and senescence [4]. Application single type of polyamine for extending the shelf life of fruits have been reported in tropical and subtropical fruits like mango [5], grape [6] and banana [7]. However, comparative effectiveness of the three most commonly found polyamiines (PUT, SPD and SPM) in fruit storage studies is limited. Therefore, the present investigation has been undertaken to assess the effects of these three polyamines on physico-chemical properties of export quality mango cultivar Alphonso.

Materials and Methods

Mango fruits cv Alphonso were harvested from the orchards of Rambhas Farm, NAU Waghai (Gujarat) at mature green stage. The harvested fruits were carefully graded, maintaining uniformity in maturity, size, color, free from disease and pests and devoid of any kind mechanical damage. The fruits were immediately given cold water treatment for 20 min.as precooling treatment to remove field heat followed by air dried to drain off excess water. A lot of 9.0 kg mango fruit was dipped in aqueous solution of putrescine (0.1 mM and 0.5 mM), spermine (0.1 mM and 0.5 mM) and spermidine (0.1 mM and 0.5 mM) for 5 min. The lot of 9.0 kg mangoes which undergone same treatment was divided into three equal parts of 3.0 kg fruits and kept in 5.0 kg capacity Corrugated Fiber Board (CFB) boxes before stored at room temperature (22 ± 2 ^{0}C) and 80-85% RH. Each treatment was replicated thrice and comprised of 3.0 kg fruits. The experiment was laid out in Factorial Completely Randomized Design. Various physico-chemical characters of the fruits were analyzed at three days interval upto 18th day of ambient storage. The firmness of the fruits was determined by penetrometer. The decay percentage was calculated as number of infected fruits divided by initial number of all fruits multiplied by hundred. Total soluble solids of the fruit were measured with the help of hand refractometer (ERMA make) and expressed in degree brix (^{0}B). The total sugars, titratable acidity, ascorbic acid and pectin content were estimated by following standard methods [8].

Results and Discussion

Physiological loss in weight and fruit firmness

A significant effect of polyamines on physiological loss in weight (PLW) was recorded from sixth day onwards to the end of storage perid (Fig. 1a). More pronounced effect of plyamine treatments was noted as the storge days progressed. Fruits dipped in 0.5 mM solutions resulted least changes in PLW and accounted almost 78% lower PLW than control fruits. Among the polyamines, 0.1 mM PUT showed higher PLW than others treatments except control. Fruits dipped in 0.5 mM SPD had resulted intermediate effect.However, no significant difference was observed between fruits treated with PUT and SPD.Up to 15th day of storage, all the treated fruits showed a progressive raise in PLW and thereafter a significant increase in PLW indicating rapid loss of water due to metabolic processes like respiration and transpiration [9]. Spermine has foumnd to be helpful in reducing the membrane electrolytic leakage [6]. It is well known fact that polyamines have the ability to retard the rate of respiration in fruits. In this experiment, 0.5 mM spermine resulted least changes in PLW of mango fruits. SPM was found to be the best than PUT and SPD in maintaining the rate of respiration of mango fruits during storage [10]. Similar results had been found in present study.

Significant retention in firmness was observed fruits dipped in 0.5 mM SPM over control immediately after storage (Fig. 1b). The differences were greater up to fifteenth day of storage over control fruits. For instance, after 15 days, the differences between polyamine treated and control fruits ranged from 0.61 kg cm^{-2} (0.5 mM SPM) to 1.27 kg cm^{-2} (0.5 mM PUT). The enzyme polygalactouronsae (PG) is reported to involve in fruit softening by hydrolytic cleavage of α- (1-4)-galacturonan linkage in pectin layer. Exogenous application of polyamine known to maintain the fruit firmness by slower down the activity of PG as well as blocks the entry of this enzyme into the cell wall by creating cross-linkage with the carboxyl group of the pectic substances, resulting in

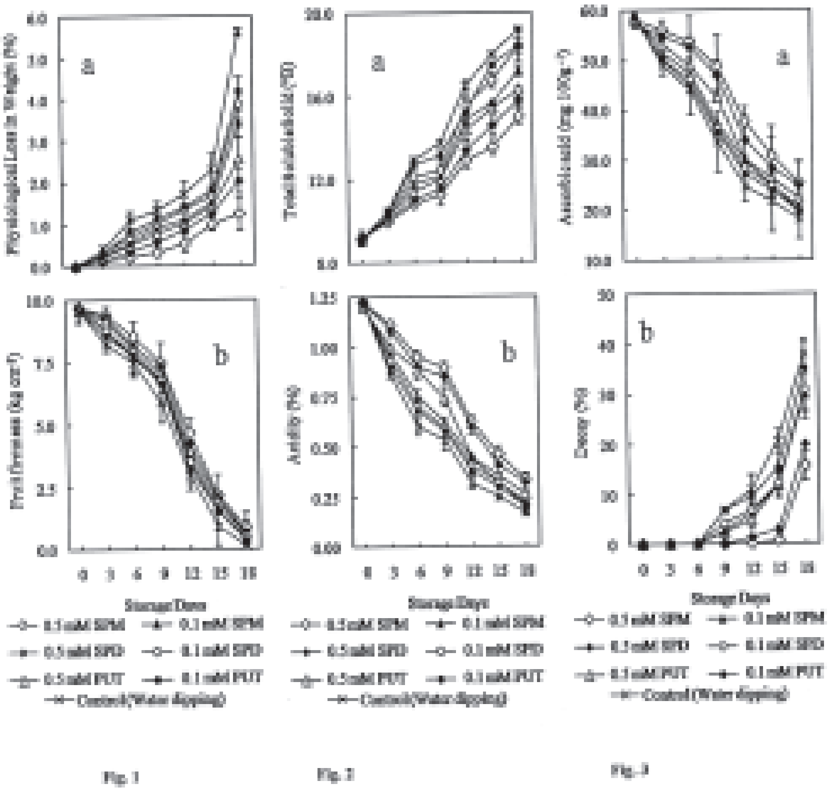

Fig. 1. Effect of different polyamine treatments on physiological loss in weight (a) and fruit firmness (b) of mango cv Kesar under ambient storage. The vertical bars indicates:standard error (n=3). **Fig. 2.** Effect of different polyamine treatments on physiological total soluble solid (a) and acidity (b) of mango cv Kesar under ambient storage. The vertical bars indicate standard error (n=3). **Fig. 3.** Effect of different polyamine treatments on physiological ascorbic acid (a) and decay (b) of mango cv Kesar under ambient storage. The vertical bars indicate standard error (n=3).

rigidification [11]. The degree of rigidification of polyamines with carboxyl group varies according to valency of polysmines (SPM^{4+} > SPD^{3+} > PUT^{2+}) [12]. Among the different treatments of polyamines, fruits dipped in 0.5 mM spermine showed the maximum retention of fruit firmness. Similar type of result is also reported in papaya [13]. A rapid decrease in firmness was observed after 9th day of ambient storage in all the treated fruits might be due to increase in PG activity with the progressive increase in storage time [11].

Total soluble solid and acidity

Polyamine treatments did not induce any significant change in TSS up to third day of storage (Fig. 2a). Dipping of fruits in 0.5 mM SPM had resulted TSS 15.0 ^{0}B after the end of storage (i.e., on 18th day) indicating SPM maintained the TSS of mango fruits as compare to rest of the treatments. Beside 0.5 mM SPM, the fruits treated with 0.5 mM SPD exhibited lower TSS value followed by 0.5 mM PUT during the entire storage period. These results are in accordance with the finding by Champa et al. [6], who reported that SPM-treated fruit exhibited lower soluble solid content than untreated fruits. TSS content of mango fruit increased subsequently with the advancement of storage period might be attributed to breakdown of starch and polysaccharides into simple sugars [1].

Significant changes in acidity content of mango fruits were noted from third day onwards (Fig. 2b). Fruits dipping in 0.5 mM SPM and 0.5 mM SPD re-

Table 1. Effect of different polyamine treatments on total sugar and reducing sugar content of mango cv Kesar under ambient storage.PUT = Putrescine, SPD = Spermidine, SPM=Spermine, 0-days = at harvest.

Treatments (T)	Total sugar (%) Storage days (S)							Reducing sugar (%) Storage days (S)						
	0	3	9	12	15	18	Mean	0	3	9	12	15	18	Mean
Control	2.93	5.00	6.23	11.60	13.67	17.03	9.41	2.00	3.29	4.38	9.35	11.18	14.03	7.37
0.1 mM PUT	2.91	3.49	4.97	8.00	9.00	11.83	6.70	1.98	2.31	3.75	6.50	7.31	9.76	5.27
0.5 mM PUT	2.97	3.34	3.89	7.25	8.69	11.47	6.27	2.00	2.27	2.70	5.80	7.10	9.40	4.88
0.1 mM SPD	2.94	4.12	5.70	10.34	11.35	15.34	8.30	2.01	2.63	4.12	8.25	9.13	12.94	6.51
0.5 mM SPD	2.93	3.65	5.15	8.54	9.15	12.99	7.07	2.01	2.31	3.78	6.90	7.43	10.83	5.54
0.1 mM SPM	2.96	3.82	5.39	9.24	10.22	14.44	7.68	1.99	2.45	3.93	7.25	8.20	12.23	6.01
0.5 mM SPM	2.94	3.26	3.56	6.50	7.31	9.58	5.53	2.01	2.26	2.42	5.20	5.75	7.77	4.24
Mean	2.94	3.81	4.98	8.78	9.91	13.24	7.28	2.00	2.50	3.58	7.04	8.01	11.00	5.69
		T		S	T × S				T		S		T × S	
P < (0.05)		0.19		0.19	0.49				0.11		0.11		0.27	

corded least change in acidity content without any significant change up to 18th day of storage. There was a significant decrease in acidity content after 9th day of storage period in all the treated fruits. In general, the acidity content of fruits decreased as storage period progressed. This can be characterised by ripening related changes of mango [14]. The rate of ethylene evaluation during storage of mango fruit has been effectively reduced with the application of SPM than PUT and SPD [10]. This might be the possible reason of higher acidity content in SPM treated mango fruits.

Total sugar and reducing sugar

The data on total sugar and reducing sugar content of mango fruits are presented in Table 1. In general, the total sugar and reducing sugar content of the fruits increase with the advancement of storage period. A rapid increase was observed from 9th day onwards. The fruits treated with 0.5 mM SPM showed minimum change in all the above stated parameters up to end of the storage period. Control fruits exhibited rapid change in total sugar and reducing sugar content during the storage. Polyamines might retard conversion of starch compounds into simple sugar which is a common phenomenon during ripening of fruits. SPM found to be more effective in maintain sugar content of fruits during storage [10]. SPM-treated fruit exhibited lower sugar content than untreated fruit was also reported in grape [6]. mango and papaya [13]

Ascorbic acid and decay

Polyamine treatments significantly affected the ascorbic acid content of the fruits (Fig. 3a). The fruits dipped in 0.5 mM SPM exhibited least change in ascorbic acid content. At the end of 18th day of storage the ascorbic acid content of mango fruits was (25.3 mg/100 g) in 0.5 mM SPM, (24.6 mg/100 g) in 0.5 mM PUT and 22.4 in (0.5 mg/100 g) mM SPD treatments. Exogenous application of (1 mM) SPM had been reported to increase the ascorbic acid content in mango fruit whereas, SPD and PUT treatments significantly reduced the ascorbic acid content [15]. Decline in ascorbic acid content with respect to storage period could be due to the fact that, utilization of glucose-6-phosfate in metabolic processes during storage which is known to precursor of L-ascorbic acid in plant tissues [1].

There was no decay in mango fruits up to 9th day of storage in all treatments (Fig. 3b). Fruits treated with 0.5 mM SPM remained unaffected till 12th day of storage. This treatment accounted only 15.6% decay at the end of storage period and registered significant reduction in decay percentage over control fruits (38.0%). Fruits treated with 0.5 mM PUT also showed lesser decay and it was statistically non--significant with fruits decay in 0.5 mM SPM dipping. Anti-microbial property of polyamines has been well documented [16]. SPM is responsible for increasing the in hypersersitive reaction (HR) and induction of PR-proteins (pathogenesis related) in barley against powdery mildew [16]. Minimization of decay with the help of SPM is also reported in grape [6].

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