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Post-harvest treatments of polyamines influence shelf-life and quality of kiwifruit (*Actinidia deliciosa*)*

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Kiwifruit [*Actinidia deliciosa* (A.Chev.) C F Liang and A R Ferguson] is a very interesting fruit because of its sweet-sour taste, nutritional value and unique appearance. It is an excellent source of potassium and vitamin C and has low sugar content. Hence, it is an ideal fruit for diabetic, hypertension and asthma patients (Chattopadhyay 2008). It is commercially cultivated in different countries of the world and in India, its importance was realized only in the recent years. Although, it is a high value crop but it hasn't become so popular because, its fruits have the problem of premature ripening and flesh softening, which lowers its shelf-life considerably (Chattopadhyay 2008). Moreover, its fruits remain in markets only for few days. Thus, development of treatments or procedures to increase its shelf-life would be very useful for extending its availability in the market. Different techniques are used to extend the shelf-life of fruits but in the recent years, polyamines (PAs) have also been used for this purpose. PAs extend shelf-life of fruits by delaying the ethylene evolution, fruit softening and maintaining fruit quality (Mirdehghan *et al.* 2007). Polyamines like SPD and SPM can be used for increasing the shelf-life of high value fruit crop like kiwifruit.

The studies were conducted during 2008–10 at the Division of Post Harvest Technology, Indian Agricultural Research Institute New Delhi. Kiwifruits cv. Allison were harvested at 6.2°B from the fruit orchard of Dr Y S Parmar University of Horticulture and Forestry, Nauni, Solan, sorted, graded and packed in CFB boxes (4 ply) and then transported by road to Delhi, which took about10 hr. Fruits were then dipped in different concentrations of SPD @ 1 mM, SPD @ 1.5 mM, SPD @ 2.0 mM and SPM @ 0.5 mM, SPM @ 1.0 mM, SPM @ 1.5 mM for 2 min. in the laboratory. The untreated fruits served as control. The treated as well as untreated fruits were stored at room temperature (22 ± 4°C and 65–70% R H) for observations on physiological loss in weight, fruit firmness, ethylene evolution, total soluble solids, and ascorbic acid content at three day's interval.

Physiological loss in weight (PLW) was measured by weighing 12 fruits kept in a box and were weighed at every three days interval using electronic balance. PLW was calculated by subtracting the initial weight and weight after known period of storage and expressed as percentage (%). Fruit firmness was determined using a texture analyzer and expressed as Newtons (N). Ethylene evolution rate was measured using the static headspace technique using gas chromatograph and expressed as μl kg/ h. Total soluble solids of samples were estimated using Fisher Hand Refractometer (0–50), and expressed as degree brix (°B) at 20 °C. Ascorbic acid content was determined by the method described by Ranganna (1999).

The experiment was laid out in factorial complete randomized design with each treatment consisting of 60 fruits with 3 replications. The data obtained from the experiments were analyzed as per design and the results were compared from analysis of variance (ANOVA) by calculating the Critical difference (P= 0.05).

Irrespective of the polyamine treatments, there was a steady increase in physiological loss in weight (PLW) with the increase in storage period from 3rd day to 15th day (Fig 1). Similarly, the PLW in untreated fruits increased sharply from 3rd day of storage to 15th day of storage. Further, PLW was maximum in untreated fruits (14.1%) and minimum in fruits treated with SPM @ 1.5 mM (7.3%). The lower weight loss in PA treated fruits can be attributed to stabilization or consolidation of both cell integrity and the permeability of tissues by PAs (Mirdehghan *et al.* 2007). Among different PAs, SPM was much effective than SPD because SPM is a

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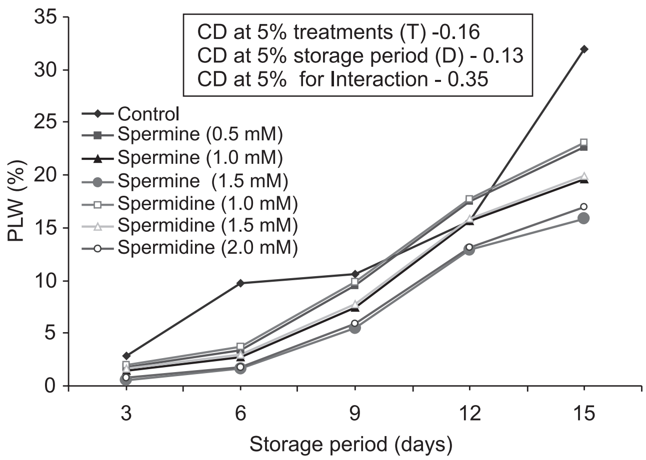

Fig 1 Effect of polyamines on physiological loss in weight (%) of kiwifruit cv. Allison

tetramine, PAs with higher number of available cations are more effective than their low number (Martinez-Romero *et al.* 2002). Further, increase in PLW with the increase in storage period may be due to increase in moisture loss from the fruits.

Fruit firmness (N), was significantly influenced by PAs and storage period (Fig 2). Fruits treated either with any concentrations of SPM or SPD had better firmness over untreated fruits. Among different treatments, fruits treated with SPM @ 1.5 mM were firmer (48.0 N), and untreated fruits had the least firmness (32.8 N). Khan *et al*. (2007) reported that the effect of PAs on maintaining fruit firmness can be attributed to their cross-linkage to the $-COO^-$ ions of the pectic substances in the cell wall, which helps in rigidification of the fruit tissues after treatment. This binding also blocks the access of degrading enzymes, such as pectin methyl esterase (PME), pectin esterase (PE) and polygalacturonase (PG), which reduce the rate of fruit softening during storage. Better firmness of SPM (1.5 mM) treated fruits than SPD (2 mM) treated fruits may be due to higher effectiveness of SPM in suppressing the activities of fruit softening enzymes, because it is a tetramine and has more number of polycations (Perez-Vicente *et al.* 2001). Further, fruit firmness decreased with the increase in storage period from 3rd day to 15th day (Fig. 2), which might be due to softening of fruits by the increasing activity of peel softening enzymes like PG and *vice versa*.

The untreated fruits evolved quite high amount of ethylene from 6th day onwards but PAs treated fruits showed no evolution of ethylene up till 6th day of storage (Fig 3). Further, in untreated fruits, ethylene evolution showed its highest peak (57.5 C_2H_4 μl/kg/h) on 12th day and then it declined thereafter, whereas in PAs treated fruits, ethylene evolution showed significantly increasing trend with the increase in storage period. However, irrespective of storage period, ethylene evolution was significantly higher in the untreated fruits (31.3 C_2H_4 μl/kg/h). Fruits treated with SPM (1.5mM) showed least ethylene evolution (Fig 3). This effect of SPM or SPD can be demonstrated on the basis that polyamine and ethylene biosynthesis are linked through the common precursor S-adenosylmethionine (SAM), and they use the common precursor, SAM for their biosynthesis, but these two molecules show opposite effects in relation to senescence (Martinez-Romero *et al*. 2002, Malik and Singh 2005). Similarly, irrespective of treatments, ethylene evolution increased with increase in storage period from 3rd day to 15th day of storage. It can be linked to increased senescence during storage, which triggered ethylene evolution (Pandey *et al.* 2000).

Interestingly, untreated fruits showed high TSS from 6th day itself, which increased till 12th day but thereafter, it declined, whereas, in PAs treated fruits, TSS showed increasing trend till 15th day of storage (Table 1). However,

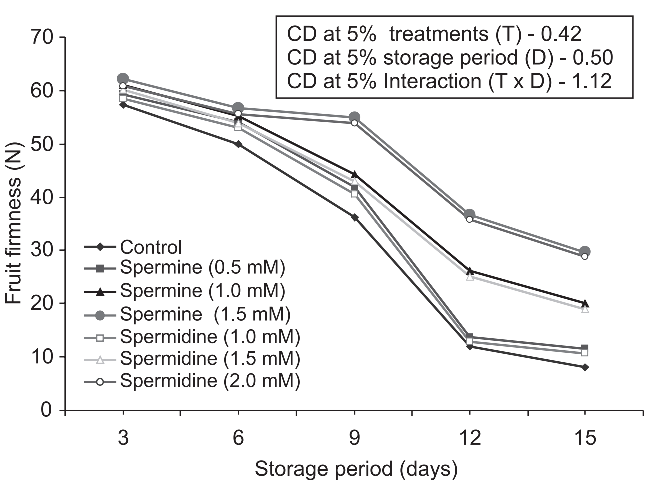

Fig 2 Fruit firmness of kiwifruit cv. Allison as affected by treatments of polyamines

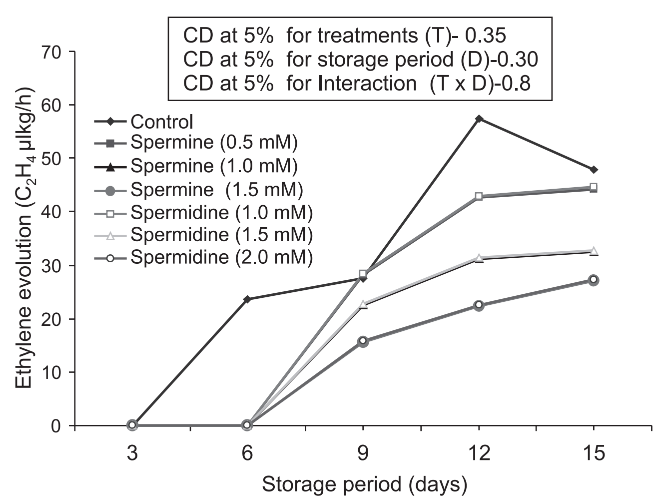

Fig 3 Effect of polyamines on ethylene evolution rate (C_2H_4 μl/kg/h) of kiwifruit cv. Allison.

Table 1 Influence of different concentrations of polyamines on the ascorbic acid content and TSS in kiwifruits cv. Allison

Treatment	Storage period (days)											
	TSS (° Brix)						Ascorbic acid content (mg/100 g pulp)					
	3	6	9	12	15	Mean	3	6	9	12	15	Mean
Control	8.0	12.7	15.7	15.4	14.2	13.2	117.1	114.1	102.8	94.9	83.3	102.5
SPM (0.5 mM)	6.7	8.3	8.7	9.8	15.4	9.8	120.3	117.9	106.1	96.9	88.7	106.0
SPM (1.0 mM)	6.4	6.6	6.8	8.0	14.7	8.5	122.1	119.3	109.9	100.8	97.9	110.0
SPM (1.5 mM)	6.2	6.4	6.5	7.4	14.3	8.2	123.0	121.1	112.9	106.3	105.9	113.8
SPD (1.0 mM)	6.9	8.5	8.9	10.0	15.7	10.0	120.1	117.7	105.9	96.3	89.1	105.8
SPD (1.5 mM)	6.6	6.9	7.0	8.2	15.1	8.8	121.8	118.6	109.3	99.7	97.0	109.3
SPD (2.0 mM)	6.4	6.6	6.7	7.6	14.6	8.4	122.6	120.0	112.8	105.0	104.9	113.0
Mean	6.7	8.0	8.6	9.5	14.9		121.0	118.4	108.5	100.0	95.2	
Initial reading			6.00							126.3		
P=0.05 for treatments (T)						0.24						0.65
P=0.05 for storage period (D)						0.20						0.55
P=0.05 for Interaction (T × D)						0.53						1.44

irrespective of storage period, mean TSS was significantly higher in the untreated fruits (13.2 °B), than the PAs treated fruits. Fruits treated with SPM (1.5 mM) showed least mean TSS (8.2°B) than those treated with SPD (2.0 mM) (Table 1), which may be due to the utilization of total soluble solids for the respiration and their conversion into other low chain organic acids (Serrano *et al*. 2003). Such conversions might have taken place at a slower rate in PA-treated fruits in comparison to untreated fruits. TSS increased with increase in storage period from 3rd day to 15th day of storage, which could be due to higher water loss and hydrolysis of starch and other polysaccharides into simple sugars at a higher rate (Malik and Singh 2005, Sharma *et al.* 2010 a,b). Similarly, reduction in TSS in untreated fruits after 12th day of storage may be due to conversion of sugars into alcohol.

PAs-treated fruits retained higher ascorbic acid content than untreated fruits. Fruits that were treated with SPM (1.5 mM) showed higher retention of ascorbic acid (113.8 mg/ 100g pulp) than SPD @ 2 mM or other treatments (Table 2). The higher retention of ascorbic acid in PA treated fruits could be attributed to the ripening retarding effect of PAs on kiwifruits and slower rate of biological activities in such fruits during storage (Serrano *et al*. 2003). Ascorbic acid content decreased sharply with the increase in storage period, which may be due to degradation of ascorbic acid in other compounds (Sharma *et al*. 2010 a, b).

SUMMARY

Kiwifruit cv. Allison fruits were treated with different concentrations of PAs like SPM and SPD by immersion method and stored at ambient conditions (22 ± 4°C and 65–70% R H) for 15 days. Our results revealed that untreated fruits showed high physiological loss in weight (10.6%) even on 9th day of storage, whereas SPM or SPD treated fruits showed very less PLW even on 15th day. PAs treated fruits showed lesser ethylene evolution rate than untreated fruits at different intervals. Similarly, TSS showed sudden increase in the untreated fruits even on 6th day, increased at a sharper rate up to 12th and then declined, whereas PAs treated fruits started showing increase in TSS from 9th day only. SPM @ 1.5 mM was the best treatment to increase the shelf-life of kiwifruit up to 15 days.

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