Vegetable Science (2015) 42 (1) : 58-62

Post-harvest application of putrescine to extend shelflife and quality of tomatoes during cold storage

Ramesh Babu[1]*, Kulbir Singh[1], S K Jawandha[2], M S Alam[3], S K Jindal[1], D S Khurana[1], K Narsaiah[4] and Neena Chawla[1]

Received: July, 2014 / Accepted: April, 2015

Abstract

Putrescine (PUT) is a polyamine responsible for plant growth and development, fruit ripening, stress response, senescence and in higher quantities to maintain postharvest quality in vegetables. Tomato (cv. Punjab Ratta) fruits of uniform size and weight were picked at mature green to breaker stage from unreplicated crop grown during 2012-13 and 2013-14 at Vegetable Research Farm, Punjab Agricultural University, Ludhiana, Punjab, India and treated with putrescine at 1 mmol/L, 2 mmol/L and 3 mmol/L concentrations and untreated control corresponding to T_1, T_2, T_3 and T_4 respectively. After imposing the treatments, tomato fruits taken in plastic crates and stored at 13±2°C and relative humidity of 85-90% for further storage studies. To find out the effect of post-harvest application of putrescine on tomato during storage, fruits were analysed at 5 day interval i.e at 1st, 6th, 11th, 16th, 21st and 26th day after treatment for various quality parameters and average of two year readings was presented. At 26th day after treatment, least physiological loss in weight % was observed in the T_3 treatment (PUT at 3 mmol/L) while, at 16th day after treatment, fruits in T_2 treatment were recorded with hue angle of 62.05^0 which was above the hue angle of acceptable red stage (55^0) compared to T1, T3 and control. Treatments T_2 and T_3 retained the decay% below threshold (10%) levels upto 16th (8.18% and 6.01% respectively) day after treatment than untreated control. However, all putrescine treatments showed higher titratable acidity compared to control at the end of the storage.

Keywords: Tomato, putrescine, post-harvest application, storage, firmness, hue angle

[1]Dept of Vegetable Science, Punjab Agricultural University, Ludhiana, 141004, Punjab, India
[2] Department of Fruit Science, Punjab Agricultural University, Ludhiana, 141004, Punjab, India
[3] Department of Processing & Food Engineering, Punjab Agricultural University, Ludhiana, 141004, Punjab, India
[4]Central Institute of Post Harvest Engineering and Technology, Ludhiana, 141004, Punjab, India
*E mail: rameshhort@gmail.com

Introduction

Polyamines are positively charged aliphatic amines and the term polyamines implies collectively putrescine (PUT), spermine (SPM) and spermidine (SPD) and other related secondary conjugated product (Malmberg et al., 1998). Putrescine ($C_4H_{12}N_2$) is one of polyamine compounds present in living cells and have been involved in plant growth and development, fruit ripening, stress response and senescence (Malik and Singh 2003). The elevated levels of polyamines are beneficial to the maintenance of postharvest quality in fruits and vegetables. The reduced rate of softening of long-keeping tomato cultivars has been correlated with elevated putrescine (PUT) (Dibble et al., 1988; Saftner and Baldi 1990). Polyamines when applied exogenously increase the level of endogenous polyamines during storage and in turn extend the shelf life. The effect of postharvest application of polyamines at different concentrations on shelf-life and other physico-chemical characteristics of tomato were studied by Bhagwan *et al.* (2000). Pre-storage treatment of polyamines maintained firmness in strawberries and apples (Kramer *et al.,* 1991; Ponappa *et al.,* 1993) while putrescine retarded flesh softening and colour development in lemons (Valero *et al.,* 1998) and reduced mechanical damage in plum, prolonging shelf life (Perez-Vincent *et al.,* 2002). An immediate increase in firmness has been observed when McIntosh and Golden Delicious apple harvested at optimum maturity and infiltered with polyamines (Kramer *et al.,* 1991).

Polyamines also act as antisense agents in plants by inhibiting ethylene synthesis. Treatment of avocado with putrescine or Spermine and peach with putrescine, Spermindine or Spermine inhibited ethylene synthesis (Winer and Apelbaum, 1986; Bregoli *et al.,* 2002) and putrescine treatment at 1 mM increased flesh firmness by 3-fold in Kiwi fruit compared to control (Petkou *et al.,* 2004). However, in fruits like citrus and tomato increase in polyamines is reported during maturation and ripening (Saftner and Baldi, 1990). There is a competition between polyamines and ethylene, through their common precursor SAM (S-Adenosyl L- Methionine) (Valero *et al.,* 2002) and balance between these two opposite growth regulators is critical in retarding or accelerating the ripening process (Pandey *et al.,* 2000). It is reported that comparatively higher levels of polyamines and lower level of ethylene have been found in long keeping tomato (Dibble *et al.,* 1988).

The present study was carried out to find out the effect of post harvest application of putrescine at different concentrations during storage of fresh tomatoes during storage at 13±2^{0}C and relative humidity of 85-90%

Materials and Methods

Fruits of uniform size and weight picked at mature green to breaker stage from unreplicated experimental plot of tomato (cv. Punjab Ratta) grown at Vegetable Research Farm, Punjab Agricultural University, Ludhiana, Punjab, India during 2012-13 and 2013-14 were brought to the laboratory and washed properly with normal tap water to remove the field heat and blemishes on the fruits followed by drying with whatmann paper and kept overnight at 20^{0}C in cold store. Next day, aqueous solutions of putrescine were prepared at putrescine @1mmol/L, 2mmol/L and 3 mmol/L concentrations corresponding to T_1, T_2 and T_3 respectively and in control (T_4) distilled water was used. The fruits dipped in aqueous solutions for five minutes and taken out fruits were open dried on Whatmann paper. After imposing these treatments, fruits taken in plastic crates stored at 13±2^{o}C and relative humidity of 85-90% for further storage studies at Post-harvest laboratory of the Department of Fruit Science, PAU, Ludhiana. In each treatment, 5kg fruits were taken and fruits were analysed at 5 day interval i.e at 1st, 6th, 11th, 16th, 21st and 26th day after treatment for various quality parameters like physiological loss in weight (%), titratable acidity (% citric acid) and ripening index (TSS/TA), hue angle, firmness (Kgf) and decay% and data obtained was presented after taking the average of two years.

Physiological loss in weight (PLW)

A separate set of fruits were stored in plastic crates and undisturbed throughout the storage period and physiological loss in weight (PLW) of fruits was calculated on initial weight basis. The per cent loss in weight after each storage interval was calculated by subtracting final weight from the initial weight of the fruits and then converted into percentage value. The cumulative loss in weight was calculated on fresh weight basis.

Physiological loss in weight (PLW %) = (Initial fruit weight - Final fruit weight) X 100

Initial fruit weight

Titratable acidity% (TA) and Ripening Index (TSS/TA)

Titratable acidity was determined by titrating the 2ml juice sample against 0.1N NaOH along with phenolphthalein as an indicator and expressed as % citric acid per 100g fresh weight. A ratio was calculated by dividing the values of TSS and that of corresponding values of titratable acidity and regareded as ripening index (Sabir and Agar, 2011).

Hue angle

Changes in surface color were determined using a Mini Scan XE Plus colorimeter with a standard C illuminant taking the b* value as a measure of degree of yellowing, L* value as a measure of surface lightness while a* being the measure of red colour. The values were expressed by the CIE L*a*b* system and hue angle was calculated using the formula h^o = tan-1 (b*/a*). Readings were taken around the equatorial point of the fruit at four places and average was taken. Likewise, in each treatment three fruits were used and again average values were recorded. Hue angle was expressed as suggested by Hurr *et al*. (2005) in which hue angle for greenness of the tomato fruit at 120^0 hue angle, acceptable redripe stage at 55^0 hue angle and for overripe stage, hue angle is 40^0.

Fruit firmness (kgf)

Firmness of randomly selected fruits (three from each replication) was measured with the help of fruit pressure tester (Model FT- 327, USA) on two opposite sides of the equatorial axis of fruit and average values expressed in terms of kgf.

Decay%

The decay percentage of fruits was calculated on number basis by counting the spoiled fruits in each replication and total number of fruits per replication.

Decay (%) = (Number of spoiled fruits/ Total number of fruits) ×100

Experimental design and statistical analysis:

The experiment was arranged in Completely Randomized Design and was replicated thrice. Statistical analysis was done using the SAS (v.9.3, SAS Institute, Cary, NC, USA) and least squares means separated by the Tukey's test at 1% significance level.

Results and Discussion

Physiological Loss in Weight % (PLW%)

In all the treatments studied, cumulative physiological loss in weight % increased progressively with the increase in storage period (Table 1). Among the putrescine treatments, fruits treated with 3 mmol/L of PUT (T_3) showed significant lower PLW% at all the days of analysis except at 11th day after treatment than treatments T1, T2 and control. However, less than threshold level of PLW% (5%) was recorded only in treatments T_3 and T_1 upto11th day after treatment. Jawandha *et al.* (2012) reported minimum physiological loss in weight % in Mango cv Langra treated with PUT (2.0 mmol/L) during the entire storage period. These results indicated that treatment with putrescine reduced the moisture loss and propably reduced the respiration rate also during storage and thus further helping in extension of storage life of the tomato fruits Jawandha *et al.* (2012).

Titratable Acidity (% citric acid) and Ripening index (TSS/TA)

The data in table 2 indicated that there was significant differences in titratable acidity between putrescine treatments and control at all the days of analysis except in treatments T_1 and T_2 at 6th day after treatment and T_3 treatment at 21st day after treatment. Among putrescine treatments, fruits dipped in PUT 1 mmol/L showed significant higher titratable acidity throughout the storage period over other putrescine treatments and control except at 6th day after treatment. However, at the end of the storage period, all the putrescine treatments were at par each other but significantly higher than control. The higher titratable acidity in putrescine treated fruits may be due to the decreased hydrolysis of organic acids and subsequent accumulation of organic acids (Pool *et al.,* 1972). Malik *et al.* (2006) reported that 'Kensington Pride' mango fruits treated with polyamines were found more acidic than control.

Putrescine treatments showed significant differences in ripening index over control (Table 3) at all the days of analysis. Tomato fruits treated with PUT 3mmol/L showed significant lower ripening index than any other treatments upto 16th day after treatment, but significant lower ripening index was observed in T_1 and T_2 at all days of analysis over control except at 6th day after treatment. The lower ripening index in putrescine treatments might be due to delayed reduction of acids to sugars by putrescine. The present results are in agreement with Khan *et al.* (2008) who reported delayed changes in SSC: acid ratio of 'Angelino' plum fruits, when treated with putrescine.

Hue angle

As storage period proceeded, there was decrease in hue angle in all the treatments and observed significant higher hue angle in putrescine treatments than in control (water dipping) at all days of analysis (Table 4). Treatments T_2 and T_1 (PUT at 2 mmol/L and 1 mmol/L) retained the fruits above acceptable red ripe stage upto 16th (62.05^0) and 11th (58.34^0) day after treatment respectively

Table 1: Effect of post-harvest application of putrescine on physiological loss in weight (PLW %) of fresh tomatoes during storage at 13±2⁰C and RH of 85-90%

Treatments	Particulars	1st	6th	11th	16th	21st	26th
T1	Putriscine 1 mmol/L	0	3.12^b	4.60^d	8.81^b	13.37^c	20.30^b
T2	Putriscine 2 mmol/L	0	3.50^a	5.20^b	9.57^a	14.03^b	19.26^c
T3	Putriscine 3 mmol/L	0	2.69^c	4.72^c	7.13^c	11.52^d	16.63^d
T4	Water dipping (control)	0	3.46^a	6.01^a	9.71^a	17.60^a	26.22^a

(Data in column followed by different letter superscripts are significantly different at P = 1%)

Table 2: Effect of post-harvest application of putrescine on titratable acidity (% citric acid) of fresh tomatoes during storage at 13±2⁰C and RH of 85-90%

Treatments	Particulars	1st	6th	11th	16th	21st	26th
T1	Putriscine 1 mmol/L	0	0.69	0.77^b	0.94^a	0.75^a	0.72^a
T2	Putriscine 2 mmol/L	0	0.69	0.78^b	0.82^c	0.74^a	0.67^b
T3	Putriscine 3 mmol/L	0	0.69	0.85^a	0.87^b	0.74^a	0.59^c
T4	Water dipping (control)	0	0.69	0.78^b	0.75^d	0.62^b	0.61^c

(Data in column followed by different letter superscripts are significantly different at P = 1%)

Table 3: Effect of post-harvest application of putrescine on ripening index of fresh tomatoes during storage at 13±2 ⁰C and RH of 85-90%

Treatments	Particulars	1st	6th	11th	16th	21st	26th
T1	Putriscine 1 mmol/L	8.49	7.27^a	5.62^c	6.76^b	6.65^c	7.67^b
T2	Putriscine 2 mmol/L	8.49	6.68^{bc}	6.41^b	6.52^{bc}	7.20^{bc}	7.69^b
T3	Putriscine 3 mmol/L	8.49	6.51^c	5.85^c	6.30^c	7.80^{ab}	8.18^a
T4	Water dipping (control)	8.49	6.93^{ab}	7.36^a	8.00^a	8.40^a	8.28^a

(Data in column followed by different letter superscripts are significantly different at P = 1%)

Table 4: Effect of post-harvest application of putrescine on hue angle (h⁰) of fresh tomatoes during storage at 13±2⁰C and RH of 85-90%

Treatments	Particulars	1st	6th	11th	16th	21st	26th
T1	Putriscine 1 mmol/L	99.50	88.52^a	57.57^a	51.93^b	44.68^a	39.81^c
T2	Putriscine 2 mmol/L	99.50	75.42^c	58.34^a	62.05^a	42.41^c	44.15^a
T3	Putriscine 3 mmol/L	99.50	68.17^d	51.21^c	50.52^c	43.55^b	41.25^b
T4	Water dipping (control)	99.50	77.79^b	54.73^b	50.49^c	42.05^c	41.01^b

(Data in column followed by different letter superscripts are significantly different at P = 1%)

whereas, in control it is upto 6th day after treatment only from the initial hue angle of 99.50⁰. However, hue angle of fruits in T_2 (44.15⁰) was higher than any other treatments studied including control at the end of the storage period. The improvement in colour during storage resulted lower hue angle which might be due to the degradation of the chlorophyll pigments of the fruits and increased synthesis of carotenoids and anthocyanin pigments (Wang *et al.,* 1971). Exogenous application of Putrescine at final fruit set stage significantly maintained higher 'hue angle' of 'Kensington Pride' fruit at the ripe stage (Malik and Singh, 2006).

Firmness (Kgf)

Data in table 5 showed that there was a gradual decrease of firmness values with the advancement of storage period in all the treatments except in T_3 (at 16th day after treatment) from the initial firmness of 49.99 Kgf. A significant higher firmness was observed in putrescine treatments over control at all the days of analysis except at 6th day after treatment. However, at the end of the storage period, only T_1 (24.97 Kgf) treatment showed significantly higher firmness compared to control (T_4). Khan *et al.* (2008) also reported that putrescine treated Angelino' plum fruit following low temperature storage (0±1°C; 90 ± 5% RH), at the ripe stage exhibited higher fruit firmness.

Table 5: Effect of post-harvest application of putrescine on firmness (kgF) of fresh tomatoes during storage at 13±2⁰C and RH of 85-90%

Treatments	Particulars	1st	6th	11th	16th	21st	26th
T1	Putriscine 1 mmol/L	49.99	41.98^c	34.73^b	32.41^b	28.64^b	24.97^a
T2	Putriscine 2 mmol/L	49.99	43.32^b	38.24^a	30.77^c	26.55^c	24.00^c
T3	Putriscine 3 mmol/L	49.99	40.70^d	30.26^c	36.62^a	30.28^a	24.07^c
T4	Water dipping (control)	49.99	45.90^a	30.26^c	29.32^d	25.28^d	24.39^b

(Data in column followed by different letter superscripts are significantly different at P = 1%)

Table 6: Effect of post-harvest application of putrescine on decay (%) of fresh tomatoes during storage at 13±2⁰C and RH of 85-90%

Treatments	Particulars	1st	6th	11th	16th	21st	26th
T1	Putriscine 1 mmol/L	0	0.28^b	1.99^b	5.70^b	13.45^{ab}	16.02^b
T2	Putriscine 2 mmol/L	0	0.28^b	2.04^b	4.37^b	8.18^{bc}	15.91^b
T3	Putriscine 3 mmol/L	0	1.70^{ab}	2.26^b	3.11^b	6.01^c	13.61^b
T4	Water dipping (control)	0	2.94^a	6.65^a	13.24^a	18.29^a	27.27^a

(Data in column followed by different letter superscripts are significantly different at P = 1%)

Decay %

All the putrescine treatments showed significant lower cumulative decay % over control throughout the storage period except T_3 treatment at 6th and T_1 treatment at 21st days after treatment (Table 6). Cumulative decay% of fruits increased with the progression of the storage period. It was observed that T_2 and T_3 treatments able to maintain decay % below threshold level (10%) upto 21st day after treatment while, in treatment T_1 and control it was upto 16th and 11th day after treatment respectively. Zheng and Zhang (2004) observed a reduction in decay % with postharvest treatments of putrescine in 'Ponkan' mandarin as compared to control.

Conclusion

Tomato fruits treated with PUT at 3 mmol/L are best observed with lowest cumulative physiological loss in weight (%) compared to other treatments and control while, PUT at 2 and 3 mmol/L retained cumulative decay % below 10% threshold level. However, all the PUT treatments maintained significant lower titratable acidity over control (water dipping) at the end of the storage (26 days after treatment).

Acknowledgement(s)

The corresponding author wish to acknowledge the Department of Fruit Science, Punjab Agricultural University, Ludhiana, India for providing cold storage facility and lab facilities for analysis of some quality parameters during 2012-13 and 2013-14 under author's programme of research work.

सारांश

सब्जियों में पुत्रेसेन (पी.यू.टी.), एक पाली एमाइन है जो पौधों के वृद्धि एवं विकास, फल पकाव, प्रतिबल प्रतिक्रिया वार्धक्य तथा अधिक मात्रा के कारण सब्जियों में तुड़ाई उपरान्त संरक्षण में सहायक है। टमाटर की किस्म 'पंजाब रटटा' से एक समान आकार व भार वाले फलों को पके हरे व तुड़ाई अवस्था में सब्जी शोध प्रक्षेत्र, पंजाब कृषि विश्वविद्यालय, लुधियाना (पंजाब) से वर्ष 2012–13 व 2013–14 में अप्रतिकृति उगाई फसल से लिया गया। पुत्रेसेन की 1 माइक्रोमोल, 2 माइक्रोमोल व 3 माइक्रोमोल की सान्द्रता से शोधित किया गया तथा अशोधित नियंत्रक जो टी.–1, टी.–2 टी.–3 व टी.–4 के सापेक्ष क्रमशः रखा गया। शोध उपरान्त टमाटर के फलों को प्लास्टिक के क्रेट में रखा गया तथा भण्डारण 13 ± 2 डिग्री सेन्टीग्रेड व सापेक्ष आर्द्रता 85–90 प्रतिशत बरकरार कर अध्ययन किया गया। तुड़ाई उपरान्त प्रयोग किये पुत्रेसेन के प्रभाव को भण्डारण में दशा को ज्ञात करने के लिए फलों को 5 दिनों के अन्तराल पर यानी प्रथम, छंठवी, ग्यारहवीं, सोलहवीं, इक्कीसवीं व छब्बीसवीं दिन पर विभिन्न गुणवक्ता गुणों हेतु विश्लेषण किया गया और 2 वर्षों के परिणाम के औसत को प्रस्तुत किया गया। छब्बीसवीं दिन एक शोधित फल के भार में सबसे कम कार्यिकी नुकसान पाया गया जो टी.–3 शोधन (पी.यू.टी.–3

माइक्रोमील/लीटर) था जबकि सोलहवें दिन तक शोधित टी.–2 शोधन में हयू एंगिल 62.05 डिग्री था जो स्वीकार्य लाल अवस्था (55 डिग्री) से टी.–1, टी.–3 व नियंत्रक से कही ऊपर था। टी.–2 व टी.–3 शोधन में नुकसान प्रतिशत डेवढ़ी (10 प्रतिशत) स्तर पर सोलहवीं तक (8.18 प्रतिशत व 6.01 प्रतिशत क्रमशः) नियंत्रक की तुलना में भण्डारण के अन्त तक शोधन उपरान्त थे।

References

Bhagwan A, Reddy YN, Rao PV (2000) Postharvest application of polyamines to improve the shelf-life of tomato fruit. Indian J Horti 57(2):133-138.

Bregoli AM, Scaramagli S, Costa G, Sabatini E, Ziosi V, Biondi S, Torrigiani P (2002) Peach (*Prunus persica*) fruit ripening: aminoethoxyvinylglycine (AVG) and exogenous polyamines affect ethylene emission and flesh firmness. Physiologia Plantarum (114): 472-481.

Dibble ARG, Davies PJ, Mutschler MA (1988) Polyamine content of long-keeping Alcobaca tomato fruit. Plant Physiol (86): 338-340.

Hurr BM, Huber DJ, Lee JH (2005) Differential responses in colour changes and softening of Florida 47 tomato fruit treated at green and advanced ripening stages with the ethylene antagonist 1-methylcyclopropene. Hort Technol 15(3): 617-622.

Jawandha SK, Gill MS, Singh NP, Gill PPS, Singh N (2012) Effect of post-harvest treatments of putrescine on storage of Mango cv. Langra. African J Agri Res 7(48): 6432-6436.

Khan AS, Singh Z, Abbasi NA, Swinny EE (2008) Pre- or post-harvest applications of putrescine and low temperature storage affect fruit ripening and quality of 'Angelino' plum. Sci Food Agric (88):1686-1695.

Kramer GF, Wang CY, Conway WS (1991) Inhibition of softening by polyamine application in 'Golden Delicious' and 'McIntosh' apples. J Am Soc Hort Sci (116): 813–817.

Malik AU, Singh WS (2006) Improved fruit retention, yield and fruit quality in mango with exogenous application of polyamines. Scientia Hort (110) : 167–174.

Malik AU, Singh Z (2003) Abscission of mango fruitlets as influenced by bio-synthesis of Polyamines. J Hort Sci Biotech (78): 721-727.

Malik AU, Singh Z, Tan SC (2006) Exogenous application of polyamines improves shelf life and fruit quality of mango. Acta Hort (699): 291-296.

Malmberg RL, Watson MB, Galloway GL, Yu W (1998) Molecular genetic analyses of plant polyamines. Cri Rev Plant Sci (17): 199-224.

Pandey S, Ranade SA, Nagar PK, Kumar N (2000) Role of polyamines and ethylene as modulators of plant senescence. J Biosci (25): 291–299.

Perez-Vicente A, Martinez-Romero D, Carbonell A, Serrano M, Riquelme F, Guillen F, Valero D (2002) Role of polyamines in extending shelf life and the reduction of mechanical damage during plum (*Prunus salicina* L.) storage. Postharvest Biol Technol (25): 25-32.

Petkou IT, Pritsa TS. Sfakiotakis EM (2004) Effects of polyamines on ethylene production, respiration and ripening of kiwifruit. J Hort Sci Biotech (79): 977-980.

Ponappa T, Scheerens JC. Miller AR (1993) Vacuum infiltration of polyamines increases firmness of strawberry slices under various storage conditions. J Food Sci (58): 361-364.

Pool KM, Weaver RJ, Kliewer KM (1972) The effect of growth regulators on the changes in fruits of Thompson seedless during cold storage. J Ame Soc Hort Sci (97): 67-70.

Sabir F, Agar IT (2011) Effect of 1-methylcyclopropene and modified atmosphere packing on postharvest life and quality in tomatoes. J Food quality (34): 111-118.

Saftner RA, Bald BG (1990) Polyamine levels and tomato fruit development: Possible interaction with ethylene. Plant Physiol (92): 547-550.

Valero D, Martinez RD, Serrano M (2002) The role of polyamines in the improvement of the shelf life of fruits. Trends Food Sci Tech (13): 228-234.

Valero D, Martinez-Romero D, Serrano M, Riquelme F (1998) Influence of post-harvest treatment with putrescine and calcium on endogenous polyamines, firmness and abscisic acid in lemon (*Citrus lemon* L. Burm *cv.* Verna). J Agri Food Chem (46): 2102-2109.

Wang SS, Haard NF, Di-Marco GR (1971) Chlorophyll degradation during controlled atmosphere storage of asparagus. J Food Sci (36): 657-661.

Winer L, Apelbaum A (1986) Involvement of polyamines in the development and ripening of avocado fruits. J Plant Physiol (126): 223–233.

Zheng Y, Zhang Q (2004) Effects of polyamines and salicylic acid on post-harvest storage of 'Ponkan' mandarin. Acta Hort (632): 317-320.