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Effect of pre-harvest putrescine treatment on quality and postharvest life of pear cv. Spadona

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Key words: cold storage, color, fruits, quality assessment.

Abstract: The study was conducted to determine the effect of pre-harvest foliar spraying with putrescine (at 0.5, 1 and 2 mM) on quality and postharvest life of *Pyrus communis* cv. Spadona during cold storage. Fruit quality assessment such as weight loss, firmness, total soluble solids (TSS), titratable acidity (TA), flavor index, skin color (L^*, hue angle), vitamin C total phenol (TP), and total antioxidant activity (TAA) were made at harvest and after 3, 6, 9, 12, 15, 18 and 21 weeks of storage at 0±1°C, 80-85% relative humidity. Weight loss, fruit softening, TSS and pH increased during storage but the rate of changes was significantly lower in fruit treated with putrescine at 1 and 2 mM. Putrescine application maintained higher levels of TA, vitamin C, TP, TAA, L^*, hue angle and reduced decay incidence compared to control. Furthermore, higher doses of putrescine were effective in terms of prolonging the storage and marketability of fruits more than 127-142 days. In conclusion, pre-harvest application of putrescine could be an effective means for extending the postharvest life of pear cv. Spadona.

1. Introduction

The polyamines as natural compounds are present ubiquitously in almost all living organisms. 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). They are known as anti-senescent agents that decrease the rate of fruit softening and senescence by suppression of ethylene production (Kramer *et al.*, 1991). Reduced values of polyamines have been attributed with enhanced ethylene production and vice versa (Walden *et al.*, 1997). This mechanism is correlated to a competition between polyamine and ethylene for the common precursor *S*-adenosyl methionine (SAM) (Pandey *et al.*, 2000). The use of polyamines has been claimed to decrease ethylene synthesis in a wide range of plants by decreasing ACC synthase (ACS) and ACC oxidase (ACO) enzymes activities (Ke and Romani, 1988; Kakkar and Rai, 1993; Lee *et al.*, 1997; Martinez-Romero *et al.*, 2001; Bregoli *et al.*, 2002; Perez-Vicente *et al.*, 2002; Serrano *et al.*, 2003; Petkou *et al.*, 2004; Malik and Singh, 2005; De Dios *et al.*, 2006; Khan *et al.*, 2007).

In several investigations putrescine applied exogenously have been reported to increase storage life and quality attributes of mango (Razzaq *et al.*, 2014), pear (Franco-Mora *et al.*, 2005), apricot (Martinez-Romero *et al.*, 2002), strawberry (Zokaee Khosroshahi *et al.*, 2007), plum (Abu-Kpawoh *et al.*, 2002; Pérez-Vicente *et al.*, 2002), grapes (Harindra Champa *et al.*, 2015; Mirdehghan and Rahimi, 2016), pomegranate (Mirdehghan *et al.*, 2007; Barman *et al.*, 2011) and litchi (Jiang and Chen, 1995).

Therefore, the aim of this study was to investigate the role of preharvest putrescine treatment on maintaining postharvest quality of pear fruit cv. Spadona.

2. Materials and Methods

The experiments were conducted on pear trees (*P. communis* cv. Spadona) in the center of horticultural research of the University of Tehran, Karaj, Iran. Eighteen 16-year-old trees (250 cm height) were selected in terms of uniformity in size and fruit load then sprayed with putrescine at 0.5, 1 and 2 mM (3.5

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L per tree) at different stages of fruit development in May, June, and July. Six trees sprayed with water (3.5 L per tree) were used as control. Fruits were harvested manually and transported to the postharvest laboratory, and selected for absence of visual symptoms of disease or blemishes, then stored (5 fruits per basket) at 0±1°C, 80-85% RH for 21 weeks. Quality attributes were measured in five fruits of each replicate at harvest and after 3, 6, 9, 12, 15, 18 and 21 weeks of cold storage.

Fruit quality assessments

Fruit color changes were calculated at two opposite sides of fruit with a Minolta Chroma Meter CR-400 (Osaka, Japan). The values of L^*(0 - black; 100 - white), a^* (green to red), b^* (blue to yellow) and hue angle ($h°=180 + \tan^{-1} b^*/a^*$, if $a^* < 0$) were recorded (Fernando *et al.*, 2007; Pek *et al.*, 2010).

The percentage of weight loss was recorded by using following equation:

$$\% \text{ weight loss} = (A-B)/B \times 100$$

in which A was the initial fruit weight and B was the final fruit weight. Fruit firmness was determined using a penetrometer FT327 (GFFECI, Italy) fitted with an 8 mm tip on the equatorial position of fruit. The results were expressed in newton (N).

Total soluble solids (TSS) in the extracted juice of each treatment were measured by a refractometer (Atago N1, Japan) at 20°C and the result was recorded as percentage. Five ml of diluted juice titrated against 0.1 N NaOH to pH 8.2 to assess TA. Phenolphthalein was used as an indicator. The TA was expressed as malic acid percentage (Saini *et al.*, 2001). The pH of fruit juice was calculated using a MTT65 (Japan) pH meter calibrated by pH 4 and 7 buffer solutions. Flavor index was estimated by dividing TSS with the corresponding TA value. Vitamin C was measured using the procedures of Tian *et al.* (2002).

Total phenol (TP) content and total antioxidant activity (TAA)

TP and TAA were assessed according to Koushesh Saba *et al.* (2012).

Decay incidence determination

Fruit decay was determined based on the procedure of Khademi and Ershadi (2013). Scales from 1 to 5 were given to individual treatment group whereas: 1= normal (without decay), 2= (up to 5 % decay), 3= (5-20 % decay), 4= (20-50% decay) and 5= (more than 50% of fruits skin was decayed).

Statistical analysis

This experiment was conducted in a randomized experimental design with three levels of putrescine (0.5, 1 and 2 mM), using plants sprayed with water as control in three replications and two trees in each experimental unit. To estimate storability of pear fruit cv. Spadona, a factorial design in completely randomized were carried out and the experimental data analyzed using SAS statistical software package 9.4 for windows and mean comparisons were conducted using Duncan's multiple range tests.

3. Results and Discussion

Color

A high rate of color changes was observed in control fruits and 0.5 mM putrescine treated fruits, whereas, they exhibited lower L^* and hue angel than others during storage (Fig. 1 A and B). Therefore, the conversion rate of green to yellow and degradation

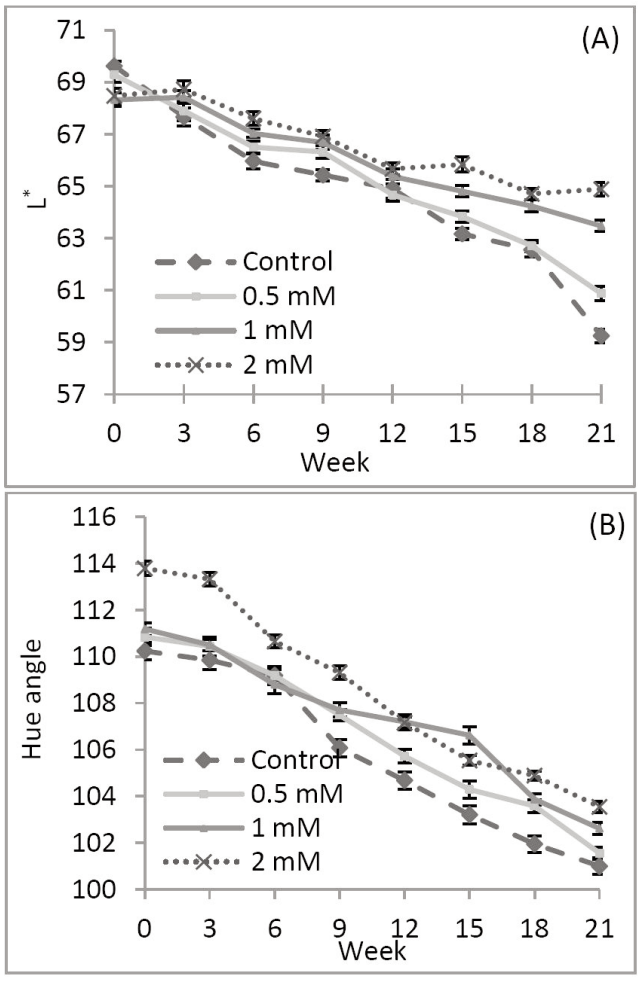

Fig. 1 - The effect of putrescine at different concentrations on L* (a) and hue angle (b) of pear cv. Spadona along the storage. Values are the mean ± SE.

of chlorophyll were shown slower in putrescine treated fruits by 1 and 2 mM. The effect of putrescine in retarding skin color changes throughout the storage by decreasing senescence rate has also been reported in table grape (Harindra Champa *et al.*, 2015), and pomegranate (Barman *et al.*, 2011).

Weight loss and firmness

The weight loss increased in all fruit samples during the 21 weeks cold storage. As shown in figure 2 A, putrescine at 1 and 2 mM reduced the weight loss value than control at the end of storage. However, fruit treated with 2 mM putrescine showed inferior weight loss which started at the third sampling date (6th week), while it was not seen in those treated with 1 mM before the fifth sampling date (12th week). Reduction of weight loss in putrescine treated fruits can be ascribed to conjugation of polyamines to the cell membrane phospholipids and consequently stabilization as well as consolidation of both cell integrity and permeability (Barman *et al.*, 2011; Mirdehghan and Rahimi, 2016). Irrespective of treatments, fruit firmness decreased with the advancement of storage but putrescine treatment at 1 and 2 mM maintained highest fruit firmness compared to control (Fig. 2B). It is suggested that polyamines maintain fruit firmness by their cross-linkage to the pectin substances carboxyl groups in the cell wall and lead to strengthening of cell wall and consequently decreasing cell wall degrading enzymes activities of pectin methyl esterase (PME), pectin esterase (PE) and polygalactouronase (PG) (Valero *et al.*, 2002). The role of putrescine in reducing weight loss and maintaining fruit firmness has been reported for peach (Zokaee Khosroshahi and Esna-Ashari, 2008) and pear (Franco-Mora *et al.*, 2005).

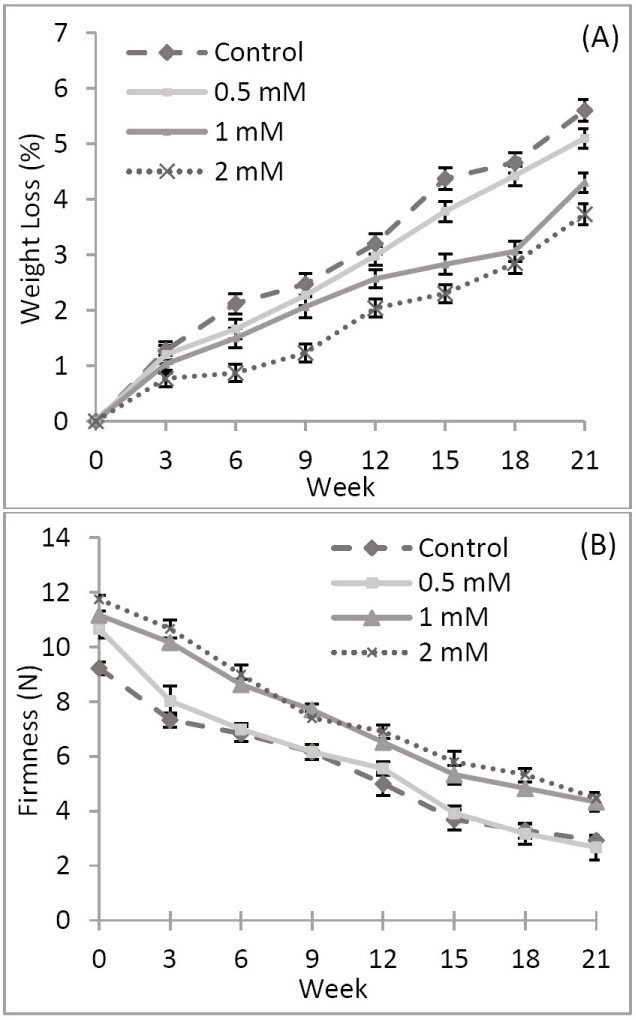

Fig. 2 - The effect of putrescine at different concentrations on weight loss (a) and firmness (b) of pear cv. Spadona along the storage. Values are the mean ± SE.

TSS, TA, pH and flavor index

The contents of TSS (in the first 12 weeks of storage), pH and flavor index increased in all treated and untreated fruits while TA showed reverse trend along the storage. However, the lowest TSS, pH and flavor index were observed in treated fruits by 1 and 2 mM (Fig. 3 A, B, C and D). The role of putrescine on maintaining TSS, TA and pH in treated fruits would be attributed to the reduction of respiration rate (Valero *et al.*, 2002), ethylene synthesis (Barman *et al.*, 2011) and subsequently retarding the ripening process. Similar results have been reported in peach (Zokaee Khosroshahi and Esna-Ashari, 2008) and apricot (Enas *et al.*, 2010).

Vitamin C

Vitamin C significantly declined as the storage advanced. However, this trend was slower in 1 and 2 putrescine treated fruits (Fig. 4). This effect can be associated with the property of putrescine on reducing or delaying the activity of ascorbate oxidase and consequently maintaining vitamin C (ascorbic acid) content (Ishaq *et al.*, 2009). Similar results have been reported in mango (Razzaq *et al.*, 2014) and apricot (Davarynejad *et al.*, 2013).

Total phenol (TP) and total antioxidant activity (TAA) measurement

Irrespective of treatments, total phenolic content and total antioxidant activity decreased at the end of storage; while these decreases were significantly higher at 1 and 2 mM putrescine treated fruits (Fig. 5 A and B). In spite of TAA, the TP changes were not constant during storage, it reached the highest value at the 9th week in fruits treated with 1 and 2 mM with the maximal values of 28 and 31 mg of GAE/100 g of FW at the 9th week respectively, then followed by reducing TP during the rest of storage period.

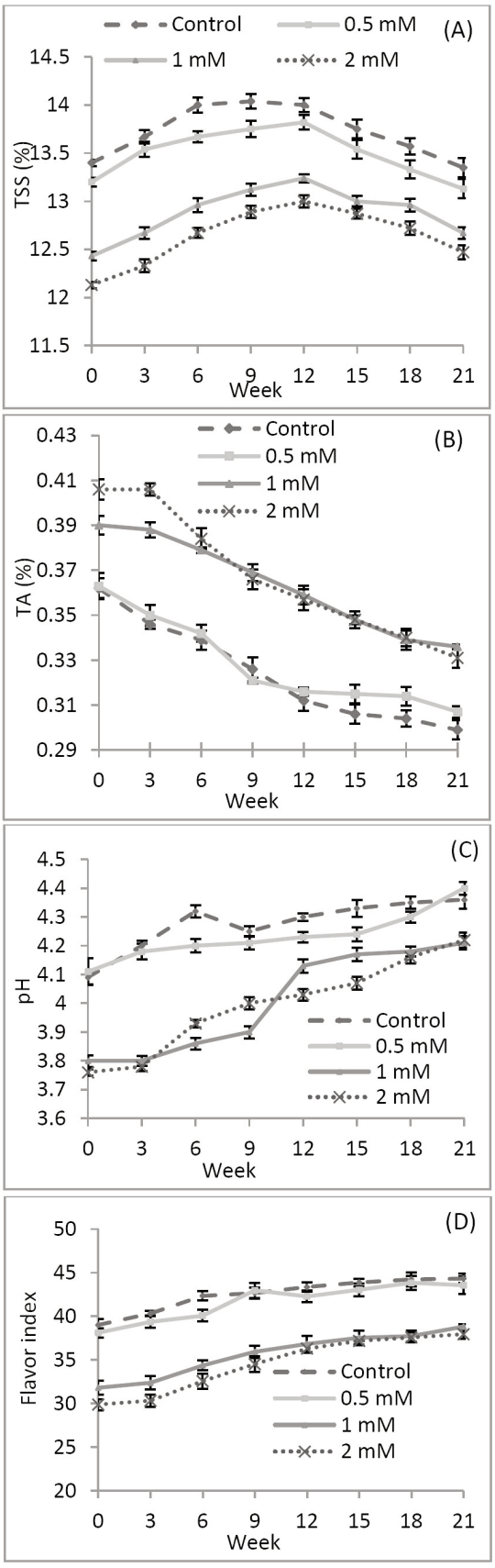

Fig. 3 - The effect of putrescine at different concentrations on TSS (a), TA (b), pH (c) and flavor index (d) of pear cv. Spadona along the storage. Values are the mean ± SE.

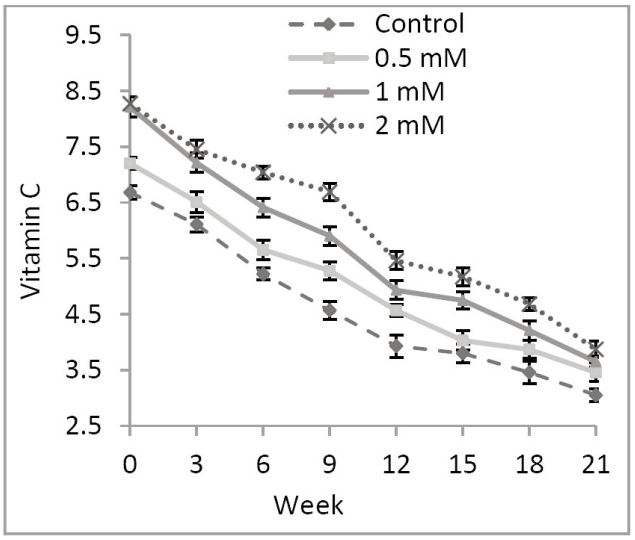

Fig. 4 - The effect of putrescine at different concentrations on vitamin C of pear cv. Spadona along the storage. Values are the mean ± SE.

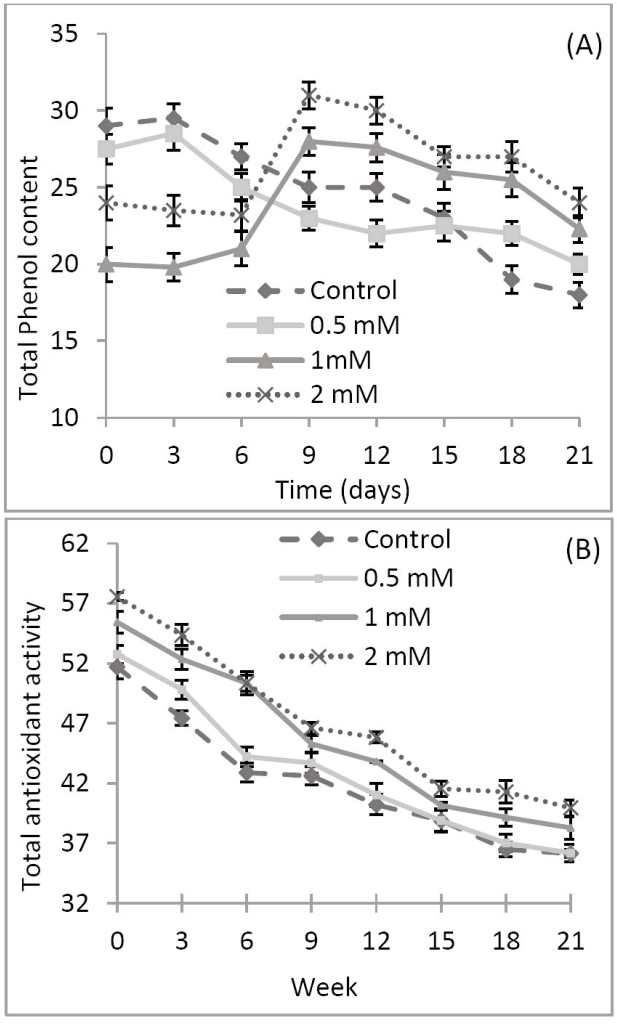

Fig. 5 - The effect of putrescine at different concentrations (0.5, 1 and 2 mM) on total phenol content (A) and total antioxidant activity (B) of pear cv. Spadona along the storage. Values are the mean ± SE.

The changes in the level of TP content may be associated to the breakdown of cell structure and subsequently senescence (Ghasemnezhad *et al.*, 2010). The role of putrescine treatment to maintain TP could be ascribed to the delay of senescence process (Arora *et al.*, 2002; Razzaq *et al.*, 2014).

As shown in figure 5, the value of TAA decreased along with a decrease of TP during storage. It may be ascribed to a direct correlation among TP content and TAA (Razzaq *et al.*, 2014). However, putrescine treatment at 1 and 2 mM maintained TAA compared to control during storage. Similar results demonstrated a positive correlation among TP and TAA in mango (Palafox-Carlos *et al.*, 2012) and apricot (Ghasemnezhad *et al.*, 2010).

Decay incidence

The lowest rate of fruit decay percentage was observed in fruits treated with 1 and 2 mM putrescine contrary to control at the end of storage (Fig. 6). It is suggested that polyamines have all requirements of an alternative approach for management of postharvest decay (Romanazzi *et al.*, 2012).

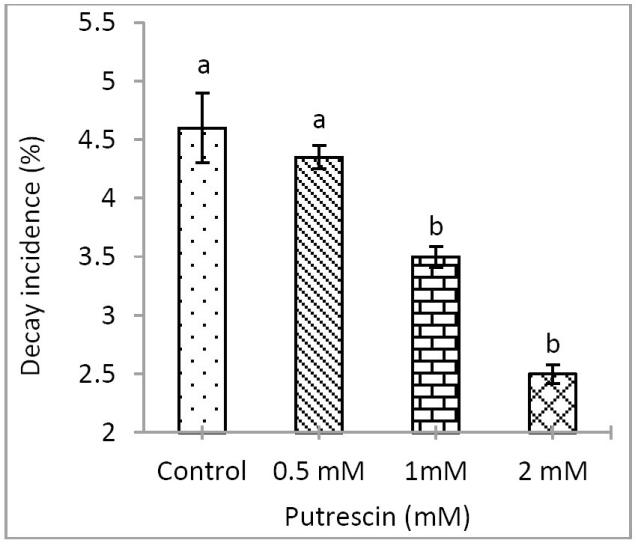

Fig. 6 - The effect of putrescine at different concentrations (0.5, 1 and 2 mM) on decay incidence of pear cv. Spadona at the end of storage. Values are the mean ± SE.

Storage life

The application of putrescine at higher doses (1 and 2 Mm) extended storage life of pear fruits, and consequently they were suitable to be exposed in the market more than 127-142 days after the beginning of storage in comparison to control (109 days) (Fig. 7).

4. Conclusions

The pre-harvest application of 1 and 2 mM putrescine treatment maintained the postharvest life of pear cv. Spadona by reducing weight loss, fruit softening, color changes as well as retarding the degradation rate of TSS, TA, pH, vitamin C, total phenol and total antioxidant in pear fruit during storage. Moreover, the storage life and marketability of putrescine treated fruits were prolonged by decreasing decay incidence. Thus, pre-harvest application of putrescine can be an effective means for extending the postharvest life of pear cv. Spadona.

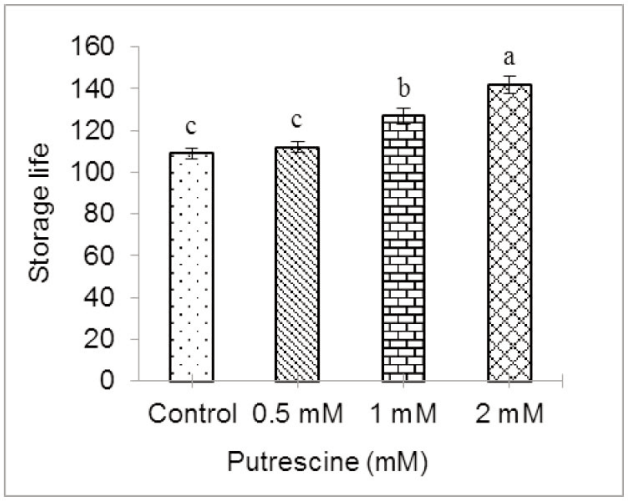

Fig. 7 - The effect of putrescine at different concentrations (0.5, 1 and 2 mM) on storage life of pear cv. Spadona. Values are the mean ± SE.

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