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RESEARCH PAPER

Influence of Exogenous Application of Putrescine on Ripening Changes in Banana cv. Grand Naine

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Abstract

Mature unripe banana cv. Grand Naine fruits were treated exogenously with 1mM putrescine (PUT) for 30 min while distilled water served as a control, then the treated fruits were packed with 200 guage polythene cover and stored at 13^{O}C and 80-85 % RH for 15 days + 20 days (ambient storage). Observations on different physico-chemical characteristics showed that the application of 1mM PUT significantly delayed the loss of firmness (1197.5g vs. 815.12g in control); reduced respiration rate (81.49 *vs.* 118.46mlCO_2/kg/h); recorded lower pulp to peel ratio (1.95 vs.2.33); delayed accumulation of total soluble solids content (13.42 *vs.*15.55 B); maintained higher titratable acidity (0.25 vs. 0.17 %); delayed peel color changes and registered lower *L**(77.62), *a**(0.78) and *b**(35.60) compared to the untreated fruits. The results clearly suggested definite role of PUT in delaying the ripening changes in banana cv. Grand Naine.

Keywords: Banana, physico-chemical quality, putrescine, storage, firmness, respiration, ripening

Banana is one of the important tropical fruit crops of the world including India. Though India is the largest producer of banana, its short shelf-life seriously limits the export, market and utilization of the fruit. Banana when ripened is a soft and very delicate fruit with a post harvest shelf-life of 5-10 days. Being a high perishable fruit, it suffers post-harvest losses estimated to be more than 25% (Srivastav and Sanjeev Kumar, 2002), since banana is a climacteric fruit controll of ripening is important to improve its utilization. The fruit ripening can be delayed by lowering the storage temperature and by using special chemicals. As banana suffers chilling injury at a very low temperature and use of chemicals has led to many health hazards, there is a need for a safe bio-based chemical which can delay ripening. Dibble *et al.* (1988) stated that deterioration of fruit quality physiologically correlates with reduction of polyamine (PA) content in the ripening fruits and increase in ethylene production. Polyamines are biological compounds of low molecular weight in their free forms which act as anti-senescent agents, delay ethylene production, reduce rate of respiration, increase fruit firmness, induce mechanical resistance, reduce chilling symptoms and retard colour changes (Valero *et al.*, 2002). It has been shown that during post-harvest life of several fruits, PAs increase firmness in apples (Kramer *et al.*, 1989; Wang *et al.*, 1993), plum (Serrano *et al.*, 2003), apricot (Davarynejad *et al.*, 2013; Koushesh *et al.*, 2012), strawberries (Ponappa *et al.*,1993; Khosroshahi *et al.,* 2007), lemon (Valero *et al.*, 1998; Mohammad *et al.*, 2013), Kiwifruit (Jhalegar *et al.*, 2012) and peach (Bregoli *et al.*, 2002). Putrescine (1mM) treatment inhibited ethylene production, low ered respiration rate and higher flesh firmness in Hayward kiwi fruit (Wen *et al.*, 2003), plum

(Serrano *et al.*, 2003) and pomegranate (Barman *et al.*, 2011). Pre and post harvest application of PUT on mango increased fruit firmness and also retarded colour development (Malik *et al.*, 2003). In another study by Malik and Singh (2005), pre-storage application of polyamines reduced fruit softness, fruit colour and physiological weight loss of mango *cv.* Kensington Pride. Most of the research indicates that polyamines have a role in delaying ripening in many fruits like plum (Serrano *et al.*, 2003), mango (Aman *et al.*, 2006; Jawandha *et al.*, 2012), kiwifruit (Jhalegar *et al.*, 2012).and To the best of our knowledge, this is the first report of exogenous application of PUT in delaying ripening of banana cv. Grand Naine. Thus, the aim of this paper was to determine the role of exogenous application of PUT on fruit ripening changes in banana stored at 13^{O}C.

Materials and Methods

Treatment with putrescine

Mature and uniform banana fruits free from bruising cracks and cuts were separated, washed with water and treated with 0.2 % sodium hypochlorite. Air dried fruits were treated with aqueous solution of 1mM PUT and 0.1% tween-20 for 30 min. the control, fruits were treated with distilled water. After treatment, fruits were packed in 200 guage polythene cover and stored at 13^{o}C and 80-85% RH for 15 days. To simulate the ripening, fruits were transferred to ambient temperature. Observations on ripening changes were recorded at 20 days.

Analyses

Firmness (g) was measured using Lutron FG-5000A penetrometer. The SSC of homogenised pulp was measured by using a Hand Refractrometer (Erma Japan). Titratable acidity was measured as outlined by Anon. (1984). Pulp-to-peel ratio was calculated by dividing weight of the pulp to weight of the peel. Respiration rate was measured with a CO_2 gas analyzer (Make: PBI Dansensor, CheckMate - II) in static method. The fruit was weighed and placed in a hermetically sealed container of 1250 ml capacity for 60 minutes. At the end of incubation period, gas sample was drawn from the container head space using gas tight syringe and injected into the CO_2 analyzer. The change in CO_2 gel concentration in the head space and time was read in the instrument was recorded. The respiration rate of the fruit was expressed as ml CO_2/kg/h.

The rate of respiration was calculated using the formula:

$$\text{Rate of respiration (ml } CO_2\text{/kg/h)} = \frac{CO_2\text{(Final-initial) (\%)} \times \text{volume of the container}}{100 \times \text{weight of the fruit (kg)} \times \text{time (h)}}$$

Peel colour was measured using a Lovibond colour meter (Lovibond RT300, Portable spectrophotometer, The Tintometer Limited, Salisbury, UK) fitted with Xrite 962 sensor, 8mm diameter aperture, D65 illuminanat and 100 observer. The instrument was calibrated using the black and white tiles provided. The colour was expressed in Lovibond units L* (lightness/darkness), a* (redness/greenness), b* (yellowness/blueness), samples of fruits were directly placed under the aperture of the colour meter. Four measurements were performed for each sample and values were averaged.

Results and Discussion

Fruit firmness: There was a decrease in the firmness of banana fruits in both treated and control during storage (15+20days). Banana fruits treated with 1mM PUT retained higher firmness (1197.59g) compared to the untreated fruits (815.12g) (Figure i). The effect of PAs on reduction of fruit augmentation is postulated to be the result of their cross-linkage to the carboxyl group of the pectic substances in the cell wall, resulting in rigidification. This binding between PAs and pectin also blocks the access of cell wall degrading enzymes, such as pectin methylesterase, pectinesterase and polygalacturonase, reducing the rate of softening during storage (Valero *et al.*, 2002). Thus, PAs might maintain fruit firmness by stabilizing cell walls, or by making cell walls less accessible to cell wall softening enzymes (Kramer *et al.*, 1989). The report by Antonia (2002) suggests that the exogenous polyamines are likely to bind to the cell wall and form a linkage. Several workers reported the firmness retention with the application of PAs in different fruits *viz.,* grapes (Champa *et al.,* 2014); plum (Serrano et al., 2003); strawberry (Ponappa *et al.*, 1993; Khosroshahi *et al.,* 2007); lemon (Valero *et al.*, 1998); apples (Kramer *et al.*, 1989); peach (Bregoli *et al.*, 2002; Chuanlai *et al.*, 2005); pomegaranate (Mirdehghan *et al.*, 2007); Angelino plum (Ahmad *et al.,* 2007) and blueberry (Fouad, 1996).

Pulp to peel ratio: Pulp to peel ratio increased during the storage of banana from initial ratio of 1.23 (Figure 1). (iii) Fruits treated with 1mM PUT registered significantly lower ratio of 1.95 compared to the untreated fruits (2.33) at $p<0.05$. Pulp to peel ratio is good ripening index of banana. The pulp:peel ratio increases as the fruit ripens. Increase in pulp to peel ratio during ripening indicate differential changes in moisture content of the peel and

pulp and increase in sugar concentration in the two tissues. During ripening, there is rapid increase in the sugar concentration in the pulp compared to the peel thus, contributing to a differential change in osmotic pressure. The peel looses water both by transpiration to the atmosphere and also to the pulp by osmosis, thereby contributing to an increase in the fresh weight of the pulp as the fruit ripens (Stover and Simmonds, 1987). The lowest pulp to peel ratio in PUT treated fruits may be attributed to delayed ripening compared to control.

Respiration rate: Respiration rate of banana fruits is significantly influenced by the PUT treatment at $p<0.05$

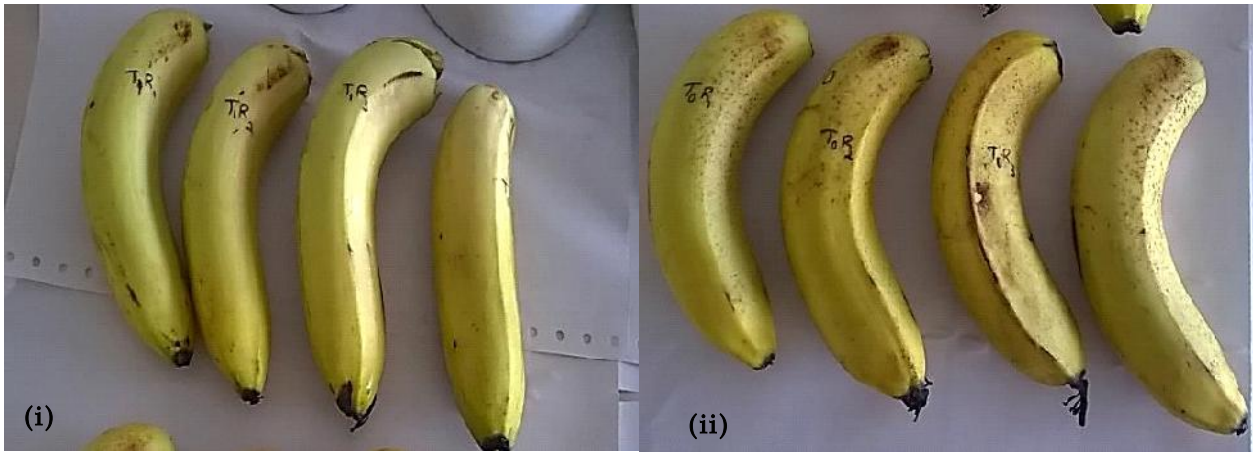

Plate 1: Effect of 1 mM PUT(Fig. i) on visual quality of banana fruits

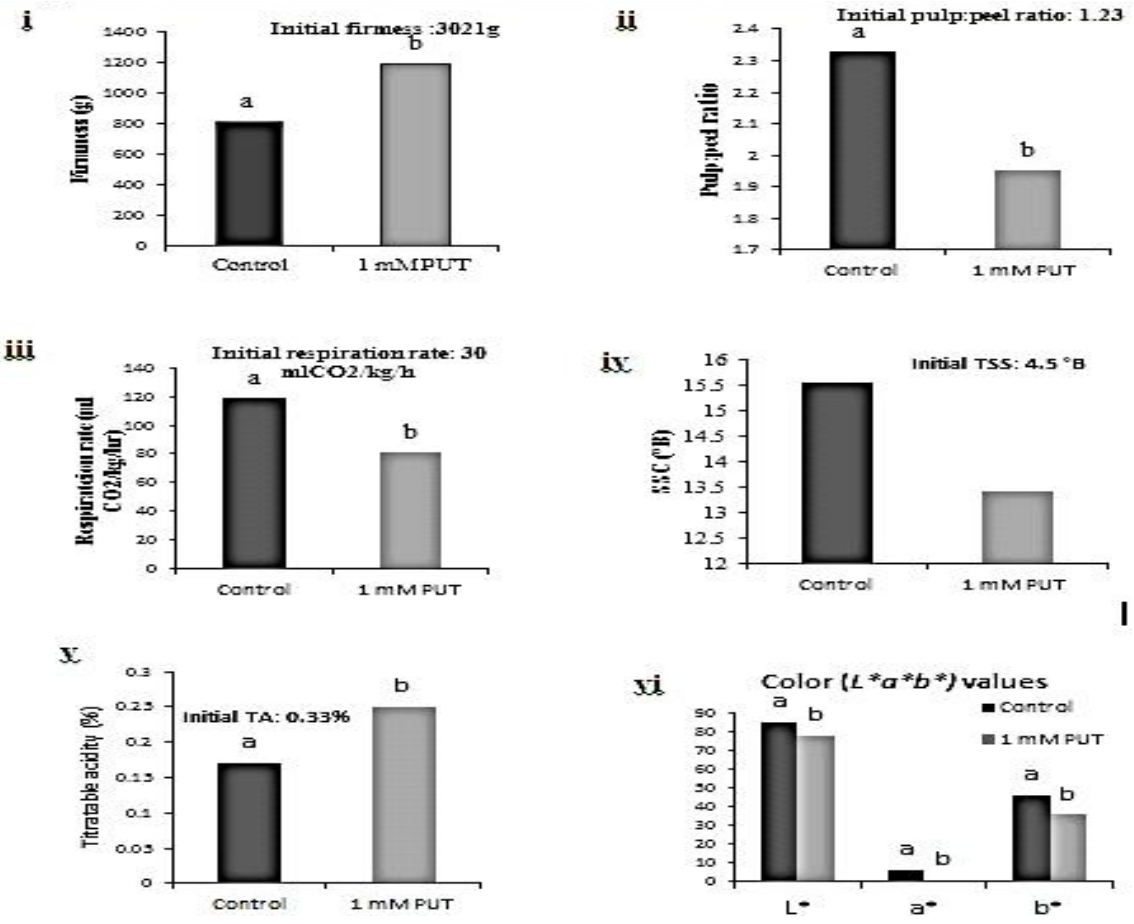

Fig. Effect of 1mM PUT on (i) firmness (g); (ii) pulp:peel ratio; (iii) Respiration rate ($mlCO_2/kg/h$); (iv) Soluble solids content (B); (v) TA (%) and; (vi) Color (*L*a*b**) values

(Fig. iv). Respiration rate of banana increased during the storage (15+20 days) from initial 30 ml CO_2/kg/h to 81.49 ml CO_2/kg/h in 1mM PUT treated fruits and 118.46 ml CO_2/kg/h in untreated banana. This effect on reducing respiration rate may be due to anti-senescent property of PUT and its potential to inhibit ethylene production. The present results corroborate the findings of Jhalegar *et al* (2012) in kiwifruit; Antonio *et al.*(2002) in plum; Malik *et al* (2005) in mango; and Barman *et al* (2011) and Mirdehghan *et al.* (2007) in pomegranate.

Soluble Solid Content: Soluble sugars content increased during storage (15+20 days) of banana in both the control and PUT treated fruits however, they registered non-significant difference ($p<0.05$) (Figure iv). Fruits treated with 1mM PUT recorded SSC of 13.42p B and control fruits recorded 15.55p B. The effect of PUT on reduced SSC can be attributed to low levels of the respiration rate, ethylene production and delay in ripening process. Champa *et al.* (2014) reported that SSC increases during storage period due to slow hydrolysis of starch to sugar in grapes. Influence of PUT on SSC of fruits also reported in Valencia orange cv. Olinda (Raeisi *et al.*, 2013), plum (Antonio *et al.*, 2002), lemon (Mohammad, 2013) and apricot (Davarynezad *et al.*, 2010).

Titratable acidity: Putrescine treatment significantly influenced the titrable acid (TA) content of banana fruits in comparison to the control at $p<0.05$ (Figure iii). TA decreased during the storage period from initial value of 0.33% to 0.17% in control and 0.25% in 1 mM PUT treated fruits. The decrease in TA during storage could be due to consumption of organic acids in fruits during the process of respiration. Retention of higher TA in PUT treated fruits can be attributed to reduction and/or delayed ripening (Serrano *et al*, 2003), respiration and reduced rate of metabolism. These results are in line with the findings of Khosroshahi *et al.,* (2007) in strawberry: Champa *et al* (2014) in grapes; Mirdehghan *et al* (2007) in pomegranate; Malik *et al.,* (2003) in mango; Raeisi *et al.,* (2013) in Valencia orange: Mohammad (2013) in lemon; and Serrano *et al.*, (2003) and Antonio *et al.,* (2002) in plum.

Instrumental colour (L, a*, b*) values:* Instrumental colour values (*L*a *b**) recorded significant difference between PUT treated and control fruits ($p<0.05$) (Figure 1(vi). Lightness values increased to 84.80 and 77.62 in untreated fruits and PUT treated fruits, respectively from initial 63.18. Redness (*a**) values recorded a shift from negative (green) to positive (red) during the storage (15+20 days). Greenness-redness (*a**) values increased from initial -11.90 to 6.49 and 0.78 in control and PUT treated fruits, respectively indicating slower colour change in treated fruits compared to the control. Yellowness (*b**) values also recorded an increasing trend. Untreated fruits recorded higher *b** values (45.52) as compared to PUT treated banana fruits (38.60). The higher *b**value in control fruits indicates faster ripening of fruits compared to PUT treated fruits. The retardation of fruit colour development by PUT indicates lower chlorophyll degradation, carotenoids biosynthesis and a delay in senescence processes. Polyamines may inhibit chlorophyll degradation in skin tissues by inhibition of peroxidase activity (Ma-Jun *et al.*, 1996). Lester (2000) reported exogenous application of PAs retarded chlorophyll loss and reduced hydrolytic activity on chloroplast thylakoid membranes in muskmelon. Similar observations were also made by Valero *et al* (1998); Martinez, (2002) in lemon; Barman *et al.*, 2011 in pomegranate and Malik *et al*, 2003 and 2005 in mango.

Visual color: A compassion of visual color is depicted in Plate 1.

Conclusion

Exogenous application of 1 mM PUT delayed changes in physico-chemical qualities of banana cv. Grand Naine. Among the quality changes, notably, weight loss, fruit firmness, respiration rate, colour changes, pulp -to- peel ratio, accumulation of soluble solid content and titratable acidity. Hence, PUT at 1mM concentration can be used to delay ripening and senescence and ultimately its shelf-life. The future studies are necessary to know the effect of different concentrations of PUT and other polyamines on ripening changes of banana cv. Grand Naineneed to be workedout to increase the effectiveness.

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