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Original Research Paper

Endogenous plant metabolites influence on shelf-life extension of tuberose flowers

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ABSTRACT

Tuberose is highly valuable for making floral ornaments, bouquets, artistic garlands, button holes and essential oil. The present study aimed to increase the shelf life of loose flowers by the exogenous application of endogenous plant metabolites i.e. polyamines-putrescine and spermidine at 15 and 20 mg each and with two controls (with/ without packaging). The polyamine-dipped tuberose florets were packed in polyethylene zip covers (56 microns thickness & 1% ventilation), and stored at room temperature (32±1°C and 65 ± 3% RH). Results revealed that putrescine (20 mg) and spermidine (20 mg) treated florets had reduced physiological loss in weight and spoilage percentage with delayed flower opening, and higher sensory acceptance when compared to other treatments and also extended vase life (4 days). The shelf life of untreated flowers without a package was just on the harvested day. Thus, the exogenous application of polyamines had a synergic effect on the shelf life of tuberose loose flowers and can be effectively utilized in the supply chain of tuberose.

Keywords: Flower opening, putrescine, room temperature, spermidine, spoilage

INTRODUCTION

Tuberose (*Polianthes tuberosa* Linn.), is a commercially grown flower crop in Italy, France, Mexico, USA, China, India, and many other tropical and sub-tropical areas of the world. In India, commercial farming of tuberose is done in an area of 21.13 mha, yielding 91.42 mMT, with West Bengal and Tamil Nadu as leading states (MoAFW, GOI, 2023). Major export destinations from India are USA, Netherland, Germany, UK and UAE. Tuberose (single type) is predominantly cultivated and used as loose flowers in garland making, social functions and perfumery industry for essential oil extraction. Tuberose as a cut flower as well as a loose flower has tremendous demand and is usually transported from the region of production to the remote market for export. Due to their highly perishable nature, there is a huge loss of tuberose florets during packaging and transport. Considering the postharvest shelf life of tuberose, each individual floret lasts only about three days on the spike (Kumar & Kumar, 2013) whereas, loose flower tuberose has only one-day shelf life. Improvement in keeping quality and shelf life of tuberose loose flowers becomes paramount necessary in the floriculture industry.

Tuberose flowers have two major quality-reducing agents in their postharvest life; ethylene sensitivity and vascular blockage (Meman & Dabhi, 2006). The generated ethylene is mainly responsible for leaf and flower senescence. Managing ethylene while in packaging and transport helps enhance the shelf life of tuberose flowers. Polyamines play a major role in growth, development, flowering, ripening and senescence (Khan et al., 2008). Polyamines are naturally occurring plant metabolites and are produced from plant-based amino acids majorly, polyamines are of three forms i.e. putrescine, spermidine and spermine. These polyamines are found to be anti-senescent agents and effective in delaying senescence in several plants. Polyamines and their response to the exogenous application in fruits and vegetables are well established (Gao et al., 2021), but research findings in flowers, especially on tuberose flowers and cultivars, are minuscule. While assessing the growing demand for fresh and loose flowers, the necessity for enhancing the post-harvest life of tuberose loose flowers becomes the priority. Against this backdrop, the present study was conducted using the polyamines for shelf-life extension of tuberose loose flowers.

MATERIALS AND METHODS

Plant material

Tuberose loose flowers of cultivar Prajwal were harvested early in the morning (4:00 am) from a farmer's field. Then the material was transported in CFB ventilated boxes wrapped with polyethylene sheets in an air-conditioned vehicle to the Department of Horticulture, Central University of Tamil Nadu, Thiruvarur. The flowers that are opened fully, diseased and damaged were sorted out and the tuberose flowers that were in unopened condition are used for further treatments.

Treatment details

The flowers were then treated with two different concentrations of spermidine (Spd) and putrescine (Put) by dipping them for 5 min. at 15 mg and 20 mg each (the concentrations were fixed on the preliminary trials) which were dissolved in double distilled water. The excess moisture was removed by spreading then on water-absorbing paper under the fan for 10 min. (rolling once in between). Then, flowers were packed in 4×6 inch and 56-micron size polyethylene zip covers provided with 1% ventilation. Two controls were used, one without a package and other with package. The treated flowers along with controls were stored at room temperature of 32 ± 1^{o}C and 65 ± 3% RH. During the period of study, the observations were taken at regular intervals.

Physiological loss in weight (%)

The initial fresh weight of the loose flowers was recorded before starting the experiment and the final weight was recorded every day till the termination of the shelf life and was expressed in per cent (AOAC, 2005). It was calculated by the following formula:

$$\text{PLW (\%)} = \frac{\text{Initial weight - Final weight}}{\text{Initial weight}} \times 100$$

Shelf life (days)

The time taken for the development of necrotic symptoms was recorded and the shelf life was determined as the number of days taken from placing of the loose flowers till wilting and fading of petals of these loose flowers (Lee & Suh, 1996). The PLW% was taken as reference with break point of 10% (economic weight loss).

Florets open (%)

Opened flower/petal buds were counted based on the grades (0%, 20%, 40%, 60%, 80% and 100%) as per Fig. 1.

Then the percentage of flowers falling under each category was calculated using the formula:

$$Opened\ flowers\ (\%) = \frac{Number\ of\ opened\ florets}{Total\ number\ of\ florets} \times 100$$

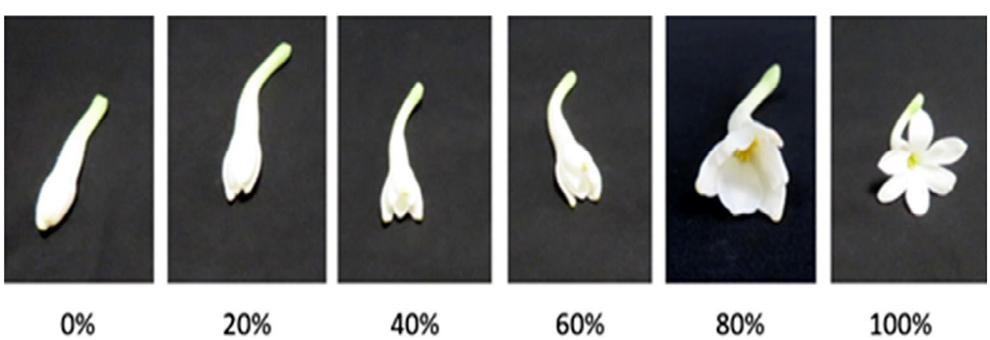


Fig. 1 : Flower (petal) opening (%) in tuberose

Fig. 2 : Percentage of spoilage in tuberose

Spoilage of flowers (%)

Spoilage flowers are counted on day 4, based on the grades fixed from 0-100% as per Fig. 2. Then the spoilage percentage under each category was calculated using the formula.

$$Spoilage\ \% = \frac{No.of\ spoilage\ florets\ on\ the\ day\ of\ observation}{Total\ number\ of\ florets} \times 100$$

Sensory evaluation

The sensory evaluation of the tuberose flowers was carried out by a panel of semi-trained 40 judges. The sensory characters like colour, fragrance, firmness, appearance and overall acceptability of flowers were evaluated on a 9-point Hedonic scale score card (Lim, 2011). The mean of scores given by the judges were used for statistical analysis.

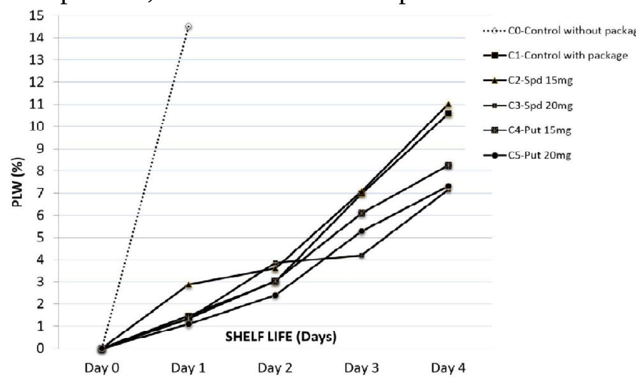
Statistical analysis

The experiment was conducted in a completely randomized design consisting of 6 treatments, stored at ambient conditions. The flowers were replicated into 4 under each treatment with 35 flowers (48.48 g) per replication and the observations were recorded at regular intervals. Statistical analysis of data was carried out using SPSS statistics 17.0 software package (SPSS Inc. US). Differences between means were evaluated using Duncan's multiple range test at $p \leq 0.05$. Analysis of variance (ANOVA) was used to determine the significance of differences among the treatments.

RESULTS AND DISCUSSION

Physiological loss in weight (PLW, %)

The fresh weight of flowers is one of the most important factors in determining their quality and shelf life. In this study, flowers treated with spermidine (Spd) (C3) 7.15%) and putrescine (Put) (C5) (7.32%) packed in a polyethylene zip cover had lower PLW per cent on the fourth day than flowers left untreated (C0) 54.87%). The C0 (14.51%) had lost economic weight on the first day and the flowers got completely shriveled by day 2 (Fig. 3). Also, in terms of economic weight loss, the C3 and C5 treatments had outperformed (reduced) than control with package (C1). Weight loss might coincide with the respiration rate which uses the food materials accumulated in the tissues but, the ideal environment inside the package minimized the weight loss of loose flowers and the results are supported by the outcomes from the study in Asiatic hybrid Lilly (Sharma et al., 2008). This might be related to the mechanism of polyamine compounds, which reduces evaporation loss from floral tissues, lowers respiration rate, prevents weight loss and maintains the quality of flowers (Kar et al., 2013).



Note: As the flowers of C0 have lost their economic weight on day 1 and completely shriveled on day 2, the date is not presented thereafter

Fig. 3 : Effect of polyamines on physiological loss in weight (PLW %) of tuberose loose flowers

Flower opening (%)

Flower opening might be considered as one of the main features in evaluating the shelf life of flowers. In this investigation, it was observed that 27.14% and 42.85% of the untreated flowers without package showed 60% and 40% flower opening, respectively on day one and completely shriveled on day 2. Whereas, on day four, C3 and C5 treatments showed 40-80% opening of flowers with more flowers showing 60% opening (Fig. 4). This might be due to the procrastination of cell expansion by putrescine through influencing the glucose metabolism of petals and flower opening. Similar studies are reported by Nowak & Rudnicki (1990) in rose. When compared with other treatments, C3 and C5 treatments delayed the flower opening from day one to day four. The delay in opening might be a positive effect of polyamines in delaying the senescence of flowers, which can be compared with the results where the application of polyamines showed improved flower quality, large mean floral diameter and extended shelf life in rose (Tatte et al., 2015) and *Dendrobium nobile* (Li et al., 2014).

Spoilage (%)

The spoilage in tuberose is determined by appearance of pinkish spots, later turning into brownish-black

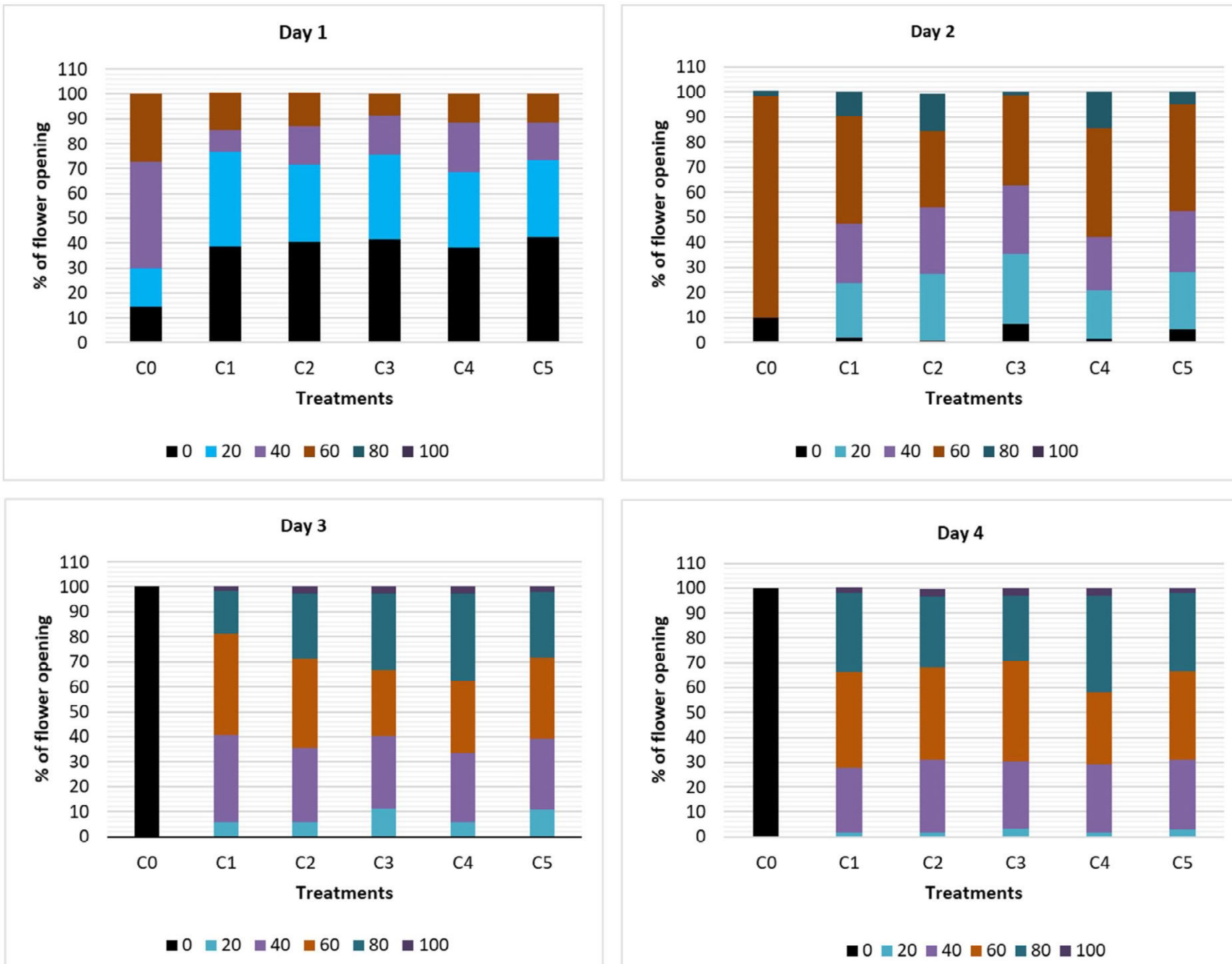


Fig. 4 : Effect of polyamines treatment on flower opening (%) of tuberose loose flowers

(C0-control without package; C1-control with package; C2- Spd 15 mg; C3-Spd 20 mg; C4-Put 15 mg; C5-Put 20 mg).

spots with water-soaked appearance on the flower. The flowers of C0 treatment completely shriveled on day 2 without showing any such symptoms. Except for C0, all the treatments packed in polyethylene zip pouches showed spoilage. It was observed that even though 1% ventilation is provided, the water droplets accumulated on the inner surface of the package aggravated the spoilage of flowers in all the treatments. But, at the end of shelf-life (day 4), the results revealed that the C3 treatment had a lesser number of flowers under spoilage followed by C5 when compared to other treatments (Fig. 5). The polyamine treatment along with the packaging had a more sympathetic effect on the flowers than the packaging alone (C1). The application of polyamines had a positive effect in constraining the ill impact of senescence, thereby improving the shelf-life and quality of flowers (Tatte et al., 2015). S-adenosyl methionine (SAM) is the common precursor for both polyamines and ethylene, during the biosynthesis of polyamines competition for common precursor SAM occurs, and biosynthesis of ethylene is inhibited and led to delay in senescence might have occurred (Vuosku et al., 2018). Also, the high polyamines especially spermidine in the tissue due to exogenous application have been reported to increase antioxidation enzyme activity, less membrane lipid peroxidation and enhanced ROS scavenging ability (Jia et al., 2008; Wu et al., 2018) which support the present findings.

Sensory evaluation

Qualities like colour, fragrance, firmness, and appearance will influence the overall acceptability of horticultural produce by consumers (Nunes et al., 2007). On the 4th day of evaluation on sensory

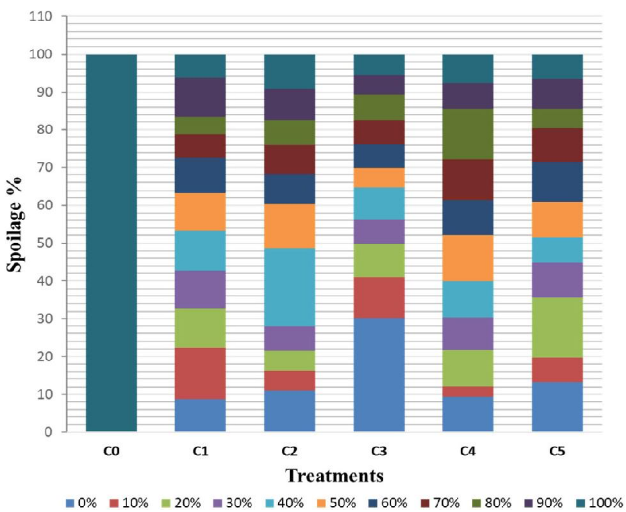


Fig. 5 : Effect of polyamines treatment on spoilage of tuberose loose flowers on day 4

(C0-control without package; C1-control with package; C2-Spd 15 mg; C3-Spd 20 mg; C4-Put 15 mg; C5-Put 20 mg).

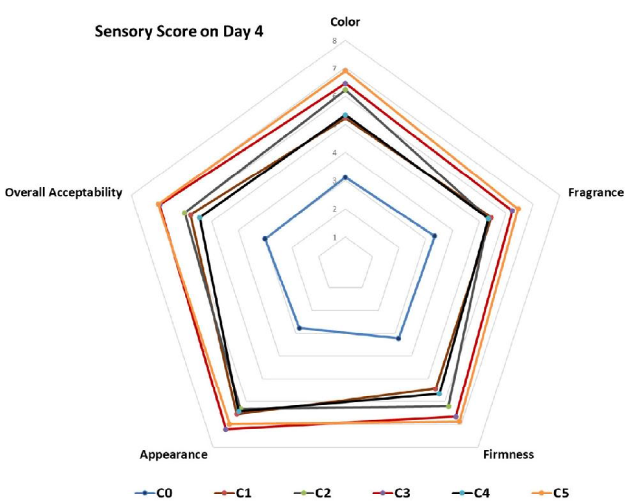


Fig. 6 : Polyamines influence on consumer acceptance (sensory evaluation) of tuberose loose flowers

(C0-control without package; C1-control with package; C2-Spd 15 mg; C3-Spd 20 mg; C4-Put 15 mg; C5-Put 20 mg)

attributes, the results reveal that C5 (6.88) had the highest score for colour followed by C3 (6.33) when compared with other treatments. C5 and C3 had higher scores for sensory attributes like fragrance, firmness, and appearance than other treatments. Moreover, the control (C0) registered the lowest values in all the sensory parameters evaluated. To summarize the sensory attributes, the overall acceptability was higher for the C5 (6.98) and C3 (6.92) treatments even when compared with the control with package (C1) and other treatments (Fig. 6). The results are in agreement with Karimi et al. (2017) where flowers treated with putrescine retained the fresh gain weight and reduced anthocyanin degradation.

Shelf life (days)

The shelf life of tuberose loose flowers was determined by taking PLW%, where the critical economic loss of weight of 10% and above is considered as the end of shelf life. From the observations, the shelf life of tuberose flowers treated with C3 and C5 (Put-20 mg and Spd-20mg, respectively) was for 4 days. Even though, the flowers treated with C4 showed a life up to 4 days, the overall acceptance by sensory panelists was less as well as showed higher spoilage than C3 and C5. The shelf life for C0 is just on the harvested day. The flowers treated with C1 and C2 had a shelf life of 3 days (Fig. & 7). This might be due to polyamines inhibiting ethylene synthesis, i.e. ethylene and polyamines compete for the same precursor, S–adenosyl methionine (SAM), for their synthesis, and one pathway is enhanced while the other is repressed (Bouchereau et al., 1999). Thus, the effect of polyamines as an inhibitor of ethylene, thereby increasing the shelf life of tuberose is consistent with prior research where the ethylene inhibitors extended the vase life of carnation flowers (Karimi et al., 2013). In addition, the high polyamines in the tissue due to exogenous application have been reported to increase antioxidation enzyme activity, less membrane lipid peroxidation, and enhanced ROS scavenging ability (Jia et al., 2008; Wu et al., 2018) thereby, higher shelf-life of tuberose flowers.

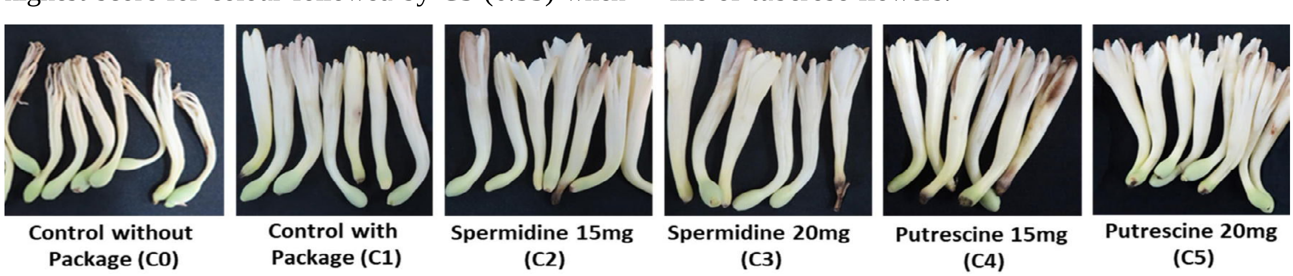


Fig. 7 : Effect of polyamines on shelf life of tuberose flowers on day 4 of treatment.

CONCLUSION

Polyamines are naturally occurring plant metabolites and are produced from plant-based amino acids. As these are being an easily utilized compound by plants because of their size, efficiency, synthesis and environmentally friendly behaviour, therefore, used for the application of horticultural products for various purposes. Putrescine (20 mg) and spermidine (20 mg) treated florets recorded reduced physiological loss in weight and spoilage percentage with delayed flower opening, and higher sensory acceptance when compared with control with/without the package and also extcend vase life (4 days). As these are effective even in low concentrations, farmers, producers, and industrialists can prefer polyamines.

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