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Effect of salicylic acid and nitric oxide on postharvest quality and senescence of cut gerbera flowers

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Abstract
Gerbera flowers have a short vase life after harvest characterized by stem bending and flower withering. In the present study, the efficacy of salicylic acid (1 mM and 2 mM) and sodium nitroprusside (0.5 mM and 1 mM) along with sucrose (2%) was tested to delay its senescence and extend its display life during storage at ambient condition. The control flowers were kept in distilled water with only 2% sucrose. Results showed that addition of 2 mM salicylic acid in vase solution was found highly effective in minimizing fresh weight loss, stem bending, flower withering and loss of anthocyanin pigments. This treatment showed extended vase life of the flowers by reducing membrane lipid peroxidation and higher uptake of treatment solutions. However, flowers treated with sodium nitroprusside (a nitric oxide donor) were not found effective in preserving postharvest quality and extending vase life of flowers. Findings of the study revealed that dipping of cut gerbera flowers in vase solution containing 2 mM salicylic acid is beneficial in extending its vase life.

Keywords: Gerbera, salicylic acid, nitric oxide, postharvest life, quality

Introduction
Gerbera (*Gerbera jamesonii*) is one of the highly prized cut flowers in the world demanded for their variable shapes and colours. These cut flowers have a limited vase life characterized by bending of stem which precedes wilting of ray florets. Stem bending primarily occurs due to gravitational pull of the floral head. However, other factors are also responsible as variations in bending have been reported among cultivars with same flower size and stem diameter (Perik *et al*., 2012) [13]. The major reason for short vase life in gerbera is microbial contamination at the stem base that block the water uptake into the xylem conduits due to production and accumulation of extracellular polysaccharides and debris from dead organisms, respectively (vanDoorn, 1997, 2012; Steinitz, 1983) [17, 21, 22]. As, rate of transpiration does not decrease, the cut stems starts to lose water and bending occurs owing to low cell turgor (van Meeteren, 1979) [23]. Therefore, prolonging vase life of gerbera is important to preserve its essence and marketing of this popular cut flower for a longer period.
During recent years, application of safe chemicals has become widely popular to delay senescence of harvested cut flowers. Postharvest application of salicylic acid (SA) and nitric oxide (NO) has been shown to be effective in extending vase life of a range of cut flowers. SA is a phenolic compound, present ubiquitously in the plant kingdom. It is a signalling molecule plays pivotal role in a variety of physiological plant processes (Raskin, 1992) [15]. SA has been reported to be effective in extending vase life of cut rose (Zamani *et al*., 2011) [25], gladiolus (Ezhilmathi *et al*., 2007) [3] and carnation (Kazemi *et al*., 2011) [8] due to its antisenescence properties. Likewise, NO is a ubiquitous signalling molecule, involved in broad spectrum patho-physiological and developmental processes in plants (Lamattina *et al*., 2003) [9]. Recently, exogenous application of NO from nitric oxide donor compounds like sodium nitroprusside (SNP), DETA/NO (2,2-(Hydroxynitrosohydrazino)-bisethanamine) have been found effective in delaying senescence of flowers like carnation (Mostofi *et al*., 2010; Vajari and Nalousi, 2013) [11,20], lilium (Kaviani and Mortazavi, 2013) [7], gerbera, tulip, snapdragon, rose, chrysanthemum (Badiyan *et al*., 2004) [1] etc. due to its antisenescence properties. Therefore, looking into the importance of this cut gerbera flowers and its limited vase life, the present study was conducted to explore the possibility of postharvest SA and SNP treatment to extend its vase life during postharvest storage.

Materials and methods

Gerbera flowers of cv. Salvador grown under net-house condition were harvested at commercial maturity stage from the Horticulture Research Farm, Banaras Hindu University, Varanasi, Uttar Pradesh (India). Harvesting was performed by hand, by sideway pulling motion at the stem base. Immediately after harvest, flowers were brought to the Postharvest Laboratory of the Department of Horticulture, Banaras Hindu University, Varanasi. Following that flowers were selected for uniform quality and lower portion of the stems were re-cut in air, resulting in the stem length of 36.5 cm. Cut flowers after recording initial fresh weight were placed in conical flasks (500 ml) of 18 cm length with different treatment solutions of SA (1 mM, 2 mM) and SNP (0.5 mM, 1 mM) along with 2% sucrose. The flowers under control were held in distilled water with sucrose (2%). The conical flasks were then plugged with non-absorbent cotton to prevent evaporation losses of vase solution and kept at ambient condition.

Fresh weight loss, solution uptake, stem bending, flower withering, vase life

Fresh weight loss was determined by weighing the cut flowers at different sampling intervals. Then fresh weight loss was calculated as the difference between initial weight and the weight at the time of observation and expressed as percentage (%). The uptake of treatment solution was determined at a particular interval by measuring the volume of solution and expressed as ml. Flower stem was considered bent when the upper surface of the floral head moved downward beyond vertical. Stem bending was calculated as the number of flowers bent at the time of measurement and was expressed as per cent (%). Withering of flowers was determined by the number of flowers withered at the day of recording observation and was expressed as per cent (%). Vase life of flowers was determined as the number of days from harvest to wilting of flowers.

Anthocyanin content

Anthocyanin pigments in the flower petals were extracted with ethanolic HCl (85:15). The solution was then stored overnight, centrifuged at 10,000 rpm for 10 min and absorbance was recorded at 535 nm in a spectrophotometer. Finally, the results were expressed as mg/100 g FW (fresh weight) (Ranganna, 2008) [14].

Malondialdehyde (MDA) content

To determine MDA content, 2 g of flower petals were crushed with 5% trichloroacetic acid. The extracted sample was then centrifuged at 10,000 rpm for 10 min and 2 ml of supernatant was mixed with 0.6% thiobarbituric acid. Following that the mixture was heated and after cooling, absorbance was recorded at 600 nm, 532 nm and 450 nm in a spectrophotometer. The results were expressed as nmol/ g FW (Zheng and Tian, 2006) [26].

Statistical analysis

The present experiment was conducted with five treatments with three replications. Data recorded under each treatment or different parameters were subjected to analysis of variance, with treatment and days of storage as sources of variation. To determine significant difference among the treatments, Tukey's HSD test was carried out at the significance level $P \leq 0.05$. The SAS statistical system 9.2 (SAS Institute, Cary, NC, USA) was used to perform the analysis.

Results

Effect of SA and SNP on fresh weight loss

Fresh weight loss of cut gerbera flowers increased with the advancement of storage period (Fig. 1). Control flowers showed 11.76% weight loss just after 2 days of storage and rapid loss in fresh weight up to 6 days was noted both in control and flowers which were placed in 1 mM SNP solutions. At the end of the experiment, maximum fresh weight loss was recorded in 1 mM SNP-treated (43.92%) followed by control (40.52%) flowers. However, best result was obtained with flowers which were kept in 2 mM SA solution showing 24.41% weight loss.

Effect of SA and SNP on solution uptake

In this study, uptake of treatment solution by the flowers decreased with the storage period (Fig. 2). Maximum uptake of solution throughout the storage was recorded in 2 mM SA (18 ml) followed by 1 mM SA-treated flowers (14 ml). After 4th day, control flowers showed lowest solution uptake of 11 ml. However, at the final day of experiment, gerbera flowers which were kept in SNP solutions showed minimum uptake of treatment solutions.

Effect of SA and SNP on stem bending

In this experiment, 50% flowers kept in SNP solutions (0.5 and 1 mM) bent just after 2 days of storage (Fig. 3). At 6th day of storage, 100% flowers under control and 1 mM SNP-treated showed stem bending. However up to 4 days of storage, no stem bending was noted in flowers kept in 2 mM SA solution. At 6th day, minimum stem bending (16.66% flowers) was observed in 2 mM SA treatment which was followed by 1 mM SA treatment (33.33%).

Effect of SA and SNP on flower withering

Withering of flowers was not noted up to 2 days in any of the treatment. At 4th day, flowers under all the treatments showed withering of florets except those under 2 mM SA treatment (Fig. 4). All the flowers (100%) in 1 mM SNP treatment showed withering of florets at 4th day while 83.33% flowers under control showed withering at 6th day. Lowest withering (16.66%) at the final day of experiment was recorded in flowers those placed in 2 mM SA solution followed by 1 mM SA solution (33.33%).

Effect of SA and SNP on anthocyanin content

The anthocyanin content in the flower petals showed decreasing with the advancement of storage period in all the treated flowers. However, the breakdown of pigments was found delayed in flowers treated with 2 mM SA (Fig. 5). After 6 days of storage, maximum retention of anthocyanin pigments was noted in 2 mM SA treated flowers (1.72 mg/ 100 g) while, it was minimum (1.32 mg/ 100 g) in flowers received 1 mM SNP treatment. However, no significant differences were noted among control, SA (1 mM) and SNP (0.5 mM) treated flowers.

Effect of SA and SNP on malondialdehyde content

Malondialdehyde (MDA) content in the treated gerbera flowers showed increased with the storage period. Among the treatments, SNP treated and control flowers were noted faster increase in MDA content than SA-treated flowers (Fig. 6). Gerbera treated with SA were maintained significantly lower MDA content throughout the storage period. At 6th day after storage, 1 mM SNP-treated flowers contained highest MDA (16.94 nmol/g FW) which was followed by control (16.48

nmol/g FW). The minimum content of MDA (10.46 nmol/g FW) was recorded in 2 mM SA-treated flowers which indicated its delayed senescence than other treatments.

Effect of SA and SNP on vase life

Postharvest treatment of gerbera flowers in SA was found to increase the vase life of flowers than control and SNP-treated flowers. The maximum vase life of up to 6.33 days was obtained with 2 mM SA followed by those treated with 1 mM SA (Fig. 7). However, control flowers showed vase life of only 3.66 days which was at par with 0.5 and 1 mM SNP treated flowers.

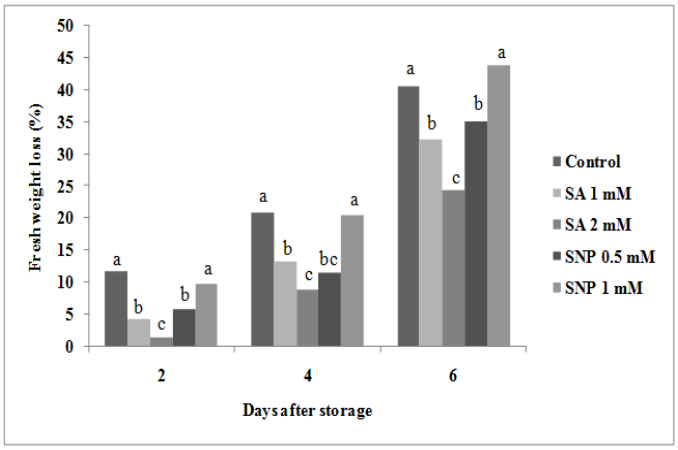

Fig 1: Effect of salicylic acid and sodium nitroprusside on fresh weight loss of cut gerbera flowers

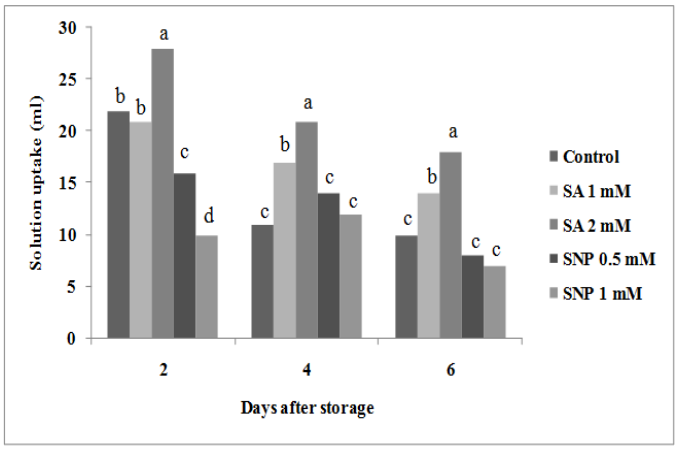

Fig 2: Effect of salicylic acid and sodium nitroprusside on solution uptake by cut gerbera flowers

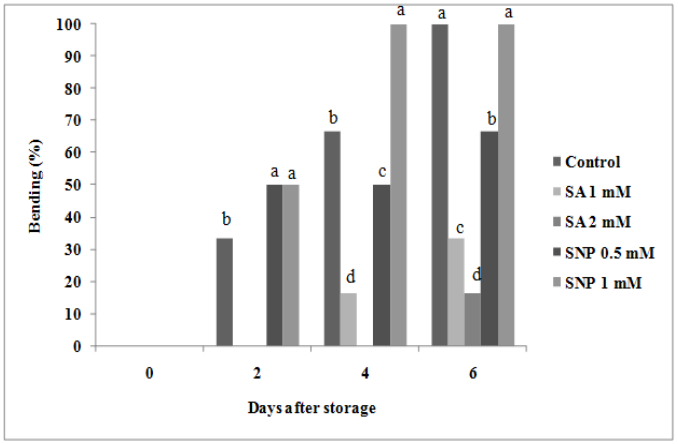

Fig 3: Effect of salicylic acid and sodium nitroprusside on stem bending of cut gerbera flowers

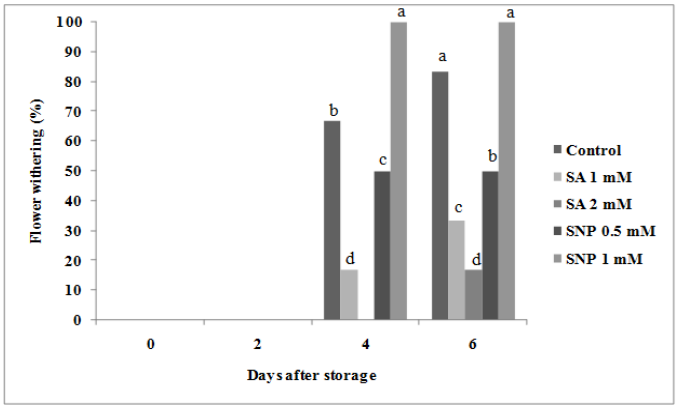

Fig 4: Effect of salicylic acid and sodium nitroprusside on flower withering of cut gerbera flowers

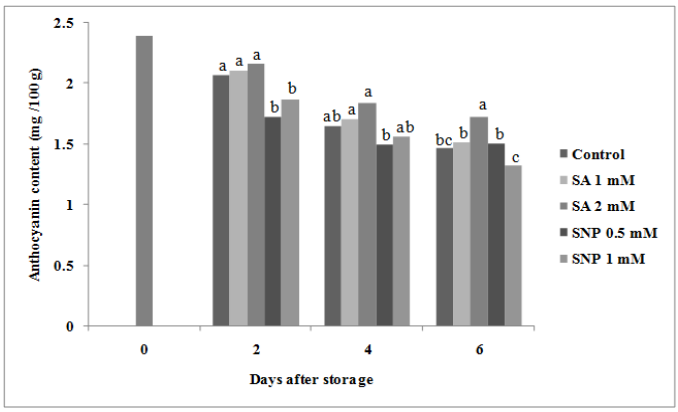

Fig 5: Effect of salicylic acid and sodium nitroprusside on anthocyanin content in cut gerbera flowers

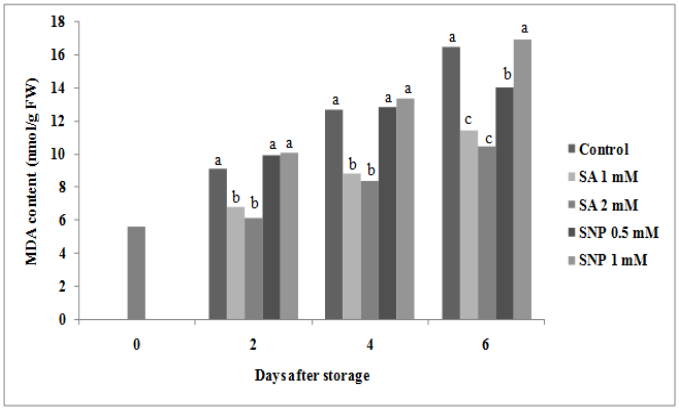

Fig 6: Effect of salicylic acid and sodium nitroprusside on malondialdehyde content of cut gerbera flowers

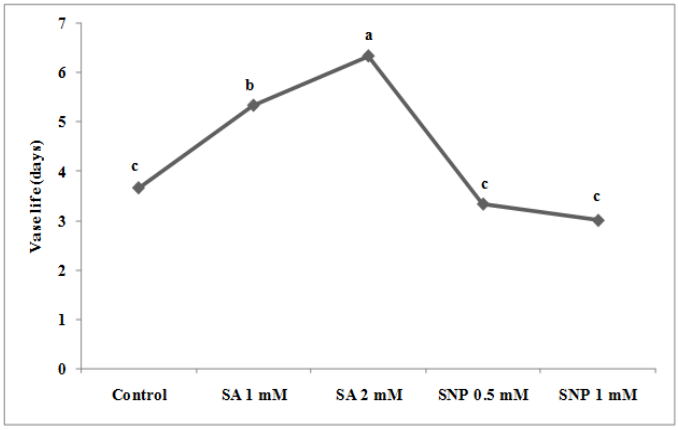

Fig 7: Effect of salicylic acid and sodium nitroprusside on vase life of cut gerbera flowers

Discussion

Gerbera flowers after harvest have a short vase life due to rapid senescence characterized by stem bending and petal wilting (Gerasopoulos and Chebli, 1998) [5]. Senescence occurs due to faster decline in water uptake owing to growth of bacteria leading to occlusion of xylem vessel and sharp decrease in fresh weight (van Meeteren, 1979; 1980) [23, 24]. In the present study, flowers which were kept in SA showed reduced loss in fresh weight than other treatments. The decrease in fresh weight of cut gerbera flowers was due to reduced water uptake and/or increase in loss of water and high respiration rate (Serek *et al*., 1995; Borochov *et al*., 1995) [2, 16]. The efficacy of SA in reducing weight loss might be attributed to suppression of transpiration and respiration rates by closing stomata as reported in gladiolus (Ezhilmathi *et al*., 2007; Hatamzadeh *et al*., 2012) [3, 6]. Moreover, SA-treated flowers showed maximum uptake of solutions than other treatments which replaced the loss of water took place during transpiration thereby showed minimum loss in fresh weight. Higher water uptake in SA-treated flowers may be due to its effectiveness in reducing microbial growth thereby preventing vascular occlusion. The germicidal action of SA by decreasing growth of bacteria that block the xylem vessel in the cut stem-end that interfere with the normal water flux through stem has also been reported earlier (Nowak and Rudniki, 1990) [12]. Owing to higher germicidal property, SA caused higher water uptake by the stem that leads to reduced stem bending and flower withering. In this study, SNP treatment was not found effective in reducing weight loss or delaying senescence of cut gerbera flowers which contradicts the previous finding of Mostofi *et al*. (2010) [11] and Vajari and Nalousi (2013) [20].

In the present experiment, flowers treated with SA showed reduced MDA content than those of SNP-treated and control. Senescence process is associated with increased membrane lipid peroxidation. Malondialdehyde (MDA) is a secondary end product produced during lipid peroxidation and therefore, serves an excellent indicator of cell membrane integrity (Kazemi *et al*., 2011) [8]. Addition of SA in treatment solution showed decreased MDA content than other treatments which might be attributed to delayed senescence of flowers by lowering cell membrane permeability, membrane lipid peroxidation thereby maintaining membrane integrity (Fan *et al*., 2008) [4]. The reduced lipid peroxidation in SA-treated gerbera flowers might be attributed to scavenging of reactive oxygen species (ROS) or by modulation of antioxidant enzymes activity (Mansouri, 2012) [10]. Kazemi *et al*. (2011) [8] also reported that postharvest SA treatment of gerbera flowers enhanced stability of membrane lipids. The loss of anthocyanin pigments in 2 mM SA-treated flowers was showed delayed than other treatments which might be attributed to delayed senescence in these flowers. With the onset of senescence leakage of anthocyanin pigments take place from the vacuoles which caused degradation of this pigment (Suttle and Kende, 1980) [19]. The delayed senescence of 2 mM SA-treated flowers which was confirmed by reduced MDA content was responsible for extending its vase life. However in this experiment, treatment with SNP was not found effective in delaying senescence of cut gerbera flowers. Although previous workers have reported antisenescence properties of NO but here the applied dose of SNP might be at higher side which exerted negative result. Earlier workers have also mentioned that NO may promote lipid peroxidation depending upon its concentration (Stöhr, 2007) [18].

Conclusion

In conclusion, postharvest dipping of cut gerbera flowers in 2 mM salicylic acid along with 2% sucrose solution effectively preserved its quality, delayed senescence and extended vase life of flowers during storage at ambient condition.

References

1. Badiyan D, Wills RBH, Bowyer MC. Use of nitric oxide donor compound to extend the vase life of cutflowers. Hort Sci. 2004; 39(6):1371-1372.
2. Borochov A, Spiegelstein H, Porat R, Field T. Membrane lipids involved in the regulation of flower senescence. Acta Hortic. 1995; 405:240-245.
3. Ezhilmathi K, Singh VP, Arora A, Sairam RK. Effect of 5-sulfosalicylic acid on antioxidant activity in relation to vase life of Gladiolus cut flowers. Plant Growth Regul. 2007; 51:99-108.
4. Fan MII, Wang JX, Shi G, Shi LN, Li RF. Salicylic acid and 6-BA effects in shelf-life improvement of *Gerbera jamesonii* cut flowers. Anhui Agricultural Science Bulletin. http://en.cnki.com.cn/Article_en/CJFDTOTAL-BFYY200808060.htm. 2008.
5. Gerasopoulos D, Chebli B. Effects of scape-injected 1-aminocyclopropane-1-carboxylic acid (ACC) on the vase life of 'Testarossa' cut gerberas. J. Am. Soc. Hortic. Sci. 1998; 123:921-924.
6. Hatamzadeh A, Hatami M, Ghasemnezhad M. Efficiency of salicylic acid delay petal senescence and extended quality of cut spikes of *Gladiolus grandiflora* cv. 'Wing's Sensation. African J Agric. Res. 2012; 7:540-545.
7. Kaviani M, Mortazavi SN. Effect of nitric oxide and thidiazuron on Lilium cut flowers during postharvest. Int. J. Agron. Plant Prod. 2013; 4(4):664-669.
8. Kazemi M, Hadavi E, Hekmati J. Role of salicylic acid in decreases membrane senescence in cut carnation flowers. Am. J Plant Physiol. 2011; 6(2):106-112.
9. Lamattina L, García-Mata C, Graziano M, Pagnussat G. Nitric oxide: the versatility of an extensive signal molecule. Annu. Rev. Plant Biol. 2003; 54:109-136.
10. Mansouri H. Salicylic acid and sodium nitroprusside improve postharvest life of chrysanthemums. Sci Hort. 2012; 145:29-33.
11. Mostofi Y, Rasouli P, Naderi R, Bagheri MG, Shafiei MR. Effect of nitric oxide and thidiazuron on vase life and some qualitative characteristics of cut carnation flowers (*Dianthus caryophyllus* cv. Nelson). Iranian J Hortic. Sci. 2010; 41(4):301-308.
12. Nowak J, Rudnicki RM. Postharvest Handling and Storage of Cut Flowers, Florist Greens, and Potted Plants. Chapman and Hall, London, 1990.
13. Perik RRJ, Razé D, Harkema H, Zhong Y, van Doorn WG. Bending in cut *Gerbera jamesonii* flowers relates to adverse water relations and lack of stem sclerenchyma development, not to expansion of the stem central cavity or stem elongation. Postharvest Biol. Technol. 2012; 74:11-18.
14. Ranganna S. Plant pigments. In: Handbook of analysis and quality control for fruit and vegetable products. Tata McGraw-Hill Publishing Company Limited, New Delhi, 2008, 98.
15. Raskin I. Salicylate, a new plant hormone. Plant Physiol. 1992; 99:799-803.
16. Serek M, Tamari G, Sisler EC, Borochov A. Inhibition of ethylene-induced senescence symptoms by 1-methyl

cyclopropene. A new inhibitor of ethylene action. Phyisol. Plant. 1995; 94:229-232.
17. Steinitz B. The influence of sucrose and silver ions on dry weight, fiber and lignin content, and stability of cut Gerbera flower stalks. Gartenbauwissenschaft. 1983; 48:821-837.
18. Stöhr C. Nitric oxide - a product of plant nitrogen metabolism. In: Lamattina L, Polacco JC. (Eds.), Nitric Oxide in Plant Growth, Development and Stress Physiology. Springer, New York, 2007, 15-34
19. Suttle JC, Kende H. Ethylene action and loss of membrane integrity during petal senescence in Tradescantia. Plant Physiol. 1980; 65:1067-1072.
20. Vajari MA, Nalousi AM. Effect of nitric oxide on postharvest quality and vase life of cut carnation flower. J Ornam. Plants. 2013; 3(3):183-190.
21. Van Doorn WG. Water relations of cut flowers. Hortic. Rev. 1997; 18:1-85.
22. Van Doorn WG. Water relations of cut flowers: An update. Hortic. Rev. 2012; 40:55-106.
23. Van Meeteren U. Water relations and keeping quality of cut gerbera flowers. IV. Internal water relations of aging petal tissue. Sci. Hort. 1979; 11:83-93.
24. Van Meeteren U. Role of pressure potential, in keeping quality of cut gerbera inflorescence. Acta Hort. 1980; 113:143-150.
25. Zamani S, Kazemi M, Aran M. Postharvest life of cut rose flowers as affected by salicylic acid and glutamin. World Appl. Sci. J. 2011; 12(9):1621-1624.
26. Zheng X, Tian S. Effect of oxalic acid on control of postharvest browning of litchi fruit. Food Chem. 2006; 96:519-523.