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Manipulation of petal senescence in *Jasminum nitidum* flowers with packaging and pre-treatment during storage: Role of phenolics

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Abstract
Flower petals are an excellent model system for the study of fundamental aspects of senescence. The present study aimed to study the changes taking place during petal senescence in flowers of *Jasminum nitidum* during storage. The experiment was laid out in CRD with four treatments and four replications. Polyethylene bags of 200 micron thickness with 15 cm x 9 cm dimension without ventilation were used for packaging the flowers. The total phenols in the flowers was estimated from initial stage to the senescent stage. The amount of total phenols had a decreasing trend with progressing stages. This reduction of phenols might have created an internal environment suitable for the senescent changes in the flowers. It was found that treating the flowers with 4% boric acid + cold storage (5 °C) was associated with higher levels of total phenols (14.06, 11.96, 9.55 and 7.65 mg/g respectively during the first four days after treatment). The lowest levels of total phenols (12.27, 10.14, 8.20 and 6.20) were observed in control, wherein the flowers were stored at room temperature

Keywords: polyethylene, boric acid, total phenols, senescence, *Jasminum nitidum*

Introduction
Jasmine belongs to the olive family Oleaceae and the genus *Jasminum* contains around 200 species [5]. It is native to tropical and warm temperate regions of Europe, Asia and Africa. The centres of diversity of jasmine are South Asia and Southeast Asia. India is one of the centres of origin of jasmine. A critical analysis of these species, however, has revealed the number of true species to be only 89, of which 40 inhabit the Indian sub-continent [24].

Among the large number of species existing, only three species (*J. sambac, J. grandiflorum, J. auriculatum*) have attained importance in commercial cultivation [8]. However, these three species do not produce flowers during the off-season from December to March. Preliminary research taken up at TNAU has indicated that besides the above species, few more species namely, *J. calophyllum, J. nitidum, J. rigidum, J. flexile* and *J. multiflorum* (Syn: *J. pubesecens*) possess economic importance since they produce flowers which are suitable for use as loose flower and the plants of these species are suitable for use as fragrant flowering garden plants. The above species have the added merit of flowering throughout the year [6], unlike the three popular commercial species namely, *J. sambac, J. grandiflorum, J. auriculatum,* besides being relatively free from major pests and diseases.

Senescence of whole flower is very complex, and so often researchers concentrate mainly on changes occurring during the senescence of petals [4]. Petal senescence is an irreversible process that leads to cellular breakdown and death [16]. Increased recognition of the importance of phenolic compounds in plant metabolic activities is well known [17] phenols are the antioxidants that have the ability to protect plant tissue against oxidative damage. Most of the metabolic abnormalities in living organisms are caused through the production of deleterious active oxygen species (AOS) such as singlet oxygen, superoxide radical, hydrogen peroxide, hydroxyl ion and free hydroxyl radical (1O2, •O-2, H2O2, OH- and •OH) which are invariably produced during normal metabolism and exposure to stresses [19].

Postharvest handling techniques such as treatment with floral preservatives and packaging can considerably help in extending the shelf life of jasmine flowers. Packaging of flowers helps in preventing mechanical damage. The package serves as a barrier between the conditions inside and outside the package. It protects the flowers from unfavourable outside conditions and enables a micro-climate to develop inside the package [13]. Packaging helps to lower the rate of transpiration, respiration and cell division during transportation and storage. The present study focuses on the content of phenolic compounds in flower petals during senescence of *Jasminum nitidum* flowers subjected to postharvest treatments.

Materials and methods

The present experiment was conducted in the Department of Floriculture and Landscaping, Horticultural College and Research Institute, Tamil Nadu Agricultural University, Coimbatore. The study involved flowers of a clonal selection 'Acc.Jn-1' of *J. nitidum* (Syn: *J. laurifolium)* evolved by the Department of Floriculture and Landscaping of TNAU, Coimbatore. This clone has year-round flowering potential and is ideal for commercial cultivation for loose flower and for use in ornamental gardening. Leaves are dark green and glossy, making the plant attractive even when not in bloom. Unopened flower buds are pinkish in colour and resemble flower buds of *J. grandiflorum*.

Uniform sized, unopened fresh flower buds of *J. nitidum* were used for the study. The experiment was laid out in CRD with four treatments and four replications. Polyethylene bags of 200 micron thickness and 15 cm x 9 cm dimension without ventilation were used for packing of flowers. Details of treatments are as follows, T_1 - Storage at room temperature (Control), T_2 - Storage under refrigeration 5 ^{0}C, T_3 - Boric acid 4 % + Room temperature, T_4 - Boric acid 4% + Refrigeration 5 ^{0}C. The physiological, visual and sensory parameters were determined for the stored jasmine flowers daily up to fourth day after packaging.

The term 'phenol' includes a large group of organic aromatic compounds having one or more hydroxyl groups on the benzene ring. They are known to provide resistance against pests and diseases to the plants and are easily oxidized by phenol oxidase to quinines which are highly reactive and toxic to the pathogens. Phenol content of the flowers was estimated as per the procedure given by [11]. Total phenolic content (TPC) of samples were determined using the Folin–Ciocalteau Reagent (FCR) [2]. Five grams of *Jasminum nitidum* flowers was weighed accurately and the flowers were ground thoroughly in a mortar with pestle with 80 per cent alcohol. The grounded mixture was filtered with a muslin cloth. The process of extraction was repeated once more. The filtrates were pooled and filtered through Whatman No. 41 filter paper and made up to a known volume with alcohol. The prepared ethanol extract of the sample (30 ml) was added to 1.0 ml of freshly diluted Folin-Ciocalteau reagent.

Two grams of sodium carbonate dissolved in 100 ml 0.1 N NaOH solution was then added to the mixture and mixed thoroughly. The mixture was taken in a test tube and placed in a boiling water bath for exactly one minute; the test tube was then cooled and the content was made up to a suitable volume. The absorbance was measured at 650 nm against a blank of distilled water using a spectrophotometer (Make: Systronics; Model: PC based double beam spectrophotometer 2202,). Catechol was used as an equivalent standard. Standard curve of catechol was used to estimate the concentration of phenols.

Results and discussion

The data on total phenol content in flower petals of *J. nitidum* are presented in Table 1. There were significant differences in the phenols content among the treatments. It was observed that the treatment (T_4) wherein the flower buds were treated with Boric acid 4% followed by storage under refrigeration (5 ^{0}C) recorded the highest level of total phenol content throughout the experiment. The total phenol content recorded by this treatment were 14.06, 11.96, 9.55 and 7.65 mg/g respectively, on the first, second, third and fourth days after treatment. This was followed by treatment (T_2) which involved storage under refrigeration (5 ^{0}C) and it recorded 13.92, 11.96, 9.55 and 7.65 mg/g respectively, on the first, second, third and fourth days after treatment.

The highest total phenol contents were observed in (T_4) buds treated with Boric acid 4% + Storage under refrigeration 5 ^{0}C for second, third and fourth day after treatment (11.96, 9.55 and 7.65 mg/g) respectively. Higher content of total phenols has been shown to be associated with longer vase life in cut rose petals and *Hemerocallis* [22, 9].

Table 1: Effect of pre-treatment and packaging on total phenols (mg/g) in petals of *Jasminum nitidum* flowers

Treatments	Total phenolic content of flower (mg g^1)			
	1 day after packing	2 days after packing	3 days after packing	4 days after packing
T_1 - Storage at room temperature (Control)	12.27	10.14	8.20	6.20
T_2 - Storage under refrigeration (5 ^{0}C)	13.92	11.74	9.40	7.40
T_3 - Flower bud treatment with Boric acid 4% + Storage at room temperature	13.09	10.93	9.00	7.10
T_4 - Flower bud treatment with Boric acid 4% + Storage under refrigeration (5 ^{0}C)	14.06	11.96	9.55	7.65
Mean	13.3350	11.1933	9.0375	7.0858
S. Ed	0.3399	0.1619	0.1804	0.1996
CD(0.05)	0.7838	0.3734	0.4159	0.4602

Boric acid has been used as a mineral salt that could increase the osmotic concentration and pressure potential of the petal cells, thus improving their water balance and longevity in cut flowers [23]. In agreement with the present finding, the potential of boric acid in prolonging the post-harvest life of flowers has been reported earlier in *Lupinus* [1], jasmine [12], crossandra [3] and carnation [18]. These works have reported the positive role of boric acid in relation to its anti-oxidant effect, involvement in maintaining water relations of flowers and effect in delaying the early rise in ethylene production in flowers.

Low temperature storage is often the best method for maintaining the quality of all horticultural produce and products. In case of flowers there is also the possibility of their post-harvest behaviour being influenced by chemical treatments [7]. Low temperature during transit has been reported to reduce the entire metabolism in the tissues, slow down the respiration, transpiration and ethylene action [14]. [10] suggested that flowers might better withstand unknown detrimental conditions by treating them with appropriate chemical solutions. These chemical treatments with proper preservative solutions prolong the post-harvest life and improve the quality of flowers when used before, after or during the storage of flowers [15].

The lowest total phenol contents (12.27, 10.14, 8.20 and 6.20 mg/g respectively on the first, second, third and fourth days after treatment) were observed in control (T_1) which involved storage at room temperature. Decrease in the floral phenol content was earlier reported in miniature rose during flower senescence [21].

As observed from the data, the total phenol content of the jasmine flowers decreased with progress in time. This decline in phenolics concentration at later stages of flower development may limit the role of the peroxidase/phenolics/ascorbic acid system in antioxidant defense and make the flower more vulnerable to oxidative stress [20]. This reduction of phenols might have created an internal environment suitable for the senescent change which leads the flower towards senescence.

Conclusion

Results of the present investigation led to the inference that treatment of flower buds with Boric acid 4% followed by cold storage at 5 ^{0}C recorded the highest level of total phenol content in the flower petals, which in turn helps in delaying the onset of senescence.

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