Current Horticulture **12**(3): 61–64, September–December 2024
DOI: 10.48165/chr.2024.12.3.09
Received: 4 July 2023; Accepted 13 March 2024

Response of packaging material and storage condition on postharvest quality of tuberose *(Polianthes tuberosa)* loose flowers

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Abstract

The study was carried out at ICAR-Indian Agricultural Research Institute, New Delhi, to study the response of packaging materials, *viz.* woven bag, high density polyethylene (HDPE) 51 micron , low-density polyethylene (LDPF) 25 micron, muslin cloth bag and bamboo basket (control, without packaging) and two storage conditions, *i.e.* ambient condition (22) and cold storage (or low temperature) condition (and 85-95% relative humidity) on keeping quality attributes of loose flowers of single petalled tuberose (*Polianthes tuberosa* Linn.) cv. Arka Prajwal. Fully developed unopened florets were harvested in early morning (before sunrise). The packaging and storage condition significantly influenced all parameters. Among all treatments, loose flowers packed in HDPE 51 micron bag and stored under cold storage recorded maximum flower diameter (8.99 mm), flower opening index (77.85%), colour (whiteness) index (89.13%) and shelf-life (6.00 day) of loose flowers under cold storage condition. On the other hand, in control treatment the above said parameters recorded were 6.98 mm, 50.00%, 54.10% and 3.50 day, respectively. Under ambient condition, maximum flower diameter (8.08 mm), flower opening index (66.00%), colour index (91.85%) and shelf-life (4.00 day) of flowers were recorded with HDPE 51 micron packaging. In control treatment, these parameters were 6.73 mm, 50.00%, 63.77% and 1.50 days, respectively. Thus, it can be concluded that among packaging materials HDPE 51-micron thickness bag was found to be the best for packing of loose flowers of tuberose cv. Arka Prajwal under both ambient and cold storage conditions.

Key words: High-density polyethylene, Loose flowers, Packaging material, *Polianthes tuberosa*, Storage condition

Tuberose (*Polianthes tuberose* Linn.) belonging to the family Agavaceae, can be used as loose flower, cut flower, landscaping or bedding purposes and extraction of essential oils for perfume industry, etc. (Jain *et al,* 2015.). The major portion of tuberose flowers consumption is in form of loose flowers, followed by cut flowers and extraction of essential oils (Singh *et al.,* 2010). Postharvest technologies like packaging and storage of flowers are helpful to restrict the changes in metabolic activities. Packaging is a technique of protecting the flowers from physical damage, water loss and external conditions during transport and enhance the shelf-life of flowers (Majumdar *et al.,* 2014, Panwar *et al.*, 2020). However, very little information is available on the storability of loose flowers of tuberose. Keeping in view, present study was undertaken to find out suitable packaging material and storage condition for enhancing shelf-life and quality of loose flowers of single petalled tuberose cv. Arka Prajwal.

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Materials and Methods

The experiment was conducted at ICAR-Indian Agriculture Research Institute, New Delhi, during 2020-2021. The unopened mature florets of Single petalled tuberose cv. Arka Prajwal were harvested during early morning hours. Five packaging materials and two storage conditions namely, P_1-woven bag, P_2-High density polyethylene, (HDPE) 51 micron () thick bag, P_3-low density polyethylene (LDPE) 25 micron () thick bag, P_4-muslin cloth bag and P_5-bamboo basket (control) and two storage conditions -S_1-ambient condition (22) and S_2-cold storage condition (or low temperature) condition -(with 5±1° and 85-95% relative humidity) were used. Mature unopened florets weighing 2 kg for each treatment were taken. Periodical observations on flower diameter (mm), flower opening index (%), colour (whiteness) index and shelf-life (days) were recorded. The flower diameter (mm) was measured with ten flowers at widest part by using Digital Vernier Calipers and then averaged. For recording the flower opening index (%) on each day of observation, number of opened flowers (whether fresh or wilted) were recorded and expressed as percentage. The colour (whiteness index, WI) used as an indicator of intensity of white colour was calculated by using numerical values of L*, a* and b*. As per the commission on Illumination (CIE) L* a* b* system of colour representation, L value corresponds to a dark-bright scale and represents the relative hue (colour). The a* and b* values extend from -60 to 60; a negative is for green a* positive is for red and b* negative is for blue and a positive for yellow.

The Whiteness index was calculated by using following formula: Whiteness index (WI) = 100 - [(100-L*) + (a^{*2} + b^{*2}) 1/2. The shelf-life of flowers was determined as the number of days taken from placing the mature flower buds till wilting/fading of petals and time taken for development of necrotic symptoms was recorded. The statistical design of experiment was followed factorial completely randomized design (FCRD) in which packaging materials and storage conditions were two factors and all treatments were replicated four times. Recorded data were subjected to statistical analyses. Complication of mean, standard error (SE) and critical difference (CD) was used for all comparisons where significance - probability () were found using OPSAT version 6.1 software for analysis of variance (ANOVA).

Results and Discussion

There was a significant difference among the packaging material, duration and their interaction on diameter of floret. Among five packaging materials, flowers packed in HDPE 51 micron recorded the maximum floret diameter, (8.08 mm) which was statistically higher with other treatments of packaging materials, whereas minimum floret diameter (6.73 mm) was recorded in control treatment (bamboo basket) (Table 1). The maximum floret diameter (8.00 mm) was recorded on fourth day which was statistically higher with other days, while minimum floret diameter (6.19 mm) was recorded on zero day, i.e. on initial day. The interaction effect of packaging material and duration indicates that the maximum floret diameter (8.83 mm) was recorded in loose flowers packed in HDPE 51 micron on fourth day, while the minimum floret diameter (5.30 mm) was recorded in control treatment on zero day.

Under cold storage condition, there was a significant difference among packaging material, duration and their interaction. (Table 1). The loose flowers packed in HDPF 51 micron recorded the maximum floret diameter (8.99 mm) which was higher with other packaging materials, whereas minimum floret diameter (6.98 mm) was observed under control treatment. The maximum mean of floret diameter (9.07 mm) was recorded on sixth day, which was higher with other days and at par with fifth day, while minimum floret diameter (6.13 mm) was observed on zero day. The interaction effect of packaging material and duration indicates that the maximum floret diameter (10.82 mm) was recorded in flowers packed in HDPE 51 micron on sixth day, which was statistically at par with P_2 treatment on fifth day, while minimum floret diameter (5.39 mm) was recorded on zero day, which was statistically at par with P_4 treatment (muslin cloth bag).

Loose flowers packed in HDPE 51 micron recorded maximum floret diameter and minimum floret diameter under control treatment (bamboo basket). This might be due to modified atmosphere conditions of high carbon dioxide, high relative humidity and low oxygen concentration within a package result in low respiration (Farber *et al.,* 2003) and helps in minimizing loss of carbohydrates as well as water by a process of respiration and transpiration, respectively (Zeltzer *et al.,* 2001) from the petal cells and increase floret opening results in increased floret diameter. Reduced floret diameter in control treatment was due to the inhibition of corolla growth and flower opening as a result of low water potential and low carbohydrates states in the petal cells (Viresh *et al.,* 2023). Our findings are in close agreement with the results obtained by Khongwir *et al.* (2017) in Single petalled tuberose cultivars.

There was a significant difference among the packaging material, duration and non-significant difference on their interaction on floret opening (Table 2). Among packaging material, loose flowers packed in HDPE 51 micron recorded the maximum mean of floret opening (66.00%) which was higher with other packaging materials, whereas the minimum flower opening (38.00%) was recorded under control treatment flowers. The maximum mean of flower opening (72.00%) was recorded on third and fourth day, which was higher with other days, while the minimum mean of flower opening (20.00%) was recorded on zero day i.e. on first day.

Under cold storage condition, there was a significant difference among packaging material, duration and non-significant difference on their interaction. Flowers packed in HDPE 51 micron observed the maximum mean of floret opening (77.85%) which was statistically higher with other packaging materials, whereas the minimum floret opening

(50.00%) was recorded in control treatment. The maximum flower opening (78.00%) was recorded on fifth and sixth day, which was statistically higher with other days, while the minimum mean of flower opening (23.00%) was recorded on zero day. In our study, loose flowers packed in HDPE recorded the maximum flower opening index. Flower opening associated with change in petal orientation. Osmotic changes in special cells, at petal base results in opening and closing movements in flowers. Metabolic activity in flowers are regulated by modified atmosphere condition created within the package (Goszezynska and Rudnicki, 1988) and maintenance of relative humidity may influence flower opening. Gladiolus spikes dry stored in polyethylene sleeves indicated considerable decline in post storage vase life and opening of florets, with an increase in storage duration (Jhanji and Dhatt 2017). Similar trend was observed in our study also where flower opening declined towards the end of storage duration. This might be due to a decline in stored food and water status in the petal cells with the advancement of storage duration (Khongwir *et al.,* 2017).

Under ambient conditions, a significant difference among packaging material, duration and their interaction was observed on colour index of loose flowers of tuberose. Among five packaging materials, flowers packed in HDPE 51 micron recorded the maximum white colour (91.85) which was statistically better with other packaging materials; whereas minimum white colour (79.19) was recorded in control treatment flowers. The maximum mean of white colour (99.19) was recorded on zero day, which was statistically superior with other days, while minimum mean of white colour (72.79) was recorded on fourth day. Interaction effect of packaging material and duration shows that the maximum white colour (99.82) was recorded in flowers packed in HDPE 51 micron on zero day, while minimum white colour (63.77) was recorded in control treatment flowers on sixth day.

There was a significant difference among packaging material, duration and their interaction. Flowers packed in HDPE 51 micron recorded the maximum white colour (89.13) which was statistically higher with other packaging materials, whereas the minimum white colour (77.79) was recorded in control treatment. The maximum mean of white colour (99.32) was recorded on zero day which was statistically superior with remaining days, while the minimum mean of white colour (65.70) was recorded on sixth day. Interaction response of packaging material and duration indicates that the maximum white colour (99.95) was recorded in flowers packed in HDPE 51 micron on zero day, while the minimum white colour (54.10) was recorded in control treatment on sixth day.

The flowers packed in HDPE 51 micron recorded maximum white colour retention on zero day under ambient (99.19) and cold storage (99.95) condition and the minimum white colour under ambient (63.77) and cold storage (54.10) conditions on sixth day. It might be due to cellular senescence process of loose flowers which proceeded even during cold storage and such senescence activities were carried out at the expense of stored food in flowers. Although, at low temperature it was possible to store the flowers for longer period, the white colour was reduced as compared to shorter period (Happy *et al.,* 2022). Higher relative humidity and lower temperature might have favoured more white colour in tuberose (Bhuvanesari and Sangama, 2017). Our results are also in close conformity with those of Sharma *et al.* (2021) and Choudhary *et al.* (2019).

There was a significant difference among different packaging materials on shelf-life of tuberose loose flowers. Among five packaging materials tested, flowers packed in HDPE 51 micron recorded maximum shelf-life (4.00 day) which was statistically higher with other packaging materials and at par with P_3 treatment (LDPE 25 micron) whereas the minimum shelf-life (1.5 day) was observed in control treatment (bamboo basket). Under cold storage condition, there was significant difference among packaging materials on shelf-life of flowers. Flowers packed in HDPE 51 micron recorded maximum shelf-life (6.00 day) which was statistically higher with other packaging materials and the minimum shelf-life (3.50 day) was recorded in control treatment (bamboo basket). The maximum shelf-life of flowers packed in polyethylene may be due to the reason that polyethylene sheet provide modified atmosphere, which increases carbon dioxide concentration as well as relative humidity and slows down the respiration process (Viresh *et al,* 2023). Furthermore, it might have more amount of carbohydrates and energy because of permeability of polyethylene sheet which may lead to increase in shelf-life of loose flowers. Our results are in close conformity with the results of Singh *et al.* (2023), (Varu and Barad, 2008); Majumdar *et al.* (2014) in tuberose and Sharma *et al.* (2021) Naveen *et al.,* (2024) in marigold flowers.

Conclusion

The high density polyethylene (HDPE) 51 micron bag was found to be the best packaging material. The maximum flower diameter, flower opening index, colour (whiteness) index and vase-life were recorded in loose flowers of tuberose cv. Arka Prajwal packed in 51 micron bag under both ambient and cold storage conditions. Tuberose flowers stored under low temperature condition recorded significantly higher flower diameter, flower opening index, colour (whiteness) index and shelf-life as compared to ambient conditions.

Acknowledgment

The second author acknowledges the receipt of Junior Research Fellowship from Post Graduate School of ICAR-Indian Agricultural Research Institute, New Delhi during her M.Sc. Programme.

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