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Effect of poly film packaging on storage life and quality attributes of French and African marigold loose flowers

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ABSTRACT

Marigold (*Tagetes* spp.) is an important loose flower crop in India, but its highly perishable nature leads to substantial post-harvest losses during handling and marketing. The present study evaluated the effectiveness of five packaging materials *viz.,* HDPE, LDPE, shrink-wrap, butter paper, and muslin cloth (control) for extending the storage life of African marigold var. Pusa Narangi Gainda and French marigold var. Pusa Arpita under ambient (27±2°C) and low-temperature (6±2°C) storage conditions. Ten uniform flowers were packed per treatment, and observations were recorded for morphological, physiological, and biochemical parameters. Shrink-wrap packaging under low temperature resulted in the maximum storage life, minimum physiological loss in weight, lowest ion leakage, and reduced enzymatic activity, indicating better maintenance of membrane integrity and delayed senescence. Overall, shrink-wrap proved most effective, particularly for Pusa Narangi Gainda, suggesting its strong potential for commercial adoption to enhance marigold storability and reduce post-harvest losses.

Key words: Floral quality, loose flower, shrink wrap packaging, poly films, storage life.

INTRODUCTION

Floriculture is an important segment of horticulture with considerable potential for generating income and employment, especially among small and marginal farmers. In recent decades, it has developed into a commercially significant enterprise globally as well as in India. Just like numerous other sectors, floriculture has swiftly advanced in terms of technology and farming methods. Marigold (*Tagetes* spp.) is a multipurpose plant having ornamental, ritual, medicinal, anthelmintic, insecticidal, colorant, food and forage applications. Healing properties of *Tagetes* species have been implemented by folk medicine for centuries (Montellano, 19). Among the 33 genera of *Tagetes*, four species mainly, *T. erecta*, *T. patula*. *T. tenuifolia* and *T. lunulata* are the most commonly grown for their ornamental values. In Indian sub-continent, *T. patula, T. erecta, and T. signata* are more popular (Singh *et al.,* 19). African marigold (*T. erecta*) is characterized by larger plants and bigger, semi-double to fully double flowers. French marigold (*T. patula*) is dwarf, compact, and exhibits a wider colour range. It is used for preparing ethno botanical remedies against rheumatism, stomach and intestinal problems, kidney and hepatic disorders, fever, and pneumonia. The flowers of marigold are sold in the market as loose flowers in bulk, as specialty flower or making garlands (Polara *et al.,* 14). The infusion of *T. patula* flowers is also used as eyewash. The efficacy of orally administered methanolic extracts of *T. patula* florets against acute and chronic inflammation.

Due to perishable nature of flowers, there are huge post-harvest losses ranging from 30- 50 percent (Kumar *et al.,*19). Flowers have limited shelf life due to the depletion of organic reserve compounds by respiration (Finger *et al.,* 16), bacteria and fungi infection (Muñoz *et al.,* 19), withering, mechanical damage (Fernandes *et al.,* 20), storage temperature (Menegaes *et al.,* 19) and increase in ethylene sensitivity (Khunmuang *et al.,* 19). Respiration is inversely related to potential postharvest storage (Tinebra *et al.,* 21). Mechanical damage caused by improper handling during harvesting, sorting, storage, and transport induces an increase in the respiration rate and reduces the useful life of flowers (Gómez-Merino *et al.,* 20). Postharvest life of flowers depends upon efficient packaging and storage (Senapati *et al.,* 16). A considerable amount of research has focused on the packaging and storage of cut flowers; however, studies on loose flowers, particularly across different varieties, remain limited. Therefore, the present investigation was undertaken

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to identify the most suitable packaging material for extending the storage life and maintaining the quality of marigold loose flowers in two selected varieties.

MATERIALS AND METHODS

The experiment was carried out at the Division of Floriculture and Landscaping, while biochemical analyses were carried out in the Division of Plant Physiology and Division of Food Science and Postharvest Technology, ICAR–IARI, New Delhi. The flowers of African marigold var. Pusa Narangi Gainda (PNG) and French marigold var. Pusa Arpita (PA) were cultivated at the Research Farm of the Centre For Protected Cultivation Technology during 2021–2022. Fully developed, uniform, and compact flowers of both varieties were harvested early in the morning and transported to the laboratory for experimental purpose. Ten uniform flowers were packed in different packaging materials, namely P1 – HDPE bags, P2 – LDPE bags, P3 – Shrink wrap, P4 – Butter paper bags, and P5 – Muslin cloth bags (control), and stored under two temperature regimes: ambient conditions (27±2°C) and low temperature (6±2°C). Observations on morphological, physiological, and biochemical parameters were recorded daily under ambient conditions, and at 4-day intervals (4th, 8th, 12th, and 16th day) and at senescence under cold storage conditions.

The storage life (days) was defined as the period from harvest until wilting of the outer three whorls of ray florets. The loss in weight of the loose flowers during the course of the experiment was calculated as

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

Counting the number of flowers spoiled day by day and expressing it as a percentage of the initial number of flowers used it. To monitor the rate of flower spoilage and to assess the quality and longevity of the flowers

$$\text{Spoilage percentage} = \frac{\text{Number of spoiled flowers}}{\text{Total number of flowers}} \times 100$$

Leakage of ions from the flowers was estimated according to method described and expressed as electrolyte leakage percentage using the formula [1-(C1 / C2)] ×100.

SOD catalyzes the dismutation of superoxide radical (O_2^-) to hydrogen peroxide (H_2O_2). The assay was based on the formation of blue-colored formazone by nitro-blue tetrazolium and O_2^- radical, which absorbs at 560 nm and SOD decreases its absorbance due to reduction in the formation of O_2^- radical by the enzyme.

Lipid peroxidation is oxidative degradation of lipid-fatty acids by reactive oxygen species. The level of lipid peroxidation is measured in terms of thiobarbituric acid reactive substances (TBARS) content.

The experiment was laid out in a factorial Completely Randomized Design (CRD) comprising 20 treatment combinations (5 packaging materials × 2 varieties × 2 storage temperatures) with three replications. The recorded data was analyzed statistically (ANOVA analysis) using the software GRAPES.

RESULTS AND DISCUSSION

Data presented in Table 1 indicated that the storage life of marigold loose flower was significantly affected by packaging material, storage conditions and varieties of marigold. Comparison of storage conditions reveals that low temperature conditions showed better storage life than ambient. Evaluation of packaging materials reveals that the maximum average life (14.92 d) was observed in shrink wrap (P_3) while minimum (9.66 d) was observed under muslin cloth bags (P_5) under low temperature. Among varieties; Pusa Narangi Gainda (V_2) exhibited maximum (13.53 and 4.80d) storage life, while

Table 1: Effect of packaging material on storage life (days) of marigold loose flower varieties under ambient and low temperature storage.

Packaging material	Storage conditions					
	Ambient temperature (27±2°C)			Low temperature (6±2°C)		
	Pusa Arpita (V_1)	Pusa Narangi Gainda (V_2)	Mean	Pusa Arpita (V_1)	Pusa Narangi Gainda (V_2)	Mean
P_1-HDPE bags	3.83^{im}	4.83^{i}	4.33^{f}	10.83^{ef}	15.33^{b}	13.08^{b}
P_2-LDPE bags	3.66^{m}	4.83^{i}	4.25^{f}	11.16^{e}	12.66^{c}	11.91^{c}
P_3-Shrink wrap	4.17^{kl}	5.33^{h}	4.75^{e}	11.83^{d}	18.00^{a}	14.92^{a}
P_4-Butter paper bags	3.50^{mn}	4.66^{ij}	4.08^{f}	8.83^{g}	11.00^{ef}	9.92^{d}
P_5-Muslin cloth bags (Control)	3.16^{n}	4.33^{jk}	3.75^{g}	8.66^{g}	10.66^{f}	9.66^{d}
Mean	3.66^{d}	4.80^{c}		10.26^{b}	13.53^{a}	

*Means with different superscripts in a particular storage temperature vary significantly with each other minimum (10.26 and 3.66d) was observed in Pusa Arpita (V_1) under low temperature and ambient conditions, respectively. The interaction effect of packaging material and varieties revealed that the flowers of var. PNG packed in shrink wrap showed maximum (18.00 days) storage life compared to Pusa Arpita loose flowers packed in shrink wrap (14.92 days).The interaction among packaging material, variety and storage condition shows effect of the var. PNG flowers packed in shrink wrap under low temperature storage conditions shows highest storage life than flowers packed in other packaging under ambient temperature conditions.

The shrink-wrap provides a secure encasement, shielding the flowers from bumps and abrasions, it may help regulate the balance of carbon dioxide and oxygen, creating ideal conditions for the flowers and this can be crucial for preserving freshness and extending shelf life. Similar results were observed by Kumar *et al.* (24) and Panwar *et al*. (20) in marigold loose flower.

Data presented in Fig. 1 depicts that on the first day, the PLW at ambient temperature conditions was found to be minimum (1.02%) in flowers of var. Pusa Narangi Gainda (PNG) packed in shrink-wrap, which was at par with var. Pusa Arpita (PA) flowers packed in shrink-wrap, while maximum (6.71%) was observed in var. Pusa Arpita flowers packed in butter paper. Similarly, during 2nd and 3rd day, minimum PLW was observed in flowers of PNG packed in shrink wrap (4.81& 8.87%), while the maximum (10.48 & 10.32%) was recorded in Pusa Arpita flowers packed in butter paper and muslin cloth, respectively.

Under low-temperature storage conditions (Fig. 2), the minimum PLW on 4th day (0.82%) was recorded in PNG flowers packed in shrink-wrap, which was at par with Pusa Arpita packed in shrink-wrap, while maximum (6.51%) was observed in same variety flowers packed in butter paper. Similarly, during 8th and 12th day, minimum PLW was observed in PNG flowers packed in shrink-wrap (4.61&8.07%), while the maximum (10.28 &10.12%) was recorded in Pusa Arpita flowers packed in butter paper and muslin cloth, respectively.

Packaging keeps the humidity level higher, which slows down the moisture-loss process. Furthermore, a concentration of oxygen and carbon dioxide is balanced that lowers the respiration process. This could be the cause of shrink-wrap having the lowest physiological loss in weight and shrinkage over the whole storage time. Furthermore, the PLW was significantly impacted by the cold storage's restriction of the rate of respiration, other enzymatic activities, and lowered moisture content. According to study of Viresh *et al*, (24) flowers are considered

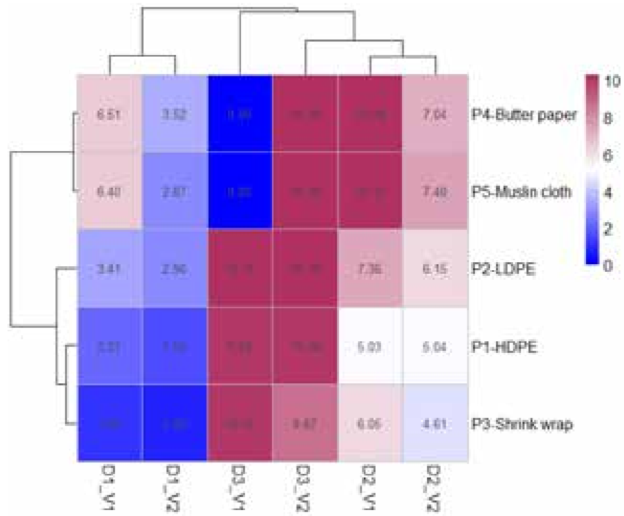

Fig. 1. Effect of packaging material and varieties on PLW (%) under ambient temperature storage.

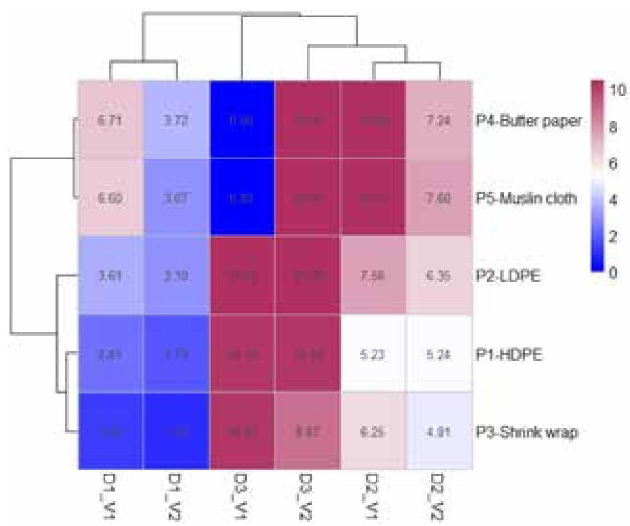

Fig. 2. Effect of packaging material and varieties on PLW (%) under low temperature storage.

unacceptable in market if PLW exceeds 10%. Similar were the observations of Lavanya *et al*. (16) and Devi *et al.* (17) in marigold, Archana *et al*. (19) in tuberose.

At ambient conditions, minimum spoilage (10.07%) was recorded after one day, in PNG flowers packed in shrink-wrap (Fig. 3), which was at par with flowers of same variety packed in HDPE (14.56%), while maximum (25.37%) was observed in var. Pusa Arpita packed in muslin cloth (Fig. 1). Similarly, during 2nd and 3rd day, minimum spoilage was observed in PNG flowers packed in shrink-wrap (21.64 & 38.41%), while the maximum (50.12 & 49.31%) was recorded in Pusa Arpita flowers packed in butter paper and muslin cloth, respectively.

Under low-temperature storage conditions, minimum spoilage on 4th day (9.75%) was recorded in PNG flowers packed in shrink-wrap, which was at par with flowers of PNG packed in HDPE (Fig. 4) while maximum (25.05%) was observed Pusa Arpita flowers packed in muslin cloth; similarly trend was observed on 8th and 12th day also. After 16 days, flowers in all treatments completely spoiled, except for the shrink-wrapped Pusa Narangi Gainda, which showed spoilage upto 48%. Flowers wrapped in shrink-wrap experience less spoilage because the material creates a microclimate that minimizes moisture loss, keeps the flowers hydrated and plump and protects against contamination, bacteria and mold can't easily reach the flowers, reducing rot. Flowers are delicate and susceptible to physical damage during transportation and handling. Shrink wrap provides a layer of cushioning that helps to prevent bruising, crushing, and petal spoilage (Kumar *et al.*, 24). Similar results were observed by Sharma *et al.* (21) in marigold loose flower and Rakesh *et al.* (22) in gaillardia.

Data related to ion leakage is presented in Fig. 5 and 6 reveals that there was significant effect of packaging material in ion leakage or membrane stability of flowers. At ambient temperature, the minimum ion leakage after Day 1 was recorded in Pusa Narangi Gainda flowers packed in shrink-wrap (28.63%), which was statistically at par with those packed in HDPE (29.23%). The maximum leakage (34.23%) was observed in the same variety packed in butter paper (Fig. 5). On Days 2 and 3, shrink-wrapped PNG flowers again recorded the lowest ion leakage (30.14% and 32.57%, respectively), whereas the highest values (38.87% and 38.14%) were noted in Pusa Arpita flowers packed in butter paper and muslin cloth. All treatments deteriorated after 4 days, except shrink-wrapped PNG flowers, which remained stable up to the 5th day of storage.

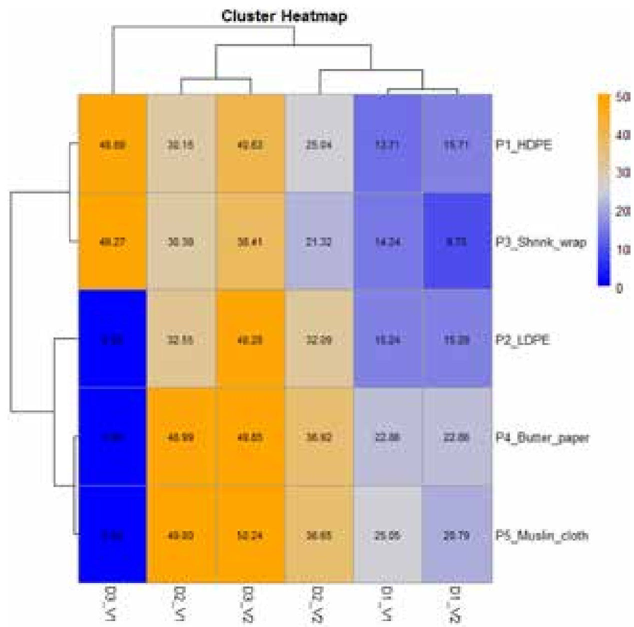

Fig. 4. Effect of packaging material and varieties on spoilage (%) under low temperature storage.

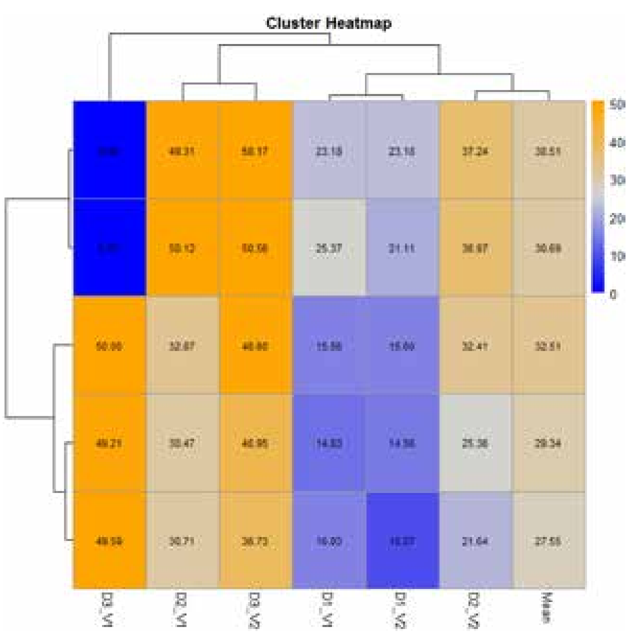

Fig. 3. Effect of packaging material and varieties on spoilage (%) under ambient temperature storage.

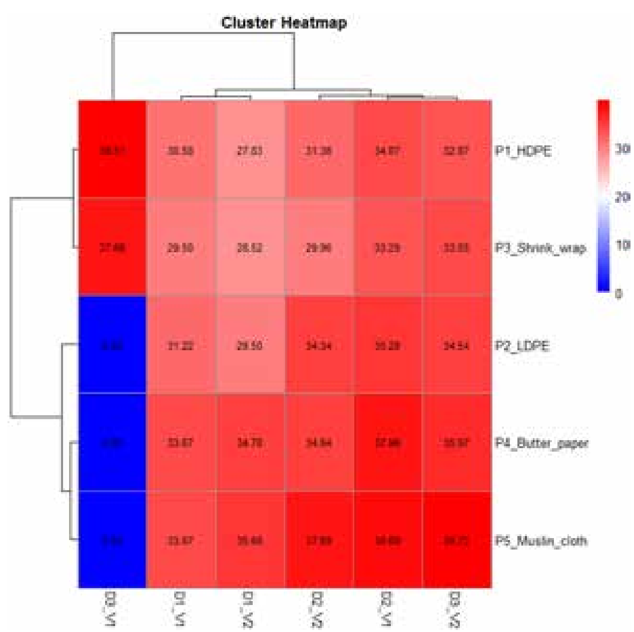

Fig. 5. Effect of packaging material and varieties on ion leakage (%) under ambient temperature storage.

Data in Fig. 6 shows that under low-temperature storage, on Day 4 the minimum ion leakage (28.52%) occurred in PNG flowers packed in shrink-wrap, which was at par with PNG packed in HDPE (27.83%). The maximum leakage (35.68%) was recorded in PA flowers packed in muslin cloth. On Day 8, shrink-wrapped PNG again showed the lowest leakage (29.96%), while after 12 days, the minimum (32.87%) was observed in PNG packed in HDPE. In contrast, the highest leakage values (37.69% and 34.94%) were recorded in PA flowers packed in butter paper and muslin cloth. All treatments deteriorated after 16 days except shrink-wrapped PNG, which remained stable until day 18.

Loss of membrane integrity during senescence is reflected through increased ion leakage. The consistently lower ion leakage in shrink-wrapped PNG under low temperature, compared to the control, suggests reduced membrane deterioration and better membrane stability, as changes in membrane permeability led to ion leakage in marigold petals.

Similar findings have been reported by Kumar *et al.* (12) in marigold.

Data presented in Fig. 7 reveals that on the first day, the SOD activity at ambient temperature conditions was found minimum (8.55 U mg^{-1} protein) in Pusa Arpita flowers packed in shrink-wrap, which was at par with PNG flowers packed in shrink-wrap (11.45 U mg^{-1} protein), while maximum (19.94 U mg^{-1} protein) was observed in Pusa Arpita flowers packed in muslin cloth.

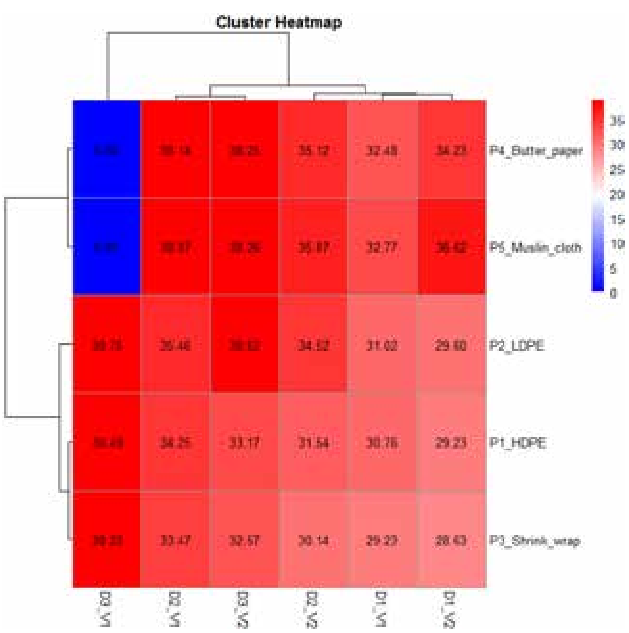

Fig. 6. Effect of packaging material and varieties on ion leakage (%) under low temperature storage.

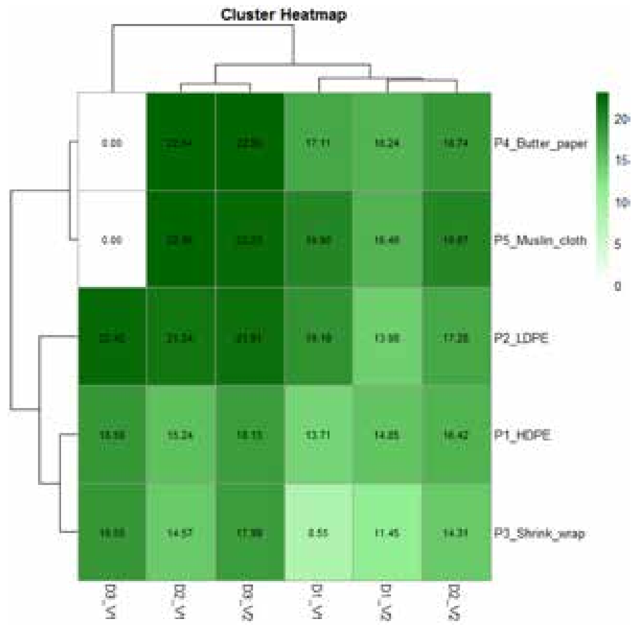

Fig. 7. Effect of packaging material and varieties on SOD activity under ambient temperature storage.

Similarly, during 2nd and 3rd day, minimum SOD activity was observed in PNG flowers packed in shrink-wrap (14.31&17.99 U mg^{-1} protein), while the maximum (22.96 and 22.54 U mg^{-1} protein) was recorded in Pusa Arpita flowers packed in butter paper and muslin cloth, respectively. However, on 5th day the SOD activity was found to be 18.55 and 17.99 in Pusa Arpita and PNG flowers packed in shrink wrap package.

Under low-temperature storage conditions (Fig. 8), on the fourth day, minimum SOD activity (12.44 U mg^{-1} protein) was recorded in Pusa Arpita flowers packed in shrink-wrap, which was at par with PNG flowers packed in shrink-wrap (14.22 U mg^{-1} protein), while maximum (21.39 U mg^{-1} protein) was observed in var. Pusa Arpita flowers packed in muslin cloth. Similarly, during 8th & 12th day minimum SOD activity (14.16&16.76 U mg^{-1} protein) was observed in PNG flowers packed in shrink-wrap while the maximum (22.81 & 22.39 U mg^{-1} protein) was recorded in Pusa Arpita flowers packed in butter paper and muslin cloth, respectively.

An inquisition of data presented in Fig. 9 reveals that on the first day, minimum lipid peroxidase (16.49micro mol/g dry wt.) was recorded in PNG flowers packed in HDPE, which was at par with Pusa Arpita flowers packed in shrink-wrap (19.93 micro mol/g dry wt.), while maximum (25.86 micro mol/g dry wt.) was observed in Pusa Arpita flowers packed in muslin cloth. Similarly, during 2nd and 3rd day, minimum lipid peroxidase was observed in PNG

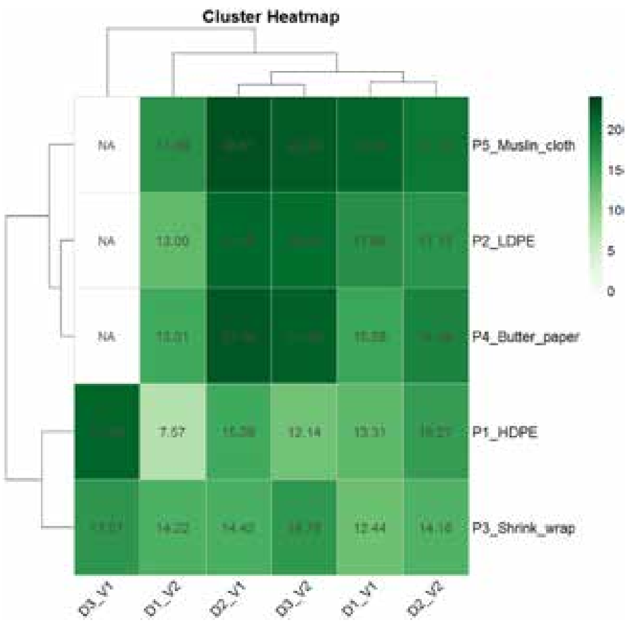

Fig. 8. Effect of packaging material and varieties on SOD activity under low temperature storage.

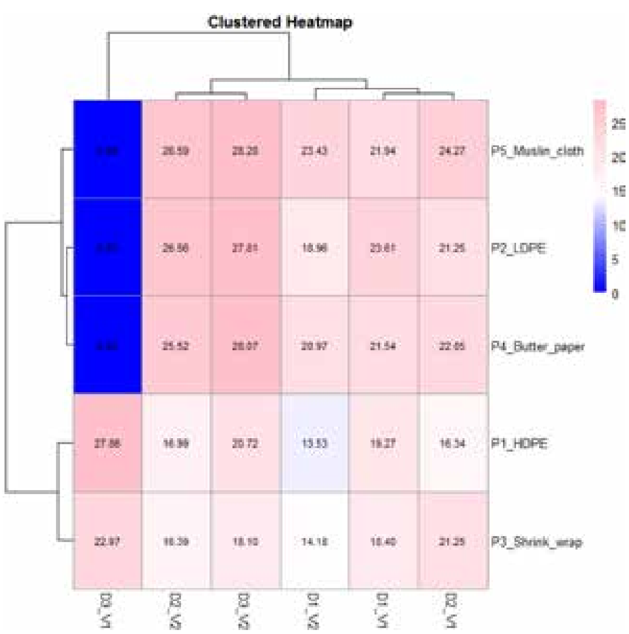

Fig. 9. Effect of packaging material and varieties on lipid peroxidase (micro mol/g dry wt.) under ambient temperature storage.

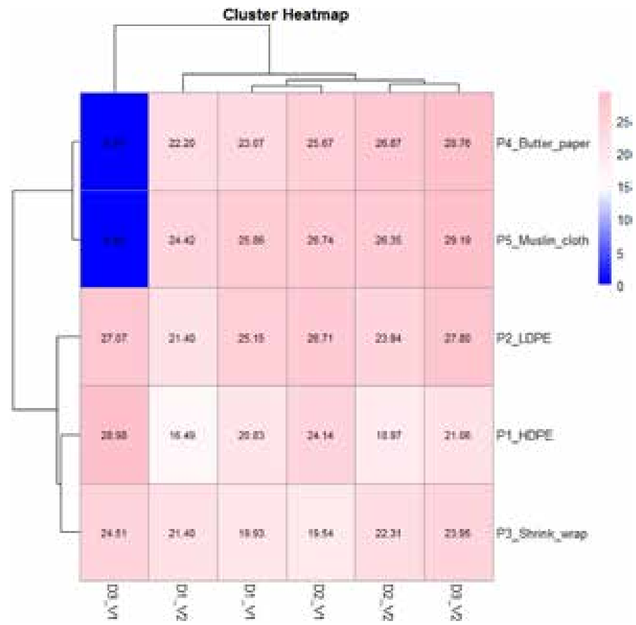

Fig. 10. Effect of packaging material and varieties on lipid peroxidase (micro mol/g dry wt.) under low temperature storage

flowers packed in HDPE (18.97&21.06 micro mol/g dry wt.), while the maximum (26.74micro mol/g dry wt.) was recorded in Pusa Arpita flowers packed in muslin cloth.

Data presented in Fig. 10 shows that under low-temperature storage conditions, on 4^{th} day minimum lipid peroxidase (13.53 micro mol/g dry wt.) activity was recorded in PNG flowers packed in HDPE, which was at par with same variety flowers packed in shrink-wrap (14.18 micro mol/g dry wt.), while maximum (23.61 micro mol/g dry wt.) was observed in Pusa Arpita flowers packed in LDPE. Similar to 4^{th} day minimum lipid peroxidase was observed in var. Pusa Narangi Gainda packed in shrink-wrap on 8^{th} & 12^{th} day (16.31&18.10 micro mol/g dry wt.). On 18^{th} day minimum lipid peroxidase activity was observed in PNG flowers packed in shrink wrap.

At the biochemical level, senescence is associated with changes in cellular damage caused by ROS and MDA may be reduced or prevented by protective mechanisms involving free radical and peroxide scavenging enzymes such as superoxide dismutase (SOD) and catalase (CAT), ascorbate peroxidase (APX) Asada, (92). The cooperative activities of these enzymes and high levels of antioxidants may increase resistance to oxidative injury and minimize cell damage. Similar results were observed by Kumar *et al.* (24) and Viresh (21) in marigold loose flower and Kumari *et al.* (17) in chrysanthemum.

Among the packaging materials investigated, shrink-wrap emerged as the superior choice, followed by HDPE, under both ambient and low-temperature storage conditions. In terms of variety, Pusa Narangi Gainda outperformed Pusa Arpita. Low-temperature storage consistently yielded better results than ambient temperature. The interaction between packaging and variety revealed that Pusa Narangi Gainda flowers packaged in shrink-wrap exhibited the best performance. Under low-temperature conditions, the three-way interaction analysis indicated that Pusa Narangi Gainda flowers packaged in shrink-wrap significantly outperformed other treatment combinations.

AUTHORS' CONTRIBUTION

Myadam Naveen Kumar – original draft, Investigation & Formal analysis. Ritu Jain: Validation, Supervision & Methodology. MC Singh: Resources. AK Tiwari: Resources. Babita Singh: Resources & Formal analysis. Shruti Sethi: Validation, Methodology. Lekshmy Sathee: Resources & Conceptualization. Khajanchi Lal: Resources.

DECLARATION

The Authors declares no conflict of interest.

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