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# Effect of dry storage on vase life of *Nephrolepis exaltata*

**Biswajit Karmakar, Suhrita Chakrabarty and Swarnayu Bagchi**

**Abstract**
Fronds of *Nephrolepis exaltata,* commonly known as Boston fern normally exhibits longer vase life compared to other ferns. To ensure the availability of the greens for a longer duration, refrigerated storage holds considerable significance. We conducted the present investigation to investigate the effect of packaging and storage on vase life of *Nephrolepis exaltata*. Two types of packaging materials are used in this experiment PP (Poly Propylene) and PE (Poly Ethylene). Vase life of the fronds of *Nephrolepis exaltata* gradually decreased due to dry storage beyond 5 days. Maximum vase life of 19.33 days was observed in ferns without storage. Under different storage condition, 5 days was the best treatment exhibiting maximum vase life of 13.33 days in PP at 25 to 30 °C and 80-85% RH. Regarding packaging, longer vase life was recorded in fronds stored in PP sleeves than for those in PE, in all cases.

**Keywords:** Dry storage, poly propylene, poly ethylene, post harvest life

## Introduction
Cut foliage is one of the major components of floricultural crops that have acquired an important position in the local and foreign markets over the world (Abou El-Ghait *et al.*, 2012) [1]. *Nephrolepis exaltata* (L.) is commonly known as sword fern or Boston fern. It belongs to the family Nephrolepidaceae and is native to North, Central, and South America. It is one of the most popular cut foliage. Leaves are hairy with serrated margins. Generally the foliages of *Nephrolepis* having deep green colour with long lasting properties are most commonly used by the floral industry all over the world (Pacifici *et al.*, 2007; Reid and Jiang 2012) [7, 8]. As a consequence, the trade of foliage indicates that India has emerged as one of the top suppliers among the developing countries and has been successful in developing a sustainable market in the EU (Ladha and Gunjal, 2011) [5]. At present, no reliable information is available regarding the demand for the cut foliage of ferns in India but their superiority over the other greens is well established in the trade.

In India, a large amount of ferns are grown in Sikkim. A primary survey made by our team revealed that the florists of Sikkim supply the green foliage to Kolkata market, or entire West Bengal and other states, throughout the year. Based on the information from the florists and various flower shop owners of Mallickghat market, Kolkata, it seemed that Boston fern not only has local demand, but bestowed with promising export potentiality also. Owing to foliage delicacy and tenderness, these are extremely susceptible to mechanical and physical damage during and after harvest. To ensure the availability of the greens for a longer duration, refrigerated storage holds considerable significance (Nowak and Rudnicki, 1990; Bhattacharjee, 1999; Singh *et al.*, 2001) [6, 9]. Thus, to investigate the effect of storage conditions on vase life of *Nephrolepis exaltata* this experiment was conducted.

## Materials and methods
Fronds of "*Nephrolepis exaltata*" were harvested early in the morning from experimental plots of AICRP on Floriculture, Mondouri, Nadia, West Bengal and were brought to the laboratory within 2 hours. After that pre-cooling for 6 hours at 4-5°C in distilled water. After precooling removing the pinnae from the lower third of the frond, re-cutting was done to obtain a uniform length of 30cm and the fronds were sealed in polymeric film sleeves (PP and PE – 100 gauge thick) without perforation and stored in refrigerator, at 4-5°C and 80 to 85% RH for 0 to 20 days. After storage, base of the fronds were recut and placed in plain water for evaluation of keeping quality in normal room temperature and the observations were recorded.

**Effective vase life (days)**
Vase life of fronds was recorded in days. It was determined by 50% pinnae abscission. When the pinnae fell below 50% from the fronds are regarded as commercially unacceptable and up to this day of observation were considered as vase life.

**Cumulative water uptake during vase life (CWU) (g/foliage)**
Equal amount of distilled water was taken in each test tube for keeping fronds after solution dipping. Water uptake was recorded daily until the end of vase life of foliage. The difference between initial weight of test tube containing distilled water without spike and weight of same test tube containing water without spike next day was calculated by following formula-
Cumulative water uptake (CWU) = Initial weight of test tube containing distilled water without spike -Weight of same test tube containing water without spike at last day.

**Transpiration loss (g/foliage)**
In this experiment transpiration loss is taken by difference between the initial foliage weight (on the first day) and final foliage weight (on the last day of vase life) along with bottle and solution gives the transpiration loss of cut foliage and it was calculated by following formula,
Transpiration loss = Initial weight of foliage spike - Weight of same foliage spike at last day.

**Cumulative water balance (g/foliage)**
The Cumulative water balance in cut foliage was calculated by following formula,
Cumulative water balance = Cumulative water uptake – Transpiration loss

**Water loss / uptake ratio (%)**
Water loss / uptake ratio of the foliage was determined by following formula,

$$\text{Water loss / uptake ratio (\%)} = \frac{\text{Transpiration loss}}{\text{Cumulative water uptake}} \times 100$$

**Relative fresh weight (RFW) (%)**
Relative fresh weight of the foliage was determined just before the immersing of the foliage into the solution and repeated every day until the vase life of the foliage were terminated. The fresh foliage of each foliage was expressed relative to the initial weight to represent the water status of the foliage and it was calculated by following formula,

$$\text{Relative fresh weight (\%)} = \frac{\text{Fresh weight on n}^{th}\text{ day}}{\text{Initial fresh weight}} \times 100$$

**Overall acceptability (1-5)**
The general appearance of foliage quality based on scale, ranging from one to four as described by Sangwanangkul *et al.,* (2008).

**Results and discussion**
Physiological loss in weight (PLW) (%), vase life (days), cumulative water uptake in vase (ml), cumulative transpiration loss (ml), cumulative water balance (g), water loss/uptake ratio.

Dry storage of fronds with Poly propylene (PP) for 5 days showed the lowest physiological loss in weight (PLW) of 6.25% followed by 10.22% for those stored in Poly Ethylene (PE) for 5 days. However foliage without storage recorded the lowest PLW % in general. *Nephrolepis exaltata* gradually decreased due to dry storage for 5 days to 20 days. Maximum vase life of 19.33 days was observed in ferns without storage. Under different storage condition, 5 days was the best treatment exhibiting maximum vase life of 13.33 days stored in PP. However, ferns could be stored for 20 days in PP with a vase life of 6.33 days. Regarding packaging, longer vase life was recorded in fronds stored with PP sleeves than for those stored in PE, in all the cases. On the contrary, loss of fresh weight was higher with enhancement of dry storage period. The longer the fronds were kept in storage, higher was the loss in fresh weight. Water loss was significantly lower in fronds packed with PP sleeves, than for those packed in PE. It could be due to higher $CO_2$ levels inside the PP sleeves, which might lead to the closure of stomata, thereby limiting water loss. Maximum water absorption (6.29 ml) was obtained in Ferns kept in PP without storage and minimum (3.83 ml) was recorded in ferns kept in PE for 20 days. The maximum cumulative transpiration loss of 0.42 ml was recorded in PE for 20 days of storage followed by PE+15 days of storage (0.40 ml). However, minimum cumulative transpiration loss of 0.29 ml was recorded in PP without storage. The highest cumulative water balance of 6.00 g was obtained in PP without storage followed by 5.95 g in PE without storage and the lowest cumulative water balance of 3.42 g was observed in PE 20 days of storage. The higher cumulative water balance in cut foliage resulted in high degree of freshness of cut foliage in the long run. The maximum water loss/uptake ratio of 0.11 was recorded in PE+ 20 days of storage followed by 0.10 (recorded in PP 20 days of storage).Whereas minimum water loss/uptake ratio of 0.04 was recorded in PP without storage.

**Chlorophyll content (mg/g), overall acceptability and relative fresh weight (%).**
It was observed that losses of chlorophyll during vase life gradually increased as the storage duration increased. Lowest (3.67 mg/g) chlorophyll degradation was observed in foliages stored for 5 days in both the PP and PE and highest in PE + 20 days of storage (5.33 mg/g). After five days in vase, ferns stored for 20 days became unacceptable. However, overall acceptability of Boston fern varied significantly in all cases (Table no.2). Better acceptability (3.83) was found in PP without storage followed by PE without storage (3.67). While the lowest grade of 1.50 was recorded in PE+ 20 days of storage. After 5 $^{th}$ day, highest percentage of relative fresh weight of 97.12 per cent was noted in PP without storage followed by 96.62 per cent in PP 5 days of storage. This indicated that, water absorption from the vase maintains a better foliage freshness which saves from early wilting and reflecting on vase life improvement. An increase in fresh weight could be attributed to improved water balance in the foliage. Fronds of *Nephrolepis exaltata* exhibited a continuous decrease in their vase life after dry storage (Table No 1). In the present experiments we found an effect of dry storage on the rate of water uptake and on the recovery of leaf Fresh Weight (FW) when the leaves had been placed in water following dehydration. During vase life the FW of leaves that were held in dry storage for 15-20 days did not decrease before day 5, thus did not decrease prior to the onset of the increase in pinnae abscission. This suggests absence of water

stress in these leaves during vase life, in the period prior to the onset of a rather high rate of abscission during storage. The increase in ethylene production during vase life might have preceded the increase in pinnae abscission, hence might be the cause of the abscission. A significantly longer vase life was recorded for fronds stored in PP sleeves than for those in PE. Even after the fronds were stored for 20 days in PP sleeves, their vase life reached 8 days as compared to 6.33 days for those kept in PE. According to Kumar (2001) [4], polypropylene has a tendency to maintain a higher level of CO2 with a low $O_2$ content inside, thereby creating a suitable environment for storage. High CO2 and low $O_2$ in the storage atmosphere have already been suggested to enhance the storage ability of many cut flowers (Goszczynska and Rudnicki, 1988; Singh *et al.*, 2001) [3, 9]. In general, a loss of fresh weight increased the longer the fronds were kept in storage, but for fronds in PP sleeves such a loss was significantly lower than for those held in PE. It could be due to higher $CO_2$ levels inside the PP sleeves, which might lead to the closure of stomata, thereby limiting water loss (Kumar, 2001) [4]. Fronds stored in PP sleeves maintained more or less constant water absorption throughout whereas for those kept in PE water absorption decreased after 20 days of storage. Therefore, one can conclude that 'Boston fern' fronds could be stored at 4±0.5°C in PP sleeves (100 gauges thick) for up to 10 days but in PE only for 5 days, to maintain their subsequent vase life more than 10 days.

**Table 1:** Effect of dry storage on physiological loss in weight (PLW) (%) in storage, effective vase life (days), cumulative water uptake in vase (ml), cumulative transpirational loss (ml), cumulative water balance (g), water loss/uptake ratio.

| Treatments | PLW (%) after storage | Effective vase life (days) | Cumulative water uptake in vase (ml) | Cumulative transpirational loss (ml/foliage) | Cumulative water balance (g/foliage) | Water loss/uptake ratio |
|---|---|---|---|---|---|---|
| PP 0 Days | 6.45 | 19.33 | 6.29 | 0.29 | 6.00 | 0.04 |
| PE 0 Days | 6.02 | 16.33 | 6.25 | 0.30 | 5.95 | 0.05 |
| PP 5 Days | 6.25 | 13.33 | 5.93 | 0.32 | 5.61 | 0.06 |
| PE 5 Days | 10.22 | 11.33 | 5.33 | 0.33 | 5.01 | 0.06 |
| PP 10 Days | 11.85 | 10.67 | 5.01 | 0.36 | 4.66 | 0.07 |
| PE 10 Days | 13.31 | 9.33 | 4.84 | 0.37 | 4.48 | 0.08 |
| PP 15 Days | 11.41 | 8.33 | 4.61 | 0.39 | 4.22 | 0.09 |
| PE 15 Days | 12.04 | 6.67 | 4.31 | 0.40 | 3.91 | 0.09 |
| PP 20 Days | 12.22 | 8.00 | 4.14 | 0.41 | 3.73 | 0.10 |
| PE 20 Days | 14.72 | 6.33 | 3.83 | 0.42 | 3.42 | 0.11 |
| SE.m (±) | 1.07 | 0.37 | 0.32 | 0.03 | 0.33 | 0.01 |
| CD at 5% | 3.17 | 1.09 | 0.96 | N/A | 0.97 | 0.02 |

**Table 2:** Effect of dry storage on chlorophyll content (mg/g) during vase life and overall acceptability.

| Treatments | Total chlorophyll content (mg/g) | | | Overall acceptability after 7 days |
|---|---|---|---|---|
| | 1st Day | Last day | Loss during storage | |
| PP 0 Days | 75.00 | 69.67 | 5.33 | 4.83 |
| PE 0 Days | 79.67 | 74.00 | 5.67 | 4.67 |
| PP 5 Days | 78.00 | 74.33 | 3.67 | 4.50 |
| PE 5 Days | 59.67 | 56.00 | 3.67 | 4.33 |
| PP 10 Days | 65.00 | 61.00 | 4.00 | 4.17 |
| PE 10 Days | 73.00 | 68.67 | 4.33 | 3.83 |
| PP 15 Days | 65.00 | 60.33 | 4.67 | 3.67 |
| PE 15 Days | 69.33 | 64.67 | 4.67 | 3.33 |
| PP 20 Days | 65.33 | 60.33 | 5.00 | 2.10 |
| PE 20 Days | 67.67 | 62.33 | 5.33 | 1.50 |
| SE.m (±) | 4.53 | 4.56 | 0.79 | 0.28 |
| CD at 5% | NS | NS | NS | 0.83 |

**Table 3:** Effect of dry storage on Relative fresh weight (%)

| Treatments | Relative fresh weight (%) | | | | | |
|---|---|---|---|---|---|---|
| | 2nd Day | 5th Day | 8th Day | 11th Day | 15th Day | 19th Day |
| PP 0 Days | 98.19 | 97.12 | 94.58 | 92.00 | 89.48 | 86.87 |
| PE 0 Days | 98.14 | 96.48 | 93.27 | 90.07 | 86.92 | 86.92 |
| PP 5 Days | 98.03 | 96.62 | 93.6 | 90.61 | 87.53 | NA |
| PE 5 Days | 97.89 | 96.16 | 92.54 | 88.81 | -- | -- |
| PP 10 Days | 97.93 | 96.36 | 92.91 | 89.49 | -- | -- |
| PE 10 Days | 97.66 | 94.87 | 89.84 | -- | -- | -- |
| PP 15 Days | 97.23 | 95.08 | 90.34 | -- | -- | -- |
| PE 15 Days | 95.29 | 90.95 | -- | -- | -- | -- |
| PP 20 Days | 97.78 | 95.64 | 91.32 | -- | -- | -- |
| PE 20 Days | 95.71 | 91.92 | -- | -- | -- | -- |
| SE.m (±) | 0.33 | 0.44 | 0.73 | 0.58 | -- | -- |
| CD at 5% | 0.99 | 1.31 | 2.19 | 1.83 | -- | -- |

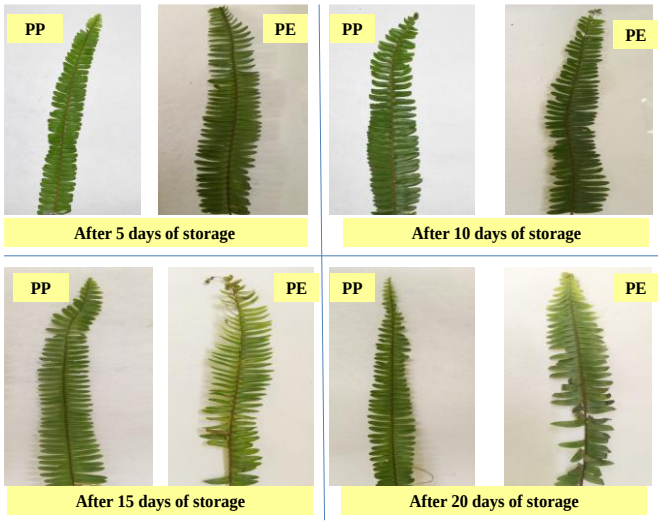


**Plate 1:** Fronds after different storage duration.

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