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Impact of Various Pulsing and Holding Solutions on the Quality and Longevity of *Nephrolepis exaltata* (L.) Schott Cut Foliage Under Room Temperature

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Abstract: Cut foliage production has been rapidly increased in recent years and has played an important role in the national income. This study was conducted during two successive seasons (2009 and 2010) to investigate the effect of various pulsing and holding solutions on keeping the quality and extending the longevity of *Nephrolepis exaltata* (L.) Schott cut foliage under room temperature. The pulsing treatments were distilled water (DW) as control and benzyladenine (BA) at 2 or 5ppm for 24h. The holding treatments were DW, methanol (M) at 2 or 4%, sucrose (Suc) 2%+M 2%, Suc 2%+M 4% and Suc 2%+salicylic acid (SA) at 150mg/l+8-hydroxyquinoline citrate (8-HQC) at 200mg/l. The results emphasized that treating *N. exaltata* with BA at 5ppm as a pulsing solution followed by Suc+SA+8-HQC as a holding solution increased the longevity, water uptake, percentage of both fresh weights and total carbohydrates, in addition to improving the general appearance. Moreover, these treatments decreased the caroteniods content and the degradation of chlorophyll *a* and *b* as compared to the control. In conclusion all the studied solutions positively affected the longevity of *N. exaltata* cut foliage. Both BA at 5ppm and Suc+SA+8-HQC solutions are the most preferable among other pulsing and holding solutions under the conditions of room temperature.

Key words: Vase life · General appearance · Benzyladenine · Methanol · Salicylic acid · Sucrose · 8-Hydroxyquinoline citrate

INTRODUCTION

Cut foliage is one of the most colorful and attractive horticultural plants, that has been rapidly increased in recent years. It occupies an important position in the local and foreign markets and plays an import role in the national income [1]. Cut foliage vegetation is either used in large quantities as a source of decoration on its own, or in association with flowers in bouquets as they represent a fundamental element of floral arrangements [2, 3]. Most often cut foliage responds to postharvest treatments (pulsing and holding solutions) and shows quite a long vase life.

One of the major problems in exporting cut foliage plant species is the acceleration of senescence process onset. Senescence is a highly organized process involving structural, biochemical and molecular changes which lead to disturbing the water balance, losing quality characteristics and desiccating within a short period [4]. Loss of chlorophyll which occurs as a result of chloroplast degradation is also a part of the cut foliage senescence process. The onset of cut foliage senescence may be induced by various external factors such as temperature, moisture content, gases, radiation and pathogens, while internal factors related to senescence are regulated mainly by two phytohormones, ethylene and abscisic acid (ABA) [5]. Wilting and leaf yellowing are the predominant postharvest problems associated with cut foliage. The use of preservatives has shown to be effective on retarding these processes. External supply of cytokinins delays senescence of cut foliage mainly by maintaining the integrity of the tonoplast membrane and

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preventing leakage of proteases which hydrolyze the soluble proteins of chloroplast and mitochondrial membranes [6].

Growth regulators and commercially available conditioners in pulsing solution are recommended to prolong the post-harvest longevity [7]. Benzyladenine (BA) is one of the pulsing regulators that delays leaf yellowing and consequently increases leaf longevity [8, 9]. Skutnik *et al.* [10] found that BA prolonged the vase life of both *Asparagus denstiflorus* 'Meyerii' and 'Myriocladus'. Pinto *et al.* [11] also reported that pulsing *Ctenanthe setosa* with BA significantly extended its leaves longevity and maintained its green coloration and brightness.

Adding chemical preservatives to the holding solution is also recommended to prolong the vase life. All holding solutions must contain essentially two components; sugar and germicide. The sugar provides a respiratory substrate [12]. While the germicides control harmful microorganisms (bacteria, algae, yeasts and fungi) that block the stems xylem vessels and prevent water uptake [13]. Among all different types of sugar, sucrose has been found to be the most commonly used in prolonging vase life, whereas 8-hydroxyquinoline (8-HQ) is the most powerful germicide [13, 14]. Moreover, sucrose was found more effective when combining it with 8-HQ [12]. Several studies proved the great effect of their combination. Skutnik *et al.* [10] mentioned that the sucrose and 8-HQC solution doubled vase life in *Asparagus denstiflorus* 'Meyerii'. Recently, methanol has also been successfully examined in prolonging the vase life and reducing abscission. It has been suggested that methanol acts by providing a readily available carbon source by limiting carbon loss. Furthermore, it showed a maintaining effect on leaf turgor by keeping weight losses to minimum [15]. Salicylic acid (SA) is a phenolic derivative, distributed in a wide range of plant species. It is a natural product of phenylpropanoid metabolism. SA has a direct involvement in plant growth, thermogenesis and uptake of ions. It affects ethylene biosynthesis, stomata movement and also reverses the effects of ABA on leaf abscission. In addition, it enhances the level of chlorophyll and carotenoid pigments, photosynthetic rate and modifying the activity of some important enzymes [16]. Lukaszewaska and Kobyliñski [17] found that SA increased the leaf longevity of *Hippeastrum* x *chmielii* and delayed chlorophyll *a* degradation. Alaey *et al.* [18] reported that vase solutions containing SA showed a significant increase in cumulative uptake, relative fresh weight and catalase activity of the cut rose flowers 'Black Magic' vase-life. Moreover, Kazemi *et al.* [19] pointed out that SA + sucrose treatment improved the quality and longevity of carnation.

Nephrolepis exaltata (L.) Schott commonly known as sword fern is an epiphytic or epilithic fern belongs to the family Lomariopsidaceae [20, 21]. Its fronds are 40-150cm long and 5-12cm broad, with alternate pinnae. Each pinnae being 2-8cm long and are generally deltoid. The pinnate vein pattern is also visible on these highly compound leaves. The edges appear slightly serrate [20]. *N. exaltata* is native to tropical regions throughout the world. It is one of the widely cultivated plants in home gardens [22] and also is one of the most popular cut foliage. *N. exaltata* is known as a pioneer species involved in recolonization of disturbed sites [22] and in accumulating arsenic [23]. Studies on the effect of post-harvest preservatives on enhancing the vase life of sword fern are limited. Therefore, the aim of the present study was to explore the effect of various pulsing and holding solutions on extending the longevity and keeping quality of *N. exaltata* cut foliage under room temperature.

MATERIALS AND METHODS

Plant Material and Experimental Design: Sword fern cut foliage (*Nephrolepis exaltata* (L.) Schott) was obtained from a local commercial farm (Flora Max), harvested in the morning as the leaves were matured, healthy and undamaged. The study was conducted on the first of February till the end of March at the Ornamental Horticulture Department, Faculty of Agriculture Cairo University, Egypt during the two successive seasons of 2009 and 2010. The obtained cut foliage was immediately transported after being graded for uniformity (50cm long) and wrapped in Kraft paper in groups to the laboratory of Ornamental Horticulture and Landscape Gardening at the Horticultural Research Institute Agric. Res. Center where the post-harvest treatments were carried out. The layout of the experiment was a complete randomized design with two factors. The first factor was pulsing solutions and the second factor was holding solutions.

Pulsing and Holding Solution Treatments: Cut foliage of *N. exaltata* were prepared firstly by pre-cooling it for half an hour at 4±2°C then 3cm from the foliage base were removed in addition to the leaves that will be attached to the treatment solutions. The obtained cut foliages were treated with three pulsing treatments for 24 hour. At the end of the pulsing treatments, the cut foliages were held till the end of the experiment in six holding treatments under room temperature (20±2°C). *N. exaltata* cut foliage were subjected to three different pulsing treatments (distilled water (DW) as control and two concentrations of benzyladenine (BA) (2 or 5ppm)), in addition to six holding treatments (DW, methanol (M) (2 or 4%), sucrose (Suc) 2%+M 2%, Suc 2%+M 4% and Suc 2%+salicylic acid (SA) (150mg/l)+8-hydroxyquinoline citrate (8-HQC) (200mg/l)).

Measurements and Analytical Methods: The effects of different treatments on sword fern cut foliage were examined by determining the longevity (the days number till wilting), water uptake ((the solution volume at the beginning of the study-the solution volume every six days)/leaves number) (ml/leaf), the increase or decrease in cut foliage fresh weight ((the cut leaves fresh weight every six days-the cut leaves fresh weight at the beginning of the study)/the cut leaves fresh weight at the beginning of the study x100) (%) and general appearance (the evaluation of cut foliage quality based on a scale ranging from 1 to 4, where 1= bad (greenish yellow), 2= moderate (yellowish green), 3= good (slightly yellowish) and 4= excellent (dark green) as described by Sangwanangkul *et al.* [24]. At the end of the study, chlorophyll *a* and *b* and total carotenoids contents (mg/100g fresh weight) were determined colorimetrically in leaves fresh weight according to Saric *et al.* [25], in addition to leaves total carbohydrates (%) which was also colorimetrically determined in leaves dry weight according to the methods described by Dubois *et al.* [26].

Statistical Analysis: The data were statistically analyzed as a factorial experiment (three pulsing and six holding treatments) using MSTAT-C [27]. Each treatment was replicated three times and each replicate contained three cut foliage (total number of cut foliage was 162/season). The results were subjected to analysis of variance (ANOVA) and the means were compared by Duncan's Multiple Rang Test at 5% probability level as described by Waller and Duncan [28] to verify differences among means of various treatments. However, the statistical analysis did not include the chlorophyll, total carotenoids and carbohydrates analyses.

RESULTS AND DISCUSSION

Longevity (days): Data presented in Table 1 show the effect of pulsing and holding treatments and their interactions on vase life (day) of *N. exaltata* cut foliage under room temperature during the seasons of 2009 and 2010. The results indicate that all pulsing solution treatments in comparison to the control (DW), prolonged the cut foliage vase life. BA solution at 5ppm was the most effective pulsing treatment for increasing the vase life (30.44 and 31.50 days in the first and second seasons, respectively) compared with BA at 2ppm (29.11 and 30.28 days in the first and second seasons, respectively) and DW (27.67 and 28.83 days in the first and second seasons, respectively). Regarding the effect of holding treatments, all treatments gave higher values of vase life in the two seasons than the control. The holding solution containing Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) helped in extending the number of days and producing the longest shelf life period (32.67 and 34.00 days in the first and second seasons, respectively), whereas M at 2% decreased the number of days and produced the shortest shelf-life period (27.22 and 28.56 days in the first and second seasons, respectively). The distilled water (control) recorded 25.33 and 26.33 days in the first and second seasons, respectively. The combination between BA at 5ppm as a pulsing solution and Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) as a holding solution gave the highest significant increase in the longevity of *N. exaltata* cut foliage (33.33 and 35.00 days in the first and second seasons, respectively) in comparison to all studied treatments. The interaction of DW as a holding solution and BA at 2ppm as a pulsing solution decreased the number of days and produced the shortest shelf life period (25.00 and 26.00 days in the first and second seasons, respectively). The control solution extended the longevity to 24.00 and 25.00 days in the first and second seasons, respectively.

The prolonging effects of the two BA concentrations on *N. exaltata* cut foliage vase life may be due to that cytokinins are known to retard senescence of detached leaves by delaying proteolysis [29]. BA has been also reported to inhibit the autocatalytic ethylene production [30]. The positive effect of 8-HQ may be due to its important role in reducing stem plugging as an antimicrobial agent [31]. SA might extend the vase life through improving plant defense against pathogens as an endogenous signal [32] in addition to suppressing biosynthesis of ethylene and consequently delaying senescence progress in plant tissues [33, 34]. The interaction effect may be due to that sugar alone tends to promote microbial growth. However, the combination of sugar and biocides might extend the vase life [31]. These effects of benzyladenine agree with the findings of Evans and Burge [35] on *Stilbocarpa polaris* and Janowska and Schroeter-Zakrzewska [36] on *Arum italicum* cut leaves.

Table 1: Effect of pulsing and holding treatments and their interactions on longevity (days) of *Nephrolepis exaltata* cut foliage under room temperature during the seasons of 2009 and 2010

	Pulsing treatments							
	2009				2010			
Holding treatments	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean
DW	24.00^{k}	25.00^{j}	27.00^{h}	25.33^{f}	25.00^{k}	26.00^{j}	28.00^{h}	26.33^{f}
M 2	25.67^{i}	27.00^{h}	29.00^{f}	27.22^{e}	27.00^{i}	28.67^{g}	30.00^{f}	28.56^{e}
M 4	26.67^{h}	28.67^{f}	30.00^{e}	28.44^{d}	28.00^{h}	29.67^{f}	31.00^{e}	29.56^{d}
Suc+M 2	28.00^{g}	30.00^{e}	31.00^{d}	29.67^{c}	29.00^{g}	31.33^{e}	32.00^{d}	30.78^{c}
Suc+M 4	30.00^{e}	31.00^{d}	32.33^{b}	31.11^{b}	31.00^{e}	32.00^{d}	33.00^{c}	32.00^{b}
Suc+SA+8HQC	31.67^{c}	33.00^{a}	33.33^{a}	32.67^{a}	33.00^{c}	34.00^{b}	35.00^{a}	34.00^{a}
Mean	27.67^{c}	29.11^{b}	30.44^{a}		28.83^{c}	30.28^{b}	31.50^{a}	

Means followed by similar letter(s) are not significantly different at 5% probability level according to Duncan's Multiple Range Test.

Table 2: Effect of pulsing and holding treatments and their interactions on water uptake (ml/leaf) of *Nephrolepis exaltata* cut foliage after 1, 7 and 13 days under room temperature during the seasons of 2009 and 2010

	Pulsing treatments											
	1 day				7 days				13 days			
Holding treatments	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean
2009												
DW	2.08^{k}	2.16^{j}	2.21^{j}	2.15^{f}	2.14^{j}	2.23^{i}	2.27^{i}	2.21^{f}	2.20^{k}	2.29^{j}	2.33^{j}	2.27^{f}
M 2	2.28^{i}	2.31^{i}	2.36^{h}	2.32^{e}	2.35^{h}	2.37^{h}	2.43^{g}	2.38^{e}	2.41^{i}	2.46^{h}	2.49^{gh}	2.45^{e}
M 4	2.36^{h}	2.43^{g}	2.49^{f}	2.43^{d}	2.43^{g}	2.49^{f}	2.55^{e}	2.49^{d}	2.49^{gh}	2.56^{f}	2.61^{e}	2.55^{d}
Suc+M 2	2.41^{gh}	2.53^{ef}	2.58^{de}	2.51^{c}	2.47^{fg}	2.59^{e}	2.65^{d}	2.57^{c}	2.53^{fg}	2.65^{e}	2.71^{d}	2.63^{c}
Suc+M 4	2.53^{ef}	2.62^{d}	2.70^{bc}	2.62^{b}	2.59^{e}	2.68^{d}	2.77^{bc}	2.68^{b}	2.66^{e}	2.74^{d}	2.83^{bc}	2.74^{b}
Suc+SA+8HQC	2.69^{c}	2.75^{b}	2.89^{a}	2.78^{a}	2.76^{c}	2.82^{b}	2.99^{a}	2.86^{a}	2.82^{c}	2.88^{b}	3.01^{a}	2.90^{a}
Mean	2.39^{c}	2.47^{b}	2.54^{a}		2.46^{c}	2.53^{b}	2.61^{a}		2.52^{c}	2.59^{b}	2.66^{a}	
2010												
DW	2.12^{a}	2.19^{a}	2.25^{a}	2.19^{a}	2.19^{n}	2.26^{mn}	2.32^{m}	2.26^{f}	2.25^{m}	2.32^{lm}	2.38^{kl}	2.32^{f}
M 2	2.30^{a}	2.39^{a}	2.44^{a}	2.38^{a}	2.37^{kl}	2.41^{jk}	2.47^{ii}	2.42^{e}	2.43^{jk}	2.48^{ij}	2.53^{i}	2.48^{e}
M 4	2.43^{a}	2.51^{a}	2.54^{a}	2.49^{a}	2.49^{hi}	2.57^{gh}	2.59^{fg}	2.55^{d}	2.55^{hi}	2.63^{gh}	2.66^{fg}	2.61^{d}
Suc+M 2	2.49^{a}	2.59^{a}	2.65^{a}	2.58^{a}	2.56^{gh}	2.65^{ef}	2.72^{de}	2.64^{c}	2.62^{gh}	2.72^{ef}	2.78^{de}	2.70^{c}
Suc+M 4	2.62^{a}	2.71^{a}	2.77^{a}	2.70^{a}	2.68^{e}	2.77^{cd}	2.81^{c}	2.75^{b}	2.75^{e}	2.83^{cd}	2.87^{c}	2.82^{b}
Suc+SA+8HQC	2.76^{a}	2.85^{a}	2.96^{a}	2.86^{a}	2.82^{bc}	2.89^{b}	3.02^{a}	2.91^{a}	2.88^{bc}	2.95^{b}	3.08^{a}	2.97^{a}
Mean	2.45^{a}	2.54^{a}	2.60^{a}		2.52^{c}	2.59^{b}	2.65^{a}		2.58^{c}	2.56^{b}	2.46^{a}	

Means followed by similar letter(s) are not significantly different at 5% probability level according to Duncan's Multiple Range Test.

Water Uptake (ml/leaf): Tables 2 and 3 show the effect of pulsing and holding treatments and their interactions on water uptake (g/cut leaf) of *N. exaltata* cut foliage under room temperature during the seasons of 2009 and 2010. The pulsing solution containing BA at 5ppm showed the highest water uptake as compared to the other concentrations and the control. For holding treatments, the solution containing Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) was the best treatment for increasing water uptake till the 25th day (4.64 and 4.57 g/cut leaf in the first and second seasons, respectively). Meanwhile, M at 2% was the less effective treatment for increasing the water uptake till the 25th day (4.17and 4.01g/cut leaf in the first and second seasons, respectively). Distilled water recorded 3.62 and 3.68g/cut leaf in the first and second seasons, respectively. The interaction between pulsing solution containing BA (5ppm) and holding solution containing Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) increased the water uptake of leaves in both seasons more than the other treatments till the 25th day.

The obtained results may be a reflection of using biocides that help in inhibiting the effect of micro-organisms in blocking the vascular system that causes decline in water uptake and plant cell breakdown thus, allowing greater hydration in leaves [12]. The combination of both 8-HQ and sucrose would help also in improving the water balance in cut leaves [31, 37]. Furthermore, the

Table 3: Effect of pulsing and holding treatments and their interactions on water uptake (ml/leaf) of *Nephrolepis exaltata* cut foliage after 19, 25 and 31 days under room temperature during the seasons of 2009 and 2010

	Pulsing treatments											
	19 days				25 days				31 days			
Holding treatments	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean
					2009							
DW	3.32^{f}	3.41^{f}	3.62^{e}	3.45^{f}	3.43^{n}	3.45^{m}	4.08^{l}	3.62^{f}	---	1.42^{b}	1.43^{b}	0.95^{c}
M 2	3.58^{e}	3.61^{e}	3.70^{de}	3.63^{e}	4.13^{l}	4.17^{kl}	4.22^{jk}	4.17^{e}	1.42^{b}	1.43^{b}	1.44^{b}	1.43^{b}
M 4	3.61^{e}	3.71^{de}	3.82^{cd}	3.71^{d}	4.25^{ik}	4.32^{hj}	4.34^{gi}	4.30^{d}	1.44^{b}	1.46^{b}	1.47^{b}	1.46^{b}
Suc+M 2	3.71^{de}	3.79^{cd}	3.93^{bc}	3.81^{c}	4.31^{hj}	4.40^{fh}	4.46^{df}	4.39^{c}	4.32^{a}	4.37^{a}	4.39^{a}	4.37^{a}
Suc+M 4	3.83^{cd}	3.90^{bc}	3.99^{ab}	3.91^{b}	4.43^{eg}	4.51^{ce}	4.55^{bd}	4.49^{b}	4.41^{a}	4.47^{a}	4.49^{a}	4.55^{a}
Suc+SA+8HQC	3.90^{bc}	4.00^{ab}	4.12^{a}	4.01^{a}	4.56^{bc}	4.62^{b}	4.75^{a}	4.64^{a}	4.59^{a}	4.67^{a}	4.78^{a}	4.68^{a}
Mean	3.66^{c}	3.74^{b}	3.86^{a}		4.17^{c}	4.25^{b}	4.40^{a}		2.69^{b}	2.97^{a}	3.00^{a}	
					2010							
DW	3.43^{k}	3.51^{j}	3.62^{h}	3.52^{f}	3.46^{l}	3.55^{k}	4.04^{i}	3.68^{f}	---	1.37^{b}	1.48^{b}	0.95^{b}
M 2	3.54^{ij}	3.61^{hi}	3.70^{fg}	3.62^{e}	3.68^{j}	4.18^{h}	4.18^{h}	4.01^{e}	2.84^{ab}	4.31^{a}	4.36^{a}	3.84^{a}
M 4	3.63^{gh}	3.71^{fg}	3.82^{d}	3.72^{d}	4.18^{h}	4.25^{g}	4.30^{f}	4.25^{d}	4.32^{a}	4.38^{a}	4.44^{a}	4.38^{a}
Suc+M 2	3.73^{ef}	3.79^{de}	3.93^{bc}	3.82^{c}	4.23^{gh}	4.34^{e}	4.39^{de}	4.32^{c}	4.39^{a}	4.44^{a}	4.51^{a}	4.45^{a}
Suc+M 4	3.86^{cd}	3.90^{c}	3.99^{b}	3.92^{b}	4.34^{e}	4.42^{d}	4.50^{bc}	4.42^{b}	4.51^{a}	4.58^{a}	4.67^{a}	4.59^{a}
Suc+SA+8HQC	3.91^{c}	4.00^{b}	4.12^{a}	4.01^{a}	4.49^{c}	4.55^{b}	4.68^{a}	4.57^{a}	4.67^{a}	4.74^{a}	4.79^{a}	4.72^{a}
Mean	3.68^{c}	3.76^{b}	3.87^{a}		4.06^{c}	4.22^{b}	4.35^{a}		3.45^{b}	3.97^{a}	4.04^{a}	

Means followed by similar letter(s) are not significantly different at 5% probability level according to Duncan's Multiple Range Test

Table 4: Effect of pulsing and holding treatments and their interactions on fresh weight changes (%) of *Nephrolepis exaltata* cut foliage after 1, 7 and 13 days under room temperature during the seasons of 2009 and 2010

	Pulsing treatments											
	1 day				7 days				13 days			
Holding treatments	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean
					2009							
DW	2.09^{l}	2.16^{k}	2.20^{k}	2.15^{f}	2.03^{l}	2.09^{k}	2.14^{k}	2.08^{f}	1.96^{m}	2.02^{lm}	2.08^{l}	2.02^{f}
M 2	2.34^{j}	2.38^{ij}	2.44^{h}	2.39^{e}	2.27^{j}	2.31^{ij}	2.37^{h}	2.31^{e}	2.19^{k}	2.24^{jk}	2.29^{h-l}	2.24^{e}
M 4	2.41^{hi}	2.46^{gh}	2.50^{fg}	2.46^{d}	2.34^{hi}	2.39^{gh}	2.43^{fg}	2.39^{d}	2.27^{i-k}	2.32^{g-j}	2.36^{f-h}	2.31^{d}
Suc+M 2	2.47^{gh}	2.53^{ef}	2.57^{e}	2.53^{c}	2.40^{gh}	2.46^{ef}	2.50^{e}	2.45^{c}	2.33^{g-i}	2.39^{fg}	2.43^{ef}	2.38^{c}
Suc+M 4	2.57^{e}	2.65^{d}	2.69^{cd}	2.64^{b}	2.49^{e}	2.58^{d}	2.62^{cd}	2.56^{b}	2.42^{f}	2.50^{de}	2.55^{cd}	2.49^{b}
Suc+SA+8HQC	2.73^{c}	2.79^{b}	2.91^{a}	2.81^{a}	2.66^{c}	2.72^{a}	2.83^{a}	2.74^{a}	2.59^{bc}	2.65^{b}	2.76^{a}	2.67^{a}
Mean	2.44^{c}	2.49^{b}	2.55^{a}		2.36^{c}	2.42^{a}	2.48^{a}		2.29^{c}	2.35^{b}	2.41^{a}	
					2010							
DW	2.12^{n}	2.19^{mn}	2.25^{lm}	2.19^{f}	2.05^{m}	2.13^{lm}	2.18^{kl}	2.12^{f}	1.98^{m}	2.06^{lm}	2.11^{kl}	2.05^{f}
M 2	2.30^{kl}	2.35^{jk}	2.41^{ij}	2.36^{e}	2.23^{jk}	2.28^{ij}	2.34^{i}	2.28^{e}	2.16^{jk}	2.21^{ij}	2.26^{i}	2.21^{e}
M 4	2.43^{hi}	2.51^{ef}	2.53^{fg}	2.49^{d}	2.36^{hi}	2.43^{gh}	2.46^{fg}	2.42^{d}	2.29^{hi}	2.36^{gh}	2.39^{fg}	2.35^{d}
Suc+M 2	2.49^{gh}	2.51^{ef}	2.65^{de}	2.58^{c}	2.42^{gh}	2.52^{ef}	2.58^{de}	2.51^{c}	2.35^{gh}	2.45^{ef}	2.51^{de}	2.44^{c}
Suc+M 4	2.62^{e}	2.71^{cd}	2.78^{bc}	2.71^{b}	2.55^{e}	2.63^{cd}	2.71^{bc}	2.63^{b}	2.48^{e}	2.56^{cd}	2.64^{bc}	2.56^{b}
Suc+SA+8HQC	2.76^{bc}	2.83^{b}	2.96^{a}	2.85^{a}	2.68^{bc}	2.76^{b}	2.89^{a}	2.78^{a}	2.61^{bc}	2.68^{b}	2.81^{a}	2.70^{a}
Mean	2.45^{c}	2.53^{b}	2.59^{a}		2.34^{c}	2.46^{b}	2.53^{a}		2.31^{c}	2.39^{b}	2.46^{a}	

Means followed by similar letter(s) are not significantly different at 5% probability level according to Duncan's Multiple Range Test.

presence of SA in the solutions may extend the vase-life by its positive regulatory role on stomatal closure which regulates the rates of transpiration and increases the water-retaining capacity of leaves [38], as well as improving the membrane permeability [39]. The obtained results coincided with the findings of Danaee *et al.* [40] on Gerbera cut flowers, treated with 50mg/l BA followed by 2.5 % ethanol and 3% sucrose. Kazemi and Ameri [41] also reported that the water uptake of cut rose flowers was increased by treating with the combination of salicylic acid and sucrose.

Table 5: Effect of pulsing and holding treatments and their interactions on fresh weight changes (%) of *Nephrolepis exaltata* cut foliage after 19, 25 and 31days under room temperature during the seasons of 2009 and 2010

	Pulsing treatments											
	19 days				25 days				31 days			
Holding treatments	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean
						2009						
DW	1.57^{l}	1.63^{k}	1.67^{k}	1.62^{f}	0.02^{l}	0.08^{k}	0.11^{k}	0.07^{f}	---	0.07^{j}	0.07^{j}	0.05^{f}
M 2	1.80^{j}	1.85^{ij}	1.91^{gh}	1.85^{e}	0.24^{j}	0.28^{ij}	$0.34^{g\text{-}i}$	0.29^{e}	-0.10^{k}	0.24^{i}	$0.33^{g\text{-}i}$	0.16^{e}
M 4	1.88^{hi}	1.93^{gh}	1.96^{fg}	1.92^{d}	0.31^{hi}	0.36^{gh}	0.39^{fg}	0.35^{d}	0.31^{hi}	$0.35^{f\text{-}h}$	$0.39^{e\text{-}h}$	0.34^{d}
Suc+M 2	1.94^{gh}	1.99^{ef}	2.04^{e}	1.99^{c}	$0.37^{f\text{-}h}$	0.42^{ef}	0.53^{d}	0.44^{c}	$0.36^{e\text{-}h}$	$0.42^{e\text{-}g}$	0.46^{de}	0.41^{c}
Suc+M 4	2.03^{e}	2.11^{d}	2.15^{cd}	2.09^{b}	0.46^{e}	0.53^{d}	0.58^{cd}	0.52^{b}	$0.45^{d\text{-}f}$	0.53^{cd}	0.57^{bc}	0.51^{b}
Suc+SA+8HQC	2.19^{c}	2.25^{b}	2.37^{a}	2.27^{a}	0.62^{c}	0.67^{b}	0.78^{a}	0.69^{a}	0.61^{bc}	0.66^{b}	0.77^{a}	0.68^{a}
Mean	1.90^{c}	1.96^{b}	2.02^{a}		0.34^{c}	0.39^{b}	0.46^{a}		0.27^{c}	0.38^{b}	0.43^{a}	
						2010						
DW	1.56^{m}	1.67^{l}	1.72^{kl}	1.66^{f}	-0.18^{n}	-0.04^{m}	0.16^{l}	-0.02^{f}	---	-0.33^{e}	-0.29^{e}	-0.21^{e}
M 2	1.77^{jk}	1.82^{ij}	1.87^{i}	1.82^{e}	0.21^{kl}	$0.26^{j\text{-}l}$	$0.31^{i\text{-}k}$	0.26^{e}	-0.21^{e}	-0.06^{e}	0.27^{cd}	-0.00^{d}
M 4	1.89^{hi}	1.97^{gh}	2.00^{fg}	1.96^{d}	$0.33^{h\text{-}j}$	$0.39^{g\text{-}i}$	$0.43^{e\text{-}h}$	0.38^{d}	0.29^{cd}	0.36^{bc}	0.38^{bc}	0.34^{c}
Suc+M 2	1.96^{gh}	2.06^{ef}	2.12^{de}	2.04^{c}	$0.45^{e\text{-}g}$	$0.51^{d\text{-}f}$	$0.54^{c\text{-}e}$	0.50^{c}	0.35^{bc}	$0.44^{a\text{-}c}$	$0.50^{a\text{-}c}$	0.43^{bc}
Suc+M 4	2.09^{e}	2.17^{cd}	2.42^{a}	2.23^{b}	$0.51^{d\text{-}f}$	$0.59^{b\text{-}d}$	0.66^{b}	0.58^{b}	$0.47^{a\text{-}c}$	$0.53^{a\text{-}c}$	$0.60^{a\text{-}c}$	0.53^{ab}
Suc+SA+8HQC	2.22^{bc}	2.29^{b}	2.44^{a}	2.32^{a}	0.64^{bc}	0.70^{b}	0.83^{a}	0.71^{a}	$0.60^{a\text{-}c}$	0.66^{ab}	0.79^{a}	0.68^{a}
Mean	1.92^{c}	1.99^{b}	2.10^{a}		0.33^{c}	0.40^{b}	0.49^{a}		0.25^{a}	0.26^{a}	0.38^{a}	

Means followed by similar letter(s) are not significantly different at 5% probability level according to Duncan's Multiple Range Test.

Table 6: Effect of pulsing and holding treatments and their interactions on the general appearance of *Nephrolepis exaltata* cut foliage after 1, 7 and 13 days under room temperature during the seasons of 2009 and 2010

	Pulsing treatments											
	1 day				7 days				13 days			
Holding treatments	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean
						2009						
DW	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.67^{c}	3.78^{bc}	3.89^{a}	3.78^{a}	2.23^{f}	2.80^{d}	3.00^{de}	2.68^{e}
M 2	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.89^{ab}	4.00^{a}	4.00^{a}	3.96^{a}	2.67^{e}	3.00^{de}	3.56^{bc}	3.08^{d}
M 4	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.33^{cd}	3.33^{cd}	3.78^{ab}	3.48^{c}
Suc+M 2	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.33^{cd}	$3.67^{a\text{-}c}$	3.89^{ab}	3.63^{bc}
Suc+M 4	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	$3.67^{a\text{-}c}$	3.89^{ab}	3.89^{ab}	3.82^{ab}
Suc+SA+8HQC	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.89^{ab}	4.00^{a}	4.00^{a}	3.96^{a}
Mean	4.00^{a}	4.00^{a}	4.00^{a}		3.93^{a}	3.96^{a}	3.98^{a}		3.19^{c}	3.45^{b}	3.69^{a}	
						2010						
DW	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.67^{c}	3.78^{bc}	3.89^{ab}	3.78^{b}	2.23^{f}	2.67^{e}	3.00^{de}	2.63^{e}
M 2	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.89^{ab}	4.00^{a}	4.00^{a}	3.96^{a}	2.67^{e}	3.00^{de}	3.33^{cd}	3.00^{d}
M 4	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.00^{de}	3.33^{cd}	3.78^{ab}	3.37^{c}
Suc+M 2	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.33^{cd}	$3.67^{a\text{-}c}$	3.89^{ab}	3.63^{bc}
Suc+M 4	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.56^{bc}	3.78^{ab}	3.89^{ab}	3.74^{ab}
Suc+SA+8HQC	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	4.00^{a}	3.89^{ab}	4.00^{a}	4.00^{a}	3.96^{a}
Mean	4.00^{a}	4.00^{a}	4.00^{a}		3.93^{a}	3.96^{a}	3.98^{a}		3.11^{c}	3.41^{b}	3.65^{a}	

Means followed by similar letter(s) are not significantly different at 5% probability level according to Duncan's Multiple Range Test.

Fresh Weight Changes (%): The effect of pulsing and holding treatments and their interactions on fresh weight changes (%) of *N. exaltata* cut foliage under room temperature during the seasons of 2009 and 2010 are presented in Tables of 4 and 5. Fresh weight percentage showed a declining trend throughout the vase life from the first day to the end of the study. Pulsing solution containing BA at 5ppm was the significantly effective treatment followed by BA at 2ppm as compared with DW in both seasons. On the other hand, Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) was the most effective holding solution for increasing the fresh weight percentage as

Table 7: Effect of pulsing and holding treatments and their interactions on the general appearance of *Nephrolepis exaltata* cut foliage after 19, 25 and 31 days under room temperature during the seasons of 2009 and 2010

	Pulsing treatments											
	19 days				25 days				31 days			
Holding treatments	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean
						2009						
DW	1.87^{g}	2.15^{f}	2.33^{f}	2.12^{f}	0.89^{k}	1.22^{ij}	1.67^{gh}	1.26^{f}	---	0.33^{f}	0.56^{f}	0.29^{f}
M 2	2.11^{f}	2.33^{f}	2.67^{e}	2.37^{e}	1.11^{jk}	1.44^{hi}	1.78^{fg}	1.44^{e}	0.44^{f}	0.56^{f}	0.78^{e}	0.56^{e}
M 4	2.33^{f}	2.67^{e}	3.00^{d}	2.67^{d}	1.44^{hi}	1.67^{gh}	2.11^{de}	1.73^{d}	0.56^{f}	0.78^{e}	1.00^{d}	0.78^{d}
Suc+M 2	2.67^{e}	3.00^{d}	3.33^{bc}	3.00^{c}	1.78^{fg}	2.11^{de}	2.33^{cd}	2.07^{c}	0.78^{e}	1.00^{d}	1.33^{c}	1.04^{c}
Suc+M 4	3.00^{d}	3.45^{a-c}	3.56^{ab}	3.34^{b}	2.00^{ef}	2.33^{cd}	2.78^{ab}	2.37^{b}	1.00^{d}	1.33^{c}	1.78^{ab}	1.37^{b}
Suc+SA+8HQC	3.22^{cd}	3.56^{ab}	3.67^{a}	3.48^{a}	2.22^{de}	2.56^{bc}	3.00^{a}	2.59^{a}	1.33^{c}	1.67^{b}	1.89^{a}	1.63^{a}
Mean	2.53^{c}	2.86^{b}	3.09^{a}		1.57^{c}	1.89^{b}	2.28^{a}		0.52^{c}	0.95^{b}	1.22^{a}	
						2010						
DW	1.67^{h}	2.00^{g}	2.33^{f}	2.00^{f}	0.67^{h}	1.00^{gh}	1.22^{fg}	0.96^{d}	---	0.11^{g}	0.67^{d-f}	0.26^{f}
M 2	2.00^{g}	2.33^{f}	2.67^{e}	2.33^{e}	1.00^{gh}	1.11^{fg}	1.44^{ef}	1.18^{d}	0.44^{f}	0.67^{d-f}	0.89^{cd}	0.67^{e}
M 4	2.33^{f}	2.67^{e}	3.00^{d}	2.67^{d}	1.44^{ef}	1.67^{de}	1.67^{de}	1.59^{c}	0.56^{ef}	0.78^{c-e}	1.33^{b}	0.89^{d}
Suc+M 2	2.67^{e}	3.00^{d}	3.56^{bc}	3.08^{c}	1.67^{de}	1.78^{de}	2.00^{b-d}	1.82^{b}	0.78^{c-e}	1.00^{c}	1.56^{ab}	1.11^{c}
Suc+M 4	3.00^{d}	3.33^{c}	3.67^{ab}	3.33^{b}	1.78^{de}	1.89^{cd}	2.33^{ab}	2.00^{a}	1.00^{c}	1.33^{b}	1.56^{ab}	1.29^{b}
Suc+SA+8HQC	3.33^{c}	3.56^{bc}	3.89^{a}	3.59^{a}	1.89^{cd}	2.22^{a-c}	2.44^{a}	2.18^{a}	1.45^{b}	1.56^{ab}	1.78^{a}	1.59^{a}
Mean	2.50^{c}	2.82^{b}	3.19^{a}		1.41^{c}	1.61^{b}	1.85^{a}		0.70^{c}	0.91^{b}	1.29^{a}	

Means followed by similar letter(s) are not significantly different at 5% probability level according to Duncan's Multiple Range Test.

Table 8: Effect of pulsing and holding treatments and their interactions on chlorophyll *a* and *b* and total caroteniods contents (mg/100g fresh weight) of *Nephrolepis exaltata* cut foliage under room temperature during the seasons of 2009 and 2010

	Pulsing treatments											
	Chlorophyll *a*				Chlorophyll *b*				Total caroteniods			
Holding treatments	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean
						2009						
DW	2.91	3.01	3.08	3.00	3.11	3.48	3.89	3.49	5.37	5.10	4.88	5.12
M 2	3.02	3.11	3.19	3.11	3.26	3.65	4.01	3.64	5.26	4.94	4.77	4.99
M 4	3.10	3.19	3.27	3.19	3.44	3.83	4.21	3.83	5.13	4.82	4.60	4.85
Suc+M 2	3.20	3.28	3.37	3.28	3.59	4.00	4.40	4.00	5.02	4.70	4.44	4.72
Suc+M 4	3.28	3.37	3.84	3.50	3.77	4.14	4.59	4.17	4.91	4.55	4.20	4.55
Suc+SA+8HQC	3.38	3.46	3.93	3.59	3.97	4.31	4.73	4.34	4.78	4.43	4.05	4.42
Mean	3.15	3.24	3.45		3.52	3.90	4.31		5.08	4.76	4.49	
						2010						
DW	2.97	3.05	3.14	3.05	3.14	3.57	3.93	3.55	5.30	5.05	4.83	5.06
M 2	3.06	3.14	3.23	3.14	3.23	3.75	4.12	3.70	5.19	4.88	4.71	4.93
M 4	3.14	3.23	3.32	3.23	3.32	3.90	4.27	3.83	5.08	4.77	4.55	4.80
Suc+M 2	3.24	3.32	3.40	3.32	3.40	4.06	4.45	3.97	4.97	4.66	4.39	4.67
Suc+M 4	3.33	3.42	3.88	3.54	3.88	4.24	4.66	4.26	4.85	4.49	4.15	4.50
Suc+SA+8HQC	3.42	3.50	3.98	3.63	3.98	4.41	4.82	4.40	4.73	4.37	3.99	4.36
Mean	3.19	3.28	3.49		3.49	3.99	4.37		5.02	4.70	4.44	

compared to the other treatments in the two seasons. The fresh weight percentage of *N. exaltata* placed in all holding treatments decreased after 7 days. Cut foliage pulsed with BA at 5ppm then held in Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) significantly increased the fresh weight percentage over other interactions.

The positive effect of applying both pulsing and holding treatments on fresh weight of *N. exaltata* cut foliage may be due to their great role on water balance [18] and defense mechanism [42] regulation causing the increase in fresh weight. These findings are confirmed by Solgi *et al.* [43] who found that Gerbera cut flowers held in 20mg/l 8-HQC at sucrose levels of 4 and 6%, had more relative fresh weight than the control (distilled water). Mansouri [39] indicated that chrysanthemum cut flowers treated by 0.1 and 1µM salicylic acid showed a significant decrease in weight loss compared to control (distilled water). On *Dendrobium* cut flowers, holding solutions containing 8-HQ+ sucrose extended the vase life and improved fresh weight [44].

General Appearance: Data presented in Tables 6 and 7 show the effect of pulsing and holding treatments and their interactions on the general appearance of *N. exaltata* cut foliage under room temperature during the seasons of 2009 and 2010. BA at 2 and 5ppm as pulsing solutions were the best treatments for maintaining the quality of cut foliage till the 19th day (2.86 and 3.09 in the first season and 2.82 and 3.19, in the second one) more than those treated with DW (2.52 and 2.50 in the first and second seasons, respectively). On the other hand, Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) was the best holding solution that helped in improving the general appearance (3.48 and 3.59 in the two seasons respectively) whereas, applying M at 2% moderately improved the cut foliage appearance (2.35 and 2.33 in the first and second seasons, respectively) as compared to DW (2.09 and 2.00 in both seasons, respectively). The significantly highest general appearance value resulted from *N. exaltata* cut foliage pulsed in BA at 5ppm then held in Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) solution (3.67 and 3.89 in the first and second seasons, respectively till the 19th day).

The positive effect of post-harvest treatments on the general appearance of cut foliage may be due to the presence of benzyladenine that preserves postharvest quality by delaying several processes involved in senescence including chlorophyll degradation [45], maintaining leaves green coloration and brightness [11] and delaying the onset of ethylene biosynthesis [3]. These results agree with the findings of Skutnik and Robiza-Swider [45] on *Nephrolepis* sp. and Pogroszewska *et al.* [46] on *Cimicifuga recemoeas*, *Ligulria clivorum and Phalaris arundinacea*. Hettiarachchi and Balas [47] indicated that quality traits (color and appearance) of croton cut foliage were affected by 8-HQS floral preservatives (biocide), compared to distilled water.

Chlorophyll *a*, *b* and Total Caroteniods Contents (mg/100g fresh weight): *N. exaltata* cut foliage treated with BA at 2 and 5ppm as pulsing solutions for 24h retarded the degradation of chlorophyll *a* and *b* and decreased total caroteniods compared to pulsing with distilled water (control) in both seasons (Table 8). Regarding the effect of holding treatments, Table 8 shows that all holding treatments gave higher values of chlorophyll *a* and *b* and lower values of total caroteniods contents in the two seasons than the control. The most effective holding solutions in this concern were Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) followed by Suc (2%)+M (4%) in both seasons as compared with distilled water. The combination of all pulsing and holding treatments followed also the same trend in the first and second seasons. Pulsing with BA at 5ppm then holding with Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) proved to be the most effective interaction treatment for maintaining chlorophyll *a* and *b* and decreasing total caroteniods contents followed by BA at 5ppm combined with Suc (2%)+M (4%) in both seasons.

The prolonging effects of BA concentrations on *N. exaltata* cut foliage may be due to that cytokinins are known to retard senescence of detached leaves and flowers by delaying proteolysis and chlorophyll degradation [48]. BA might also prevent the early lack of sugar availability for respiration as it effectively delayed leaf yellowing and also delayed senescence [49]. These observations on photosynthetic pigments are in agreement with those of Skutnik *et al.* [10] on *Asparagus setaceus* and Rubinowska *et al.* [7] on *Weigla florida* who showed that the highest content of photosynthetic pigments (chlorophyll *a* and *b*) was found under the effect of BA. Canakci [50] reported that treating carnation cut flowers with salicylic acid significantly increases total chlorophyll content. Moreover, Asrar [31] showed that sucrose+8-HQS reduced chlorophyll content degradation and preserved carbohydrates content.

Total Carbohydrates (%): Table 9 shows that pulsing *N. exaltata* cut foliage in BA at 2 and 5ppm solutions increased the percentage of total carbohydrates compared to pulsing in distilled water (control) during both seasons. Holding in different preservative solutions recorded high content of total carbohydrates percentage than distilled water (control) during both seasons. *N. exaltata* cut foliage placed in holding solution containing Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) presented the highest total carbohydrates value followed by Suc (2%)+M (4%) compared with the control in the two seasons. The combination between pulsing solution of BA at 5ppm for 24h and holding solution of Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) increased the percentage of total carbohydrates in *N. exaltata* cut foliage followed by Suc (2%)+M (4%) as compared with distilled water (control) in the two seasons.

Table 9: Effect of pulsing and holding treatments and their interactions total carbohydrates (%) of *Nephrolepis exaltata* cut foliage under room temperature during the seasons of 2009 and 2010

	Pulsing treatments							
	2009				2010			
Holding treatments	DW	BA 2	BA 5	Mean	DW	BA 2	BA 5	Mean
DW	9.71	10.33	14.61	11.55	9.79	10.37	14.67	11.61
M 2	12.19	13.25	15.59	13.68	12.23	13.32	15.64	13.73
M 4	12.36	14.57	15.67	14.20	12.41	14.61	15.73	14.25
Suc+M 2	15.50	15.54	16.34	15.79	15.57	15.60	16.39	15.85
Suc+M 4	15.59	15.98	16.95	16.17	15.64	16.01	16.99	16.21
Suc+SA+8HQC	20.22	20.71	23.27	21.40	20.28	20.79	23.32	21.46
Mean	14.26	15.06	17.07		14.32	15.12	17.12	

The pronounced effect of BA on the total carbohydrates content may be due to that it enhances the availability of sugars in cells by increasing α-amylase and invertase activities [51]. BA might also prevent the early lack of sugar availability for respiration as it effectively delayed senescence [49]. These results are in harmony with the findings of Amin [52] who found that the maximum amount of total sugars resulted from treating *Asparngus, Lavandula, Ruscus, Aspidistra and Pittoporum* with BA at 2.5ppm before storage. Ichimura and Suto [53] on cut sweet pea flowers and Elgimbi and Ahmed [14] on rose cut flowers retarded the carbohydrates degradation during their postharvest life by using 8-HQS (100ppm)+Suc (3%). Moreover, Mansouri [39] showed that reducing sugars content increased with SA treatment in chrysanthemum cut flowers.

CONCLUSION

Adding various pulsing and holding solutions individually positively affected the quality and longevity of *Nephrolepis exaltata* (L.) Schott cut foliage under room temperature. The interaction between pulsing solution presented in BA at 5ppm for 24h and holding solution presented in Suc (2%)+SA (150mg/l)+8-HQC (200mg/l) showed a pronounce effect on the keeping quality of the cut foliage through all the studied traits. Therefore, it is recommended to be used as commercial preservatives for prolonging the vase life and post harvest quality of sword fern.

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