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Improving Vase-life and Keeping Quality of *Fatsia japonica* Cut Foliages by Post-Harvest Treatments

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Abstract: This study was conducted during two seasons (2012 and 2013) at the laboratory of Ornamental Horticulture Department, Faculty of Agriculture, Cairo University to investigate the effect of different pulsing and holding solutions treatments and their interactions on keeping quality and extending vase life of *Fatsia japonica*. The pulsing treatments were: distilled water (DW), benzyladenine (BA), citric acid (CA) and Clorox (NaOCl). After the pulsing, foliages of *Fatsia japonica* were stored in polyethylene bags for 6 days in darkness at 4°C and then transferred to 23-25°C where their vase life was compared with those of freshly foliages under room temperature (23-25°C). The holding solutions were DW, 20 g/l sucrose + 10mg/l BA + 200 mg/l CA + 2ml/l Clorox and 1g/l Ca EDTA + 20 g/l sucrose. The obtained results showed that pulsing solutions with benzyladenine (BA) and citric acid were most effective treatments in increasing vase life, general appearance and leaves content of chlorophyll a and b in both non stored and stored leaves compared to distilled water (control); however cold storage decreased longevity, general appearance and leaves content of chlorophyll a and b in cut foliage of *F. japonica* compared to room temperature conditions. Through the cold storage respiration rate and water loss percentage decreased by BA treatment; however the highest result in CO_2 and the less O_2 percentage was obtained by Clorox. Interaction of holding and pulsing solutions indicated that BA and CA as pulsing solutions and the combination of 20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox as a holding solution gave the best results in all parameters, whereas 1g/l Ca EDTA + 20 g/l sucrose gave the best general appearance in the leaves, however it remains in vase the less days.

Key words: *Fatsia japonica* · Benzyladenine (BA) · Clorox · Citric acid (CA) · Ca EDTA · Cold Storage

INTRODUCTION

Cut foliage plants are colorful and attractive plants which can be cut and put in a vase within your home. In the recent years cut foliage has an important position in the local and foreign markets and national income [1]. Cut foliage is also used in large quantities as a source of decoration on its own or in association with flowers in bouquets [2, 3]. Evergreen plants with green, silver or variegated leaves are usually used and also species with berries become popular.

A recent statistic from Holland indicated that 25-30% of bouquets now consist of foliage compared to 5%, 15 years ago. This trend is set to increase further because of the green, healthy image presented by such products and because of the predicted increase in consumption of floral products [4].

Fatsia japonica (Fatsi or Japanese Aralia) is a species of flowering plant in the family Araliaceae, native to southern Japan and South Korea *F. japonica* is an evergreen flowering shrub, grow up to 3-6 m with branched stems. The leaves are large in width, leathery and lobed with 7–9 lobes, the lobes are edged with coarse. The flowers are small, white, compound umbels in late autumn or early winter, the fruits are small and black.

F. japonica grows as an ornamental plant in warm temperate regions. *F. japonica* has been shown to effectively remove gaseous formaldehyde from indoor air [5].

The aim of this investigation was to study the effect of pulsing solutions DW, 10 mg/l BA, 200 mg/l CA and 2ml/l Clorox and holding solutions DW, 20 g/l sucrose + 10mg/l BA + 200 mg/l CA + Clorox 2ml/l + and 1g/l Ca EDTA + 20 g/l sucrose on quality of *Fatsia japonica* as cut foliage.

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MATERIALS AND METHODS

This study was carried out at laboratory of Department of Ornamental Horticulture, Faculty of Agriculture, Cairo University during two successive seasons of 2012 and 2013 to investigate the effect of different pulsing solutions containing distilled water (DW), benzyladenine (BA), citric acid (CA), Clorox and holding solutions containing DW, 20 g/l sucrose +10 mg/l BA + 200 mg/l CA + 2ml/l Clorox and 1g/l Ca EDTA + 20 g/l sucrose under room condition and dry cold storage at 4°C for 6 days on keeping quality of cut foliage of *Fatsia japonica*. Cut foliage was taken at the length 50-55 cm on March 27th 2012 and 2013 in the first and second seasons, respectively.

The plants were put under the room condition in the following pulsing solutions for 24 hours: distilled water (DW), 10 mg/l benzyladenine (BA), 200 mg/l citric acid and 2 ml/l Clorox. At the end of pulsing treatment the cut foliage was divided into equal two groups. First group was hold till the end of the experiment in one of the under study holding solutions DW, sucrose 20 g/l + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox and 1 g/l Ca EDTA + 20 g/l sucrose under room temperature (23-25°C – 65-75% RH) and continuous light (1000 lux) of white fluorescent. The second group was put into polyethylene bags of 130mμ thickness; the bags sealed tightly and stored at 4°C for 6 days. After the end of storage periods, cut foliage was transported to the lab and held in the same previous holding solutions.

The following data were recorded at the end of vase-life:

- Vase life (day)
- Weight loss during storage (%)
- Carbon dioxide CO_2 (%) and Oxygen O_2 (%)
- General appearance in respect of the quality of cut foliage was evaluated 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) according to Sangwanangkul *et al.* [6].
- Chlorophyll a, b and carotenoids (mg/g FW) were determined in leaf samples according to Böger [7].

The layout of this experiment was in factorial completely randomized design (FCRD) with two factors including pulsing solutions and holding solutions in two experiments under room condition and cold storage at 4°C for 6 day with three replicates. Each replicate contained 3 cut foliages. The treatment means were compared by least significant difference (L.S.D.) test [8]. Statistical analysis was carried out by special statistical program (MSTAT-C).

RESULTS AND DISCUSSION

Longevity (Vase Life): As shown in Tables (1 and 2), data indicated that BA under room temperature was the best pulsing solution treatment prolonged the cut foliage vase life (33.00 and 34.11 days) compared to control (25.33 and 26.33 days) in the first and second seasons, respectively. However the cold storage conditions (for 6 days at 4°C) indicated that BA was the best pulsing solution as it prolonged the cut foliage vase life to (19.78 and 19.00 days) compared to control (17.08 and 17.78 days) in the first and second seasons, respectively, but the vase life period was less than that it recorded under room temperature. These effects of benzyladenine agreed with the finding of Evans and Burge [9] on *Stibocarpa polaris* and Janowska and Schroeter-Zakrzewska [10] on *Arum italicum* cut leaves. Also, the beneficial effect of citric acid on vase life as shown in Tables (1 and 2) was recorded by Jowkar and Salehi [11] on tuberose.

Regarding the effect of holding solutions, the combination of 20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox helped in extending the shelf life period for *F. japonica* (36.83 and 41.17 days) compared with the control (36.67 and 34.58 days) in the first and second seasons, respectively. These results agreed with Parminder *et al*. [12]. Whereas vase life of *F. japonica* was the least due to 1g/l Ca EDTA + 20 g/l sucrose treatment as a holding solution under room temperature (15 days) and in cold storage conditions (10 days) in all tested foliages in both seasons. External supplying of sugar provides a respiratory substrate while the germicides control harmful bacteria and prevent plugging of the water conducting tissues and these results agreed with Abdel-Kader and Rogers [13] on Gerbera; Moon-Soo *et al.* [14] on *Eustoma grandiflorum*; Khenizy [15] on *Dianthus caryophyllus*; Patil and Sathyanarayana-Reddy [16] on golden rod flowers and Shahri *et al.* [17] on *Aquilegia vulgaris* and *Consolida ajacis*. However, the finding that the vase life in cold storage conditions was less than the data recorded under room temperature agreed with Delaporte *et al.* [18] on Eucalyptus. Also, the data indicated that the best holding solution in cold

Table 1: Effect of pulsing and holding solutions on vase-life (day) of *Fatsia japonica* cut foliage under room temperature during two seasons 2012 and 2013

	Holding				Holding			
	DW	BA*	Ca EDTA	Mean	DW	BA*	Ca EDTA	Mean
Pulsing	First season (2012)				Second season (2013)			
DW	31.33	29.67	15.00	25.33	29.67	34.33	15.00	26.33
BA	41.00	43.00	15.00	33.00	42.67	44.67	15.00	34.11
CA	36.33	38.67	15.00	30.00	34.67	44.67	15.00	31.44
Clorox	38.00	36.00	15.00	29.67	31.33	41.00	15.00	29.11
Mean	36.67	36.83	15.00		34.58	41.17	15.00	
LSD value at 0.05:								
Holding:	7.19				5.70			
Pulsing:	7.25				6.91			
Interactions:	14.38				11.40			

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

Table 2: Effect of pulsing and holding solutions on vase-life (day) of *Fatsia japonica* cut foliage under storage conditions for 6 days at 4°C during two seasons 2012 and 2013

	Holding				Holding			
Pulsing	DW	BA*	Ca EDTA	Mean	DW	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
DW	21.67	21.67	10.00	17.78	20.27	20.97	10.00	17.08
BA	23.33	26.00	10.00	19.78	21.77	25.22	10.00	19.00
CA	21.67	25.00	10.00	18.89	20.67	24.50	10.00	18.39
Clorox	21.67	22.33	10.00	18.00	21.37	22.33	10.00	17.90
Mean	22.08	23.75	10.00		21.02	23.26	10.00	
LSD value at 0.05:								
Holding:	0.919				0.568			
Pulsing:	1.062				0.656			
Interactions:	1.839				1.173			

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

storage conditions was in BA (23.75 and 23.26 days) compared to the control (22.08 and 21.02 days) and Ca EDTA (10 days) in first and second seasons, respectively and this agreed with Wachowicz *et al*. [19] on cut Hosta leaves and Asil and Karimi [20] on cut Eustoma flowers.

Interaction between pulsing and holding solutions had a significant effect on prolonging vase life of *F. japonica* (43.00 and 44.67 days) in the combination of BA pulsing solution and 20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox as a holding solution compared to control (31.33 and 29.67 days) in the first and second seasons, respectively. Whereas the least vase life was recorded (15 days) from the combination of all pulsing solutions and 1g/l Ca EDTA + 20 g/l sucrose as a holding solution in the two seasons. The cold storage conditions (at 4°C for 6 days) gave similar trend for the effect of pulsing solutions in the two seasons. The prolonging effect of the interaction between pulsing and holding solution containing 10 mg/l BA on *F. japonica* cut foliage vase life may be due to that cytokinins are known to retard senescence of detached leaves by delaying proteolysis as described by Subhashini *et al.* [21]. BA has been also reported to inhibit the autocatalytic ethylene production according to Asil and Karimi [20]. However, the combination of sugars and bactericides might extend the vase life according to Asrar [22].

Weight Loss During Cold Storage: Data recorded in Table (3) showed the loss in *F. japonica* cut foliage after treating the foliage with pulsing solutions before and after the storage period at 4°C for 6 days. The data indicated that the best pulsing solution caused the least water loss in the fresh weight during cold storage was benzyl adenine and citric acid (0.183 % and 0.281%), respectively compared with the control treatment (0.556 %). The water potentials were lowered depending on the rate of transpiration which decreased by lowering temperature.

Table 3: Effect of pulsing solutions on weight loss of *Fatsia japonica* cut foliage during cold storage for 6 days at 4°C. (Weight for 6 cut foliage)

Pulsing Solutions	Before storage	After storage	Water loss %
D.W.	157.13	156.26	0.556
BA	187.60	187.26	0.183
CA	165.23	164.76	0.281
Clorox	167.62	167.03	0.357

DW: distilled water, BA: benzyladenine, CA: citric acid

Table 4: Effect of pulsing solutions on O_2 and CO_2 percentage after cold storage period (6days) at 4°C of *Fatsia japonica* cut foliage during two seasons 2012 and 2013

	O_2%	CO_2%	O_2%	CO_2%
Pulsing solutions	First season (2012)		Second season (2013)	
D.W.	12.3	2.9	12.2	2.8
BA	13.4	2.2	12.6	3.0
CA	13.3	1.9	12.5	2.6
Clorox	11.6	3.4	12.0	3.2

DW: distilled water, BA: benzyladenine, CA: citric acid

These results agreed with Çelike and Reid [23] on *Matthiola incana*. Growth regulators gave a significantly smaller loss of accumulated fresh mass percentage compared to control is in agreement with Pinto *et al.* [24] and the weight loss reduced by the application of BA according to Asil and Karimi [20] on Eustoma flowers.

CO_2 and O_2 Percentage: According to Table (4) data indicated that cold storage period (at 4°C for 6 days) decreased the respiration rate. The dry-stored cut flowers, however, remained bud tight but had lost substantial weight at the end of cold storage according to Muchiri [25] on *Eustoma grandiflorum* and the fresh weight percentage decreased in accumulated fresh mass. Theses results agreed with Geerdink *et al.* [26] on *Ctenanthe setosa*. Clorox gave the highest CO_2 percentage (3.4 % and 3.2 %) compared to CA (1.9 % and 2.6 %) in the two seasons, respectively. However the least percentage of O_2 was obtained from Clorox (11.6 % and 12.0%) in the two seasons, respectively. BA and CA gave the highest percentage of O_2 (13.4% and 13.3% and 12.6% and 12.5 % in the two seasons, respectively). The lowest percentage of CO_2 was obtained from CA pulsing solution recording 1.9% and 2.6% in the first and second seasons, respectively. These effects of BA agreed with Halevy [27] and Rabiza-Œwider *et al.* [28] on *Zantedeschia aethiopica* as well as Skutnik and Rabiza-Œwider [29] on *Asparagus setaceus*.

General Appearance: The data in Tables (5-8) indicated that BA as a pulsing solution under room temperature was the best treatment in maintaining the quality of cut foliage (3.56 and 3.22) for the two seasons, respectively compared to the control (3.11 and 2.72) after 10 days of treating the foliage. The cold storage conditions (at 4°C for 6 days) indicated that BA was the best pulsing solution treatment in improving the appearance of the cut foliage (3.11 and 2.78) compared to control (2.67 and 2.17) in the first and second seasons, respectively. The observations after 30 days indicated that stored and 20 days in non-stored cut foliage gave the best display using BA as a pulsing solution compared to the control in the two seasons. These positive effects of benzyladenine was due to delaying several processes involved in senescence including chlorophyll degradation, maintaining leaves coloration and delaying ethylene biosynthesis. These findings agreed with the findings of Philosoph *et al.* [30] on *Solidago canadensis*; Skutnik and Rabiza-Œwider [31] on *Zantedeschia aethiopica* and Reid and Jiang [3] on cut flowers and potted plants.

Regarding the effect of holding solutions, the combination of 20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox helped in enhancing the general appearance of *F. japonica* (3.50 and 3.55) compared with the control (2.83 and 2.54) in the first and second seasons, respectively. Whereas the best quality of *F. japonica* foliage was obtained from 1g/l Ca EDTA + 20 g/l sucrose as a holding solution (2.75 and 2.50) under room temperature after 30 days in the first and second seasons, respectively. The effect of Ca EDTA was due to delaying senescence, involving the protection of membrane proteins and phospholipids from degradation, thus preserving the integrity of the membranes, reducing ethylene production and hence maintaining solute transport and tissue vitality. These results agreed with Paliyath *et al.* [32] on carnation; Torre *et al.* [33] on rose and Nan [34] on sunflower. The observations indicated that after 30 days in stored and 20 days in non-stored cut foliage gave the best display from the holding solution combination 1g/l Ca EDTA + 20g/l sucrose in the two seasons. The quality of *F. japonica* foliage in cold storage conditions was less than the data recorded under room temperature. These results agreed with Bredmose [35] on cut Roses.

Interaction between pulsing and holding solutions had a significant effect on improving cut foliage quality (3.83 and 4.00) in the combination of BA as a pulsing solution and 20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox as a holding solution compared to control (2.33 and 2.00) after 10 days in the first and second seasons, respectively as mentioned in the study done by Han [36]. Whereas after 30 days the best results obtained were from the combination of BA as a pulsing solutions

Table 5: Effect of pulsing and holding solutions on general appearance of *Fatsia japonica* cut foliage after 10 days under room temperature during two seasons 2012 and 2013

	Holding				Holding			
Pulsing	DW	BA*	Ca EDTA	Mean	DW	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
DW	2.33	3.33	3.67	3.11	2.00	3.17	3.00	2.72
BA	3.17	3.83	3.67	3.56	2.66	4.00	3.00	3.22
CA	3.00	3.67	3.33	3.33	2.50	3.67	3.33	3.17
Clorox	2.83	3.17	3.00	3.00	3.00	3.33	2.66	3.00
Mean	2.83	3.50	3.42		2.54	3.55	3.00	
LSD value at 0.05:								
Holding:	0.525				0.660			
Pulsing:	0.602				0.775			
Interactions:	1.051				1.330			

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

Table 6: Effect of pulsing and holding solutions on general appearance of *Fatsia japonica* cut foliage after 30 days under room temperature during two seasons 2012 and 2013

	Holding				Holding			
Pulsing	DW	BA*	Ca EDTA	Mean	DW	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
DW	0.83	2.00	2.50	1.78	1.00	2.17	2.50	1.89
BA	1.67	2.50	3.00	2.39	1.50	2.50	2.83	2.28
CA	1.50	1.67	2.83	2.00	1.33	2.33	2.33	2.00
Clorox	1.33	2.33	2.67	2.11	1.17	1.83	2.33	1.78
Mean	1.33	2.13	2.75		1.25	2.20	2.50	
LSD value at 0.05:								
Holding:	0.307				0.410			
Pulsing:	0.356				0.479			
Interactions:	0.615				0.821			

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

Table 7: Effect of pulsing and holding solutions on general appearance of *Fatsia japonica* cut foliage under cold storage conditions for 6 days at 4°C after 10 days of putting the cut foliage in the solutions during two seasons 2012 and 2013

	Holding				Holding			
Pulsing	DW	BA*	Ca EDTA	Mean	DW	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
DW	1.83	3.17	3.00	2.67	1.67	2.50	2.33	2.17
BA	2.50	3.50	3.33	3.11	2.50	3.00	2.83	2.78
CA	2.50	2.67	3.33	2.72	2.17	2.83	2.67	2.55
Clorox	2.33	2.83	2.67	2.61	2.00	2.67	2.50	2.39
Mean	2.30	3.05	3.00		2.08	2.75	2.58	
LSD value at 0.05:								
Holding:	0.634				0.564			
Pulsing:	0.721				0.657			
Interactions:	1.269				1.129			

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

Table 8: Effect of pulsing and holding solutions on general appearance of *Fatsia japonica* cut foliage under cold storage conditions for 6 days at 4°C after 20 days of putting the cut foliage in the solutions during two seasons 2012 and 2013

	Holding				Holding			
Pulsing	DW	BA*	Ca EDTA	Mean	DW	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
DW	0.83	1.67	2.00	1.50	0.67	1.50	2.00	1.39
BA	1.50	2.33	2.50	2.11	1.67	2.17	2.83	2.22
CA	1.33	1.83	2.17	1.78	1.33	1.50	2.33	1.72
Clorox	1.00	1.67	1.83	1.50	1.33	1.83	2.17	1.78
Mean	1.17	1.88	2.13		1.25	1.75	2.33	
LSD value at 0.05:								
Holding:	0.603				0.611			
Pulsing:	0.702				0.712			
Interactions:	1.216				1.232			

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

Table 9: Effect of pulsing and holding solutions treatments on chlorophyll "a" (mg/g fresh weight) of *Fatsia japonica* leaves under room temperature during two seasons 2012 and 2013

	Holding solutions							
Pulsing Solutions	D.W	BA*	Ca EDTA	Mean	D.W	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
D.W	0.58	1.14	0.99	0.90	0.57	0.88	0.75	0.73
BA	1.12	1.35	1.29	1.25	0.83	1.09	0.90	0.94
CA	1.09	1.30	1.10	1.16	0.76	1.07	0.82	0.88
Clorox	0.91	1.20	0.98	1.03	0.74	0.94	0.78	0.82
Mean	0.93	1.25	1.09		0.72	1.00	0.81	

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

Table 10: Effect of pulsing and holding solutions treatments on chlorophyll "b" (mg/g fresh weight) of *Fatsia japonica* leaves under room temperature during two seasons 2012 and 2013

	Holding solutions							
Pulsing Solutions	D.W	BA*	Ca EDTA	Mean	D.W	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
D.W	0.30	0.56	0.58	0.48	0.25	0.33	0.42	0.33
BA	0.62	0.69	0.76	0.69	0.56	0.75	0.86	0.72
CA	0.47	0.68	0.69	0.61	0.55	0.66	0.84	0.68
Clorox	0.37	0.62	0.65	0.55	0.48	0.41	0.58	0.49
Mean	0.44	0.64	0.67		0.46	0.54	0.68	

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

Table 11: Effect of pulsing and holding solutions treatments on carotenoids (mg/g fresh weight) of *Fatsia japonica* leaves under room temperature during two seasons 2012 and 2013

	Holding solutions							
Pulsing Solutions	D.W	BA*	Ca EDTA	Mean	D.W	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
D.W	0.88	0.56	0.69	0.71	1.10	0.61	0.97	0.89
BA	0.55	0.23	0.26	0.35	0.70	0.58	0.55	0.61
CA	0.78	0.41	0.50	0.56	0.98	0.59	0.79	0.79
Clorox	0.85	0.45	0.57	0.62	1.01	0.70	0.80	0.84
Mean	0.77	0.41	0.51		0.95	0.62	0.78	

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

Table 12: Effect of pulsing and holding solutions treatments on Chlorophyll "a" (mg/g fresh weight) of *Fatsia japonica* leaves under cold storage at 4°C for 6 days during two seasons (2012 and 2013)

	Holding solutions							
Pulsing Solutions	D.W	BA*	Ca EDTA	Mean	D.W	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
D.W	0.37	0.70	0.58	0.55	0.53	0.55	0.60	0.56
BA	0.72	0.95	0.82	0.83	0.86	0.88	1.00	0.91
CA	0.60	0.84	0.79	0.74	0.66	0.82	0.79	0.76
Clorox	0.52	0.79	0.64	0.65	0.75	0.80	0.69	0.75
Mean	0.55	0.82	0.71		0.70	0.76	0.77	

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

Table 13: Effect of pulsing and holding solutions treatments on chlorophyll "b" (mg/g fresh weight) of *Fatsia japonica* leaves under cold storage at 4°C conditions for 6 days during two seasons 2012 and 2013

	Holding solutions							
Pulsing Solutions	D.W	BA*	Ca EDTA	Mean	D.W	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
D.W	0.12	0.15	0.20	0.16	0.10	0.11	0.13	0.11
BA	0.17	0.20	0.40	0.26	0.17	0.22	0.34	0.24
CA	0.16	0.19	0.28	0.21	0.12	0.20	0.20	0.17
Clorox	0.13	0.15	0.23	0.17	0.11	0.16	0.18	0.15
Mean	0.15	0.17	0.28		0.13	0.17	0.21	

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

Table 14: Effect of pulsing and holding solutions treatments on carotenoids (mg/g fresh weight) of *Fatsia japonica* leaves under cold storage at 4°C conditions for 6 days during two seasons 2012 and 2013

	Holding solutions							
Pulsing Solutions	D.W	BA*	Ca EDTA	Mean	D.W	BA*	Ca EDTA	Mean
	First season (2012)				Second season (2013)			
D.W	0.50	0.21	0.48	0.40	0.65	0.39	0.50	0.51
BA	0.25	0.16	0.17	0.17	0.43	0.12	0.14	0.23
CA	0.48	0.18	0.43	0.43	0.47	0.20	0.38	0.35
Clorox	0.59	0.19	0.44	0.44	0.55	0.32	0.45	0.44
Mean	0.46	0.19	0.38		0.53	0.26	0.37	

DW: distilled water, BA: benzyladenine, CA: citric acid, BA*: [20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox], Ca EDTA: [1g/l Ca EDTA + 20 g/l sucrose]

and 1 g/l Ca EDTA + 20 g/l sucrose as a holding solution in the two seasons (3.00 and 2.83) compared to the control (0.83 and 1.00). However, in the stored foliage the combination of 20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox) as a holding solution and BA as a pulsing solution gave the best results (3.50 and 3.00) compared to the control (1.83 and 1.67) in the two seasons. After 20 days in stored foliage the combinations of 1g/l Ca EDTA + 20 g/l sucrose as a holding solution and BA as a pulsing solution gave the best result (2.50 and 2.83) compared to control (0.83 and 0.67) in the first and second seasons, respectively. These results agreed with the finding on cut hosta leaves [19] and gerbera cut flowers [37].

Chlorophyll A, B and Total Carotenoids Contents: As shown in Tables (9-14) the data indicated that BA as a pulsing solution under room temperature recorded the best values of chlorophyll a and b content in leaves (1.25 and 0.94 mg/g FW) and (0.69 and 0.72 mg/g FW)

compared to the control (0.90 and 0.73 mg/g) and (0.48 and 0.33 mg/g FW) and gave the lowest value of total carotenoids (0.35 and 0.61 mg/g FW) compared to the best values for the control (0.71 and 0.89 mg/g) for the two seasons, respectively. The cold storage conditions (at 4°C for 6 days) gave similar trend for the pulsing solutions in the two seasons.

Most effective holding solution for maintaining best values in chlorophyll a (1.25 and 1.00 mg/g) was 20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox and in chlorophyll b (0.67 and 0.68 mg/g) was 1g/l Ca EDTA + 20 g/l sucrose compared to the control (0.93 and 0.72 mg/g) in chlorophyll a and (0.44 and 0.46 mg/g) in chlorophyll b in the two seasons, respectively. These results were in agreement with Torre *et al.* [33] and Nan [34]. The best value of carotenoids was obtained from the control (0.77 and 0.95 mg/g) in the two seasons, respectively. The cold storage conditions (at 4°C for 6 days) gave similar trend from the holding solutions in the two seasons.

Interaction between pulsing and holding solutions had a significant values for increasing chlorophyll a, b and decreasing total carotenoids by BA as a pulsing solution and 20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + 2ml/l Clorox as a holding solution which gave the best chlorophyll a content (1.35 and 1.09 mg/g FW) compared to control (0.58 and 0.57 mg/g FW) in the two seasons and BA combined with 1g/l Ca EDTA + 20 g/l sucrose) which gave the best chlorophyll b content (0.76 and 0.86 mg/g FW) compared to control (0.30 and 0.25 mg/g FW) in the two seasons, respectively in non-stored foliage. The best value of carotenoids was obtained from the control (0.88 and 1.10 mg/g FW) in the first and second seasons, respectively. The cold storage conditions (at 4°C for 6 days) gave similar trend in the two seasons. In previous studies Zavaleta-Mancera *et al.* [38] concluded that exogenous cytokinins were able to promote re-greening in yellow leaves. Moreover Petridou *et al.* [39] stated that treatment with BA increased chlorophyll content in chrysanthemum leaves and Skutnik *et al.* [40] stated the same result on Asparagus setacens. The effect of benzyladenine was due to retarding senescence of detached leaves by delaying proteolysis and chlorophyll degradation as reported by Subhashini *et al.* [21]. BA also prevents the early lack of sugar availability for respiration as it delayed leaf yellowing and senescence.

CONCLUSION

Treating *Fatsia japonica* cut foliage with BA as a pulsing solution gave the highest vase life, general appearance and Chlorophyll a. Best values of chlorophyll b was obtained from the combination 1g/l Ca EDTA + 20 g/l Sucrose as a holding solution. Best general appearance was obtained from 1g/l Ca EDTA + 20 g/l sucrose whereas this combination gave the least vas life. Clorox gave the highest percentage of CO_2 and the less percentage of produced O_2 during the storage period. CA gave the least percentage of CO_2 and the highest percentage of produced O_2 was obtained from BA. The least weight loss (%) during cold storage obtained from BA. BA and CA at 10 mg/l and 2 ml/l, respectively, were the best pulsing solutions treatments in all tested foliages. Best results in all investigated parameters were obtained from the combination of 20 g/l sucrose + 10 mg/l BA + 200 mg/l CA + Clorox 2ml/l as a holding solution.

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