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A Study on the Effect of Storage Periods and Some Packaging Materials on Some Cut Branches of Plants B-*Schefflera arboricola*

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Abstract: This experiment was conductedin the Postharvest Laboratory of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., Giza, Egypt during the two successive seasons; 2019 and 2020 to investigate the influence of different packaging materialsduring long storage periods on keeping the quality and extending the shelf life of cut *Schefflera arboricola* branches. The packaging materials were cellophane paper, news paper, kraft paper, foil paper and butter paper in addition to the control(without packaging materials) and the cold storage periods were five, twenty and sixty days at 5°C and the holding solution containingcitric acid at 0.2g/l + sucrose at 25g/l. The results emphasized that; all the packaging materials used gave positive results on all the measurements that were taken. Foil paper packaging achieved the greatest reduction in physiological loss during different storage periods and increased the moisture retention compared to the control and the rest of the different packaging materials used. Prolonging the storage period led to an increase in the percentage of loss and a decrease in the percentage of water retention.Wrapping the branches in kraft paper minimized water loss during cold storage, whilst wrapping in foil and butter paper increased the amount of water absorbed almost to the same extent. Moreover, kraft, foil and butter papers had increment effect on relative fresh weight. All packaging materials that used asthe wrappers various storage periods improved general appearance even after holding cut branches in vase solutionespecially foil paper as well as it had an excellence effect on shelf life. The obtained results cleared that by increasing the storage period of the cut branches, the shelf life was gradually reduced. Almost all packaging materials usedsignificantly increased the contents of chlorophyll (a), (b) and carotenoids in comparison with control (unwrapped cut branches), in addition they maintained the percentage of total sugars alongside with phenols content. In conclusion, all the studied packaging materials positively affected on the quality of cut branches of *Schefflera arboricola*.

Key words: *Schefflera arboricola* · Packaging materials · Physiological loss · Shelf life · Storage

INTRODUCTION

Cut foliage is one of the major components of filler crops that assume a significant place in the domestic and international markets and it makes up an important section of floral industry as cut foliages, they are used for floral decoration either alone or in association with flowers in bouquets and flower arrangements. They are gaining increasing popularity due to diversification of floricultureand lower cost of production compared to the traditional production of cut flowers. There is a great possibility for exploitation of cut foliages because of year-round production, low investment and lesser risk [1].

Schefflera arboricola (Hayata) Kanehira, (syn. *Heptapleurum arboricolum*, H. sasakii) dwarf schefflera, parasol plant, umbrella tree, dwarf umbrella tree, it is in the Araliaceae family, native to the islands of Taiwan and Hainan, China. It is an evergreen shrub reach to 3-4 m tall. The trailing stems are weak and frequently scramble over other vegetation. The leaves are palmate compound (7-9 leaflets), leaflets are 9-20 cm long and 4-10 cm across in the wild, but normally smaller when are cultivated. Flowers are produced in a 20 cm panicle of small umbels, (7-10 mm diameter), with 5-10 flowers. It is a tender frost tolerant. It needs a light shade, humid air and a regular watering. It is a popular houseplant for its ability to

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tolerate neglect and poor growing conditions. Many cultivars exist with a variety of leaf colors and patterns, with variegation ranging from creamy-white to yellow edges or centers and dwarf forms especially selected for. It can be useful as a bonsai [2].

During the post harvest management of flowers and foliages, quality determining factors like freshness or appearance and color of fresh commodities change during storage, handling and display and are greatly influenced by the pre- and postharvest factors such as cultivation period, developmental stages and postharvest conditions [3]. Storage plays a crucial role and provides an opportunity for long term shipment of cut flowersand foliages. There are various methods by which storage can be done (dry and wet cold storage), low pressure storage, controlled atmospheric storage, modified atmospheric storage etc. Storage extends the sale period and prevents surplus production from degradation that, post-harvest processing such as storage conditions and temperature determine stability, quality and economical value of the final product. This finding was demonstrated before by Vieira *et al*. [4] who found that, the use of refrigeration for storage of cut flower is very important because it reduces senescence, water loss, injury caused by microorganism thus extending the shelf- life of flowers during the storage period. The application of low temperature during storage is important factor for the conservation; it inhibits bacterial and fungal infections, reduces degradation of certain enzymes, ethylene production, sweating, breathing and slows the various processes related to growth and senescence [5].

Packaging material: the main function of packaging is to reduce respiration rate and water loss by transpiration and injurious atmosphere inside the package. A number of packaging materials are used while placing flower spike for storage most frequently used are polyolefin, cellophane, butter paper, newspaper etc. to minimize friction damage during transport. The spikes of gladiolus dry-stored in polyethylene sleeves showed considerable decline in post-storage vase life and opening of florets with an increase in storage duration. Storage extends the marketing season and regulates marketing in times of glut production. An appropriate method of storing flowers offers the possibility of long term shipment [6]. Pre-storage pulsing with 8-HQ+sucrose gave higher water uptake, maintained anti-oxidative defense, decreased lipid peroxidation and ion leakage that led to a delay in cut flowers senescence [7]. Keeping quality is an important parameter for evaluation of cut flower quality for both domestic and export markets. With increasing the demand in different parts of the country, there is a need to transport the flowers to long distances in an attractive condition which requires good transportation facilities and the use of suitable packaging materials and preservative chemicals.

So the current work was done to extend the shelf life of schefflera cut foliage(branches) by using different packaging methods and materials to select the best one used in the current research during cold storage.

MATERIALS AND METHODS

The present trial was undertaken at the Postharvest Laboratory of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., Giza, Egypt during two consecutive and successive seasons 2019 and 2020, to elicit the response of cut branches of dwarf umbrella tree foliage (*Schefflera arboricola*) to wrap with some wrapping materials under storage at various periods.

Plant Material: Cut branches (foliage) were obtained freshly from the well-known local commercial farm in Al-Qanater Alkhayriuh, Egypt, in the two seasons. Cut branches were picked in the early morning and directly wrapped in groups and transported quickly to the laboratory within nearly an hour. As soon as arrived to the Lab, these branches were firstly pre cooled by placing in cold water for half hour to remove the effect of high field heat. Thereafter, stem bases were re-cut under water to avoid air embolism before treatments and stems were adjusted to the same size and shape (stem length about 40cm). Injury-free stems were selected for the experiment.

Experimental Conditions: Cut branches were placed in ambient conditions at 24±1°C, light level was about 15 μmol $m^{-2}S^{-1}$, partially from natural light and partially from fluorescent cool light 12h/day.

Experimental Design and Treatments: The cut branches of dwarf umbrella tree were pulsed for half an hour in solution contained sucrose at 25 g/l + citric acid at 0.2g/l and were subjected to 5 types of packaging materials in addition to control with 3 replications under 3 storage periods that:

- Storage for five days ($St._1$).
- Storage for twenty days ($St._2$).
- Storage for sixty days ($St._3$).

All cut branches were stored at 5°C, at the end of storage, it arranged in a completely randomized design and stems were inserted in glass bottles (500 ml) containing 400 ml of citric acid at0.2g/l + sucrose at 25g/l, after that, each bottle was covered at its mouth with cellophane wrap to prevent evaporation. Treatments (packaging materials) were as following:

(T_0) Without wrapping as control.
(T_1) Wrapping with cellophane paper.
(T_2) Wrapping with news paper.
(T_3) Wrapping with kraft paper.
(T_4) Wrapping with foil paper.
(T_5) Wrapping with butter paper.

Experimental Measurements

Physiological Loss in Weight (PLW): It was expressed as percentage of relative weight loss after storage to the initial weight.

PLW (%) = $\frac{IWa - FWa}{IWa}$ x 100, where IWa: initial fresh weight of cut foliage branches and FWa : final weight, according to Safeena *et al.* [8].

Moisture retention ratio:the percentage of plant retention of moisture.

Water Loss: Expressed as water loss (ml.gfw^{-1}) = $\frac{Tt-1-Tt}{FW0}$

where: Tt= weight of flower plus vase containing water or solution (g) at days, T_{t-1}= the weight of flower plus vase containing water or solution (g) at the previous day, FW_0= the weight of flower (g) at day $_0$. [9]

Water Uptake: It was evaluated as the amount of the solution (g) at the beginning of the experiment subtract the amount of the solution remaining at the end of the experiment, according to Safeena *et al.*[8]

Relative fresh weight (RFW): RFW (%) = (FWt / FW_0) ×100. Where FWt = weight of flower (g) at days after vase incubation, FW_0 = weight of flower (g) at day 0 [10].

General Appearance: Evaluated based on a scale ranging where 1= bad (25 %)greenish yellow, 2= moderate (25 to 50%) yellowish green, 3= good (50 to75 %) slightly yellowish and 4= excellent (75 to 100%) completely healthy, according to Sangwanangkul *et al.*[11].

Shelf Life: It was determined as the number of days from starting the experiment to the fading stage (days).

Chemical Analysis

Photosynthetic Pigments: The content of chlorophyll (a), (b) and carotenoids (mg/g fw) were estimated according to Saric *et al.* [12].

Total Sugars: Determination of total sugars (%) in leaves according to Dubois *et al*. [13].

Total Phenols: Determination of total phenols percentage in leaves was done according to Ferrante *et al*. [14].

Statistical Analysis: Data were tabulated and subjected to analysis of variance as a factorial experiment using MSTAT-C statistical software [15]. Means of treatments were compared by Duncan's Multiple Range Test at 5% level as indicated by Waller and Duncan [16].

RESULTS AND DISCUSSION

Physiological Loss in Weight: Data illustrated in Table (1) showed that, the physiological loss of weight during storage of *Schefflera arboricola* cut branches was significantly influenced with different packaging materials during entire storage periods. Among the different packaging materials, foil paper recorded, the lowest percent of physiological loss in the two seasons. It reduced the physiological loss with a significant difference from the rest of wrappers, especially cut branches stored without packaging, wrapping cut branches as foil paper recorded 8.14 and 7.38% compared to 70.22 and 58.80 % control, while the second rank occupied by wrapping cut branches by kraft paper giving 34.84 and 33.41% in the first and second seasons, respectively. The results confirm that the packaging maintains higher humidity, which slows down the process of moisture loss and proper balance of carbon dioxide and oxygen concentrations, which in turn reduces the process of respiration and this might be the reason for recording least physiological loss. Moreover the role of packaging materials in reduction physiological loss of w eight was reviewed by Pacifici *et al.* [17] who mentioned that the packaging systems play an important role in preventing water losses (physiological loss), product damage and reducing transportation costs [18]. The result was found significant and minimum physiological loss of weight was registered from almost all packaging giving the lowest physiological loss of weight, which may be due to the modified atmosphere in around cut branches. It was probably due to the gaseous composition and higher relative humidity in packaging.

Table 1: Influence of packaging materials on physiological loss and moisture retention ratio (%) of *Schefflera arboricola* cut branches under three cold storage periods during 2019 and 2020 seasons

Packaging materials	Physiological loss(%) Storage periods St.$_1$	St.$_2$	St.$_3$	Mean	Moisture retention ratio(%) Storage periods St.$_1$	St.$_2$	St.$_3$	Mean
First season								
T_0	65.32c	66.17b	79.18a	70.22A	34.68o	33.83p	20.82r	29.78F
T_1	34.41k	42.71h	58.17d	45.10B	65.59g	57.29j	41.83n	54.90E
T_2	29.27m	39.69i	46.37f	38.44C	70.73f	60.31i	53.63l	61.56D
T_3	31.01l	28.01n	45.49g	34.84E	70.70f	71.99e	54.49k	65.72B
T_4	5.21r	7.57q	11.65p	8.14F	94.79a	92.43b	88.35c	91.86A
T_5	36.60j	20.15o	53.90e	36.88D	63.40h	79.85d	46.10m	63.12C
Mean	33.64C	34.05B	49.13A		66.64A	65.95B	50.87C	
Second season								
T_0	60.73a	61.01a	54.65c	58.80A	39.27n	35.66o	42.67m	39.20E
T_1	31.32i	39.17f	57.34b	42.61B	68.68g	60.83j	42.66m	57.39D
T_2	25.43k	35.25g	44.45e	35.04C	74.57e	64.75i	55.55k	64.96C
T_3	30.37j	25.53k	44.32e	33.41D	69.63f	74.47e	55.68k	66.59B
T_4	4.50o	7.25n	10.39m	7.38E	95.50a	92.75b	89.61c	92.62A
T_5	33.16h	15.45l	52.10d	33.57D	66.83h	85.05d	47.90l	66.59B
Mean	30.92B	30.61C	43.87A		69.08A	68.91B	55.67C	

(T_0): control. (T_1):cellophane paper. (T_2):news paper. (T_3):kraft paper. (T_4):foil paper. (T_5):butter paper (St.$_1$): five days. (St.$_2$): twenty days. (St.$_3$): sixty days

In relation of the effect of storage periods it was found that this value recorded comparatively more physiological loss during long storage for sixty days which were 49.13 and 43.87 % compared to various types of packaging materials and stored in ambient cold storage for five days which gave 33.64 and 30.92 % in the two seasons, respectively. Data proves that prolonging the storage period increased the physiological loss gradually during first season, theincreasing trend was supported by Hong *et al*. [19] who evaluated the vegetable weights that lost gradually as time went along and a linear relationship was found. This finding was also confirmed by van Doorn and Han [20] who found that thelong periods of cold storage have been previously identified as having a negative effect on the length of the vase life. The highest physiological weight loss percent was observed in *Jasminumsambac* cv. Gundumalli flowers after they treated with water and packed in 40-micron polyethylene sheet and stored at room temperature compared to cold storage [21].

As for the interaction treatments among the packaging materials and the storage periods on thephysiological loss of cut branches, data in Table (1) declared that, wrapping the cut branches in foil paper was the most superior treatment, as it gave 5.21 and 4.50 % in the first and second seasons, respectively whilst cut branches without wrapping gave the maximum percentage of loss as were 65.32 and 60.73 % in the same cold storage period(short period). This established the importance of using packaging materials during storage periods, especially long ones due to minimized physiological loss in cut branches. This finding was demonstrated by Goszczynska and Rudnicki [22]; Joti and Balakrishnamoorthy [23] on rose cv. Happiness; Singh and Mirza [24] on cut rose, Jain *et al*. [6] on rose, Anju *et al*. [25] on chrysanthemum, Beaura and Singh [26] on gladiolus and Sharma *et al*. [27] on Asiatic lily cv. Apeldoorn. Weight loss is a physiological trait not only can be limited by controlling storage temperature and durations, but also by using appropriate packaging. This result may be due to the better balance between CO_2 and O_2 concentrations inside the packaging material which was achieved by faster cooling rate and precooling which improved the keeping quality [28]. Also, it may be attributed to the percent of physiological loss in weight when cut flowers were stored at lower temperature and smallvapour pressure deficit causing less moisture as well as weight loss. Moreover, low cold storage temperature slows down transpirational loss of water and carbohydrates which reduces the loss of weight during storage. The results are in conformity with the findings of Srivastava *et al*. [29]. Khongwir *et al.* [30] explained that the higher physiological loss in weight was reported in control treatment compared with all packing in cut *Polianthestuberose* flowers.

Moisture Retention Ratio: The data pertaining to moisture retention of *Schefflera arboricola* cut branches with different packaging materials in Table (1) showed that, the moisture retention of cut branches was significantly influenced with different packaging materials during entire storage periods. The data revealed that the maximum ratio was obtained by packing cut branches in foil paper then stored at 5°C, recording the highest percentage of moisture retention ratio as 91.86 and 92.62% in comparison with cut branches without packaging which recoded 29.78 and 39.20% in the first and second seasons respectively. Packaging materials help to maintain the turgidity of cut branches by retaining themoisture apart from lack of photosynthesis then, moisture retention was maximized using foil paper as packaging material, there will bebetter maintenance of general condition. The main principle of packaging is towards long storage life, keeping quality, lower the rate of transpiration and respiration. Hence, the ideal packaging should be airtight, water proof and strong enough to withstand handling [31]. In a similar way, Varu and Barad [18] postulated that, the loss of water was reduced packing *Polianthes tuberosa* in metal paper. It might be due to lower permeability with high concentration of CO_2 as compared to O_2 leads to higher retention of water in the spike with higher turgidity, freshness and better transpiration pool.

With reference to the influence of diversified storage periods on water retention of cut branches, the obtained data were significantly differences with different storage durations. The percentage of moisture retention of cut branches rapidly decrease with increase the duration of cold storage. As for the storage for 5, 20 and 60 days they produced 66.91, 65.64 and 50.87 %in the first season, in parallel with second season as 69.08, 68.91 and 55.67 %, respectively.

Regarding the interaction between treatments and storage periods, all the tested treatments had a positive and distinctive effect on the cut branches whereas cut branches without packaging at various cold storage periods recorded the lowest percentage of moisture retention. The first rank is occupied by the use of foil paper for wrapping branches and stored for five days in cold storage, followed by used news paper gave a significant difference in comparison with control treatment. Similar observations were also attained by Miano *et al.* [32] who proved that the best packaging material was newspaper because it has moisture balancing capacity, which reduces the risk of fungal diseases and chilling injury and maximized water uptake which ultimately extended vase life of orchid, newspapers are easily available, low cost and have no harm or pollution to environment. Normally the treatment resulting in more moisture retention percentage of cut foliages is considered good because these may result in longer shelf life as compared to those showing less ones.

Water Loss: It is evident from the data presented in Table (2) that all treatments decreased the rate of water loss compared to control, with significant differences among almost all of the studied treatments including the control. The control treatment achieved high rates of water loss through the three storage periods. Cut schefflera branches wrapped by kraft paper reduced the rates of water loss and showed superiority in this assignment, as it gave 0.92ml.gfw^{-1} in thetwo seasons with comparison to control which gave 2.36 and 2.38ml.gfw^{-} in the first and second seasons, respectively.Considering the effect of storage periods on loss of water, it turns out thatthe rate of water loss gradually increased with the increase in the storage period. Whereas, storing the cut branches for five days gave the lowest rates of water loss. On the contrary, when it stored for sixty days, it gave the highest rates of water losswhile storing for twenty days had a median rank between them in the two seasons under low temperatures. Temperature is the easiest option adopted to increase the relative humidity to within 90 to 95 percent so as to prevent water loss in cut flowers [33]. Moreover, the low cold storage temperature slows down transpirational loss of water and carbohydrates which reduces the loss of weight during storage.

The interaction between storage periods and wrapping materials showed that the treatment by wrapping the harvested branches with kraft paper achieved a clear progress in terms of reducing the rate of water loss, especially when using storage for a period of five and sixty days, as it gave in the first period (five days) 0.65 and 0.63ml.gfw^{-1} in the first and second seasons, respectivelyand also after storage for the longest period used in this study was 1.41 and 1.43ml.gfw^{-1} in comparison with the control that more comprehensively achieved the highest rates of water loss during the experiment.

Under the storage for a period of twenty days, it was found that the rate of water loss was reduced in cut branches, treated by wrapping in newspaper (0.69 and 0.70ml.gfw^{-1} in the first and second seasons, respectively), which was theoptimal treatment, without a significant difference with kraft paper treatment (0.71 and 0.72 ml.gfw^{-1} in the first and second seasons respectively). Hence, the cut branches were wrapped with

Table 2: Influence of packaging materials onwater loss(ml.gfw^{-1}) andwater uptake(g) of *Schefflera arboricola*cut branches under three cold storage periodsduring 2019 and 2020 seasons

	Water loss (ml.gfw^{-1})				Water uptake (g)			
	Storage periods				Storage periods			
Packaging materials	St. $_1$	St. $_2$	St. $_3$	Mean	St. $_1$	St. $_2$	St. $_3$	Mean
				First season				
T_0	0.96ef	2.02b	4.11a	2.36A	14.72i	13.12j	12.14k	13.33C
T_1	0.82e-g	0.87e-g	1.50d	1.06C	19.65c	17.36ef	16.80g	17.94A
T_2	0.75fg	0.69g	1.72c	1.05C	18.71d	15.39h	15.27h	16.46B
T_3	0.65g	0.71g	1.41d	0.92D	21.24a	16.43g	15.59h	17.75A
T_4	0.79e-g	0.99e	2.14b	1.31B	19.52c	17.80e	16.86fg	18.06A
T_5	080e-g	0.75fg	1.57cd	1.04C	20.51b	16.94fg	16.55g	18.00A
Mean	0.80C	1.01B	2.08A		19.06A	16.17B	15.53C	
				Second season				
T_0	0.95f	2.04b	4.16a	2.38A	15.35g	13.29h	12.37i	13.67D
T_1	0.79f-h	0.88fg	1.81c	1.16C	19.76c	17.61e	16.82f	18.06AB
T_2	0.71gh	0.70gh	1.72cd	1.04D	18.83d	15.56g	15.32g	16.57C
T_3	0.63h	0.72gh	1.43e	0.93E	21.31a	16.54f	15.63g	17.83B
T_4	0.73gh	1.30e	2.21b	1.41B	19.70c	17.92e	16.93f	18.18A
T_5	0.79f-h	0.76f-h	1.61d	1.05D	20.67b	17.59e	16.67g	18.31A
Mean	0.77C	1.07B	2.16A		19.27A	16.42B	15.62C	

(T_0):control. (T_1):cellophane paper. (T_2):news paper. (T_3):kraft paper. (T_4):foil paper. (T_5):butter paper ($St._1$): five days. ($St._2$): twenty days. ($St._3$): sixty days

newspaper, it had a strong effect on reducing water loss and one of its advantages is that it is a cheap-priced material as well as being environmentally friendly. It can be inferred out that shorter storage duration with suitable packaging materials maximized the benefits from wrapping materials than longer durations.

Water Uptake: Data in Table (2) showed that all packaging materials used in this experiment raised the amount of water uptaken by cut foliage of *Schefflera arboricola* throughout the various storage periods with significant differences as compared to the amount absorped by cut branches without packaging which clarify the impact of the importance of packaging on the absorption process. These findings agreed with the findings of Gawde *et al.* [34] who found that the minimum water uptake was recorded under control (without packaging) compared to packaging cut spike of tuberose cv. Shringar. Wrapping cut branches in foil and butter paper recorded the utmost high amount of water uptake during vase life in the two seasons with no significant difference among the two packaging materials. These results are in harmony with the findings of observed by Happy *et al*. [35] who found that wrapping cut spikes of *Polianthes tuberosa* in butter paper gave maximum amount while the minimum amount of solution consumed was observed by unwrapped cut spikes.

Regarding the effect of storage periods on water uptake of cut branches, it is logical that the most important components of cold storage technique which might adversely affect quality are water loss during storage, low temperature injury, continued ageing during the increasing time at low temperature led to decreasing in water uptake during shelf life. The results recorded on cut branches were significantly influenced by the duration of storage. The cut branches of schefflera stored for five days recorded the maximum amount of solution consumed during vase life while the other stored for sixty days recorded the minimum amount of solution consumed. Therefore, with increasing the storage duration the water uptake decreasing. Similar results are reported by Shil *et al*. [36] and Happy *et al*. [35] on cut spikes of tuberose.

As for the interaction between treatments obviously in the long term of the storage period, treating by foil paper showed a great efficiency in the process of wrapping the cut branchesmeanwhile storing for twenty and sixty days. Foil paper as a wrapperproved a high efficiency where it gave 17.80 and 16.86 g compare to 13.12 and 12.14 g from control at the second and third storage periodssequentially in first season as well as it gave 17.92 and 16.93 g compare to 13.29 and 12.37 g from control at the second and third storage periods in second one. This may beattributed to the fact that water uptake

Table 3: Influence of packaging materials onrelative fresh weight(%), general appearance andshelf life(days) of *Schefflera arboricola* cut branches under three cold storage periodsduring 2019 and 2020 seasons

	Relative fresh weight (%)				General appearance				Shelf life (days)			
	Storage periods				Storage periods				Storage periods			
Packaging materials	St. $_1$	St. $_2$	St. $_3$	Mean	St. $_1$	St. $_2$	St. $_3$	Mean	St. $_1$	St. $_2$	St. $_3$	Mean
First season												
T_0	43.29l	46.36k	43.56l	44.40E	1.22j	1.33j	1.33j	1.29E	7.00l	6.00m	5.00n	6.00E
T_1	55.79g	58.14d	56.26fg	56.73C	3.66a	2.22hi	3.00cd	2.96C	8.67ij	11.00d	9.33gh	9.67C
T_2	52.80hi	52.21i	51.45j	52.15D	2.55fg	2.00i	2.00i	2.18D	9.67fg	9.00hi	7.67k	8.78D
T_3	67.44a	56.47f	53.22h	59.04B	3.00cd	3.67a	2.33gh	3.00C	13.00a	10.00ef	8.33j	10.44B
T_4	57.24e	62.29b	58.28d	59.27AB	3.89a	2.89de	3.33b	3.37A	11.67bc	12.00b	11.00d	11.56A
T_5	62.36b	60.20c	55.78g	59.45A	3.67a	3.22bc	2.67ef	3.18B	10.33e	11.33cd	10.00ef	10.55B
Mean	56.49A	55.94B	53.09C		3.00A	2.55B	2.44C		10.06A	9.89A	8.56B	
Second season												
T_0	43.73l	46.60j	44.38k	44.90D	1.33i	1.55i	1.55i	1.48D	7.00i	6.33j	5.33k	6.22F
T_1	56.40fg	58.48e	56.43fg	57.10B	3.77a-c	2.55g	3.22d	3.18B	9.00g	11.00d	9.67f	9.89D
T_2	53.58h	52.36i	52.37i	52.77C	2.67fg	2.11h	2.11h	2.29C	10.00ef	9.67f	8.00h	9.22E
T_3	69.00a	56.62f	54.18h	59.93A	3.22d	4.00a	2.44g	3.22B	13.00a	10.00ef	8.33h	10.44C
T_4	59.09e	62.29c	58.81e	60.06A	4.00a	3.11de	3.55c	3.55A	11.67bc	12.00b	11.33cd	11.67A
T_5	63.50b	60.32d	55.85g	59.89A	3.89ab	3.67bc	2.89ef	3.48A	11.00d	11.67bc	10.33e	11.00B
Mean	57.55A	56.11B	53.67C		3.15A	2.83B	2.63C		10.28A	10.11A	8.83B	

(T_0):control. (T_1):cellophane paper. (T_2):news paper. (T_3):kraft paper. (T_4):foil paper. (T_5):butter paper ($St._1$): five days. ($St._2$): twenty days. ($St._3$): sixty days

decreased in thecut flowers as the storage duration increased as the ability ofxylem cells to absorb water continuously decreased asthe duration of storage increased. In case of unpackaged flowers, undesired gaseous equilibrium might have appeared causing higher cell damage resulting in poor water uptake as also earlier observed by Punetha and Srivastava [37].

Relative Fresh Weight: As shown in Table (3) data indicated that among various packaging materials, butter paper was the proper packaging one for cut branches which was important factor in increment and maintain relative fresh weight after take it out of storage. The highest increase was gained by butter paper in the first season compared to control and even other treatments. On the other hand, in the second season, wrapping cut branches in foil paper gave maximum percentage of fresh weightfollowed by kraft paperafterwards butter paper with slight difference between them but no significant.This confirms the importance and necessity of using suitablepackaging materials during storage of branches to improve the relative weight after holding them in the solution. This general effect was confirmed by Mazumder *et al.* [38] on cut tuberose spikes. Dastagiri *et al.* [39] recorded minimum percent weight lossin cut sspikes wrapped in cellophane paper in *Ornithogalum thyrsoides*. This reduction of weight loss might be due to the reason that these wrapping materials prevented the water loss and maintained high relative humidity which helped in reducing weight loss from cut stems. Similar result found by Gawde *et al.* [34] who reported that, packaging gladiolus cut spikes by film gave a highly percent of weight. Also, Sisodia *et al.* [40] found that, maximum weight of spike of gladiouls cv. Punjab Dawn at third, sixth and ninth day was observed with spikes stored in cellophane paper followed by brown paper and news paper treatments. Significantly lower weight of spike was recorded with control condition.

The obtained results showed the impact of storage periods on relative fresh weight of cut schefflera. The gradual increase in the storage period negatively affected the relative fresh weight of the cut branches in the two seasons. This may be attributed to carbohydrate depletion and oxidative stress during cold storage that explain the mechanism for the decrease in fresh weight of stored cut branches then rapid senescence which corresponds toRanwala and Miller [41] on hybrid lilies. These results are in agreement with the findings of Chore *et al.* [42] who postulated that the decrease in fresh weight increased as the storage duration increased from 4 to 5 days in cut gladiolus. Concerning to the interaction effect of packaging materials and cold storage periods, the results revealed that using a five-days storage period for the harvested schefflera branches after being wrapped them in kraft papers gave the highest percentage of fresh weight, while the foil had this great effect on the relative fresh weight when storing the cut branches for sixty days of cold storage. Wrapping cut branches in kraft paper prior stored for five days in cold storage maintained fresh weight (67.44 and 69.00% in the first and second seasons, respectively) compare to control as gave least percentage (43.29 and 43.73 % in the first and second seasons, respectively). In addition usingfoil paper was optimum packing material for cut branches in long storage periods giving 62.29 and 58.28 % compared to control which gave 46.36 and 43.56 % in twenty and sixty days, respectively cold storage in the first season. Also, usage the foil paper gave 62.29 and 58.81 % compared to control which gave 46.60 and 44.38 %, respectively in twenty and sixty days, cold storage in the second season. The use of different wrapping materials during storage creates a modified atmosphere which reduces metabolism during storage, thereby minimize carbohydrate consumption. This might be based on the fact that wrapping materials decrease the rate of respiration by generating a modified atmosphere as limit oxygen and highly carbon dioxide concentration which reduce the rate of respiration and decrease the loss of stored energy and maintain percentage of fresh weight.

General Appearance: The importanceof the process of using packaging materials on the quality of the appearance of cut branches presented in Table (3) it showed that all packaging materials used during this study showed a remarkable superiority in improving the general appearance of the cutschefflera branches. Wrapping cut branches in foil paper was the best treatment in maintaining the quality in both seasons (3.37 and 3.55), while cut branches without packaging gave minimal value (1.29 and 1.48). Regarding the effect of various storage periods on quality of general appearancethe effect rates varied during the different storage periods and showed an important fact that with prolonging storage period of the harvested schefflera branches, the quality rate of these branches decreases. The results from Table (3) showed that the three storage periods of five, twenty and sixty days gave 3.00, 2.55 and 2.44 in the first season and 3.15, 2.83 and 2.63 in the second season. This might be due that the shorter storage periods did not reduce stored food and the modified atmosphere created by wrapping materials retarded metabolic processes such as respiration and moisture loss. Similar results were also reported by Murry [43] in tuberose.

Concerning the interaction between the effects of all packaging materialsand storage periods, the data presented in Table (3) revealed that in both seasons, significant differences in the value of general appearance existed between cut branches treated with different combinations of packaging materials and storage periods. Wrapping cut branches in foil paper was the superior when it stored for the long period of cold storage (sixty days) in both seasons. Cellophane paper packaging in the same storage period ranked second in the degree of packaging to maintain quality with a small significant difference from the best treatments. This shows the importance of the packaging process itself, with most packaging materials that succeed in maintaining the quality of the stored product. These results are also in accordance withMakhwana *et al.* [44] who found that packing cut rose flowers by polypropylene at the cold storage conditions gave the retained best flower quality, as for Senapati *et al.* [45] found thatflowers should be wrapped in soft paper to absorb condensed moisture appearing on the bloom. Also, Jadhav [46] on marigold flowers. These results have been interpreted by Dastagiri *et al.* [39] who pointed that, the best appearance of retaining maximum color and freshness scoring of chincherinchee cut flowers when wrapped in cellophane paper. This might be due to the fact that this wrapping material reduces the rate of respiration by creating a sort of modified atmosphere with limited oxygen and higher carbon dioxide concentrations. The limited oxygen concentration can retard the rate of respiration as oxygen is needed for this process. This condition in turn reduces depletion of stored food and maintaining appearance. Kumar *et al.* [47] found that, the highest freshness index in packaging *Polianthes tuberosa*. Newly Sharma *et al*. [48] found that best freshness index in flowers packed in the cellophane gave 3.63 compared to 3.17 in newspaper as packaging materials for marigold flowers and the storage duration gave more score (3.76 out of 5) was obtained by the flowers stored for three days than the flowers stored for the six days. spoilage was 15.03% in storage for 3 days but it increased to 28.49% at 6 days storage.

Shelf Life: According to data in Table (3) pointed out the importance of using various packaging materials in this investigation and their effect on the survival period of the cut branches after placing them in the permanent solution. Generally, all packaging materialsgave a positive effect and extended the shelf life. This finding was demonstrated before by He *et al.* [10] who postulated all bagging treatments extended the vase-life of grevillea cut stems and agree with them Pal *et al*. [49] declared that differenttypesofpackagingdesigns/materialshavebeensu ccessfully employed for extension of shelf lifeof cutflowers. Results showed that wrapping in foil paperwas the most efficient treatment which prolonged the cut branches shelf life (11.56 and 11.67 days) compared to control (6.00 and 6.22 days) in the first and second seasons, respectively also Abdel-Kader *et al.* [50] proved that aluminum foil improved the shelf life of the *Rosmarinusofficinalis* through creating a modified atmosphere inside the package that would lead to delaying the senescence. Also, Senapati *et al.* [45] found thataluminium lamination foil is used to enhance the shelf life of flowers under different temperature conditions. Concerning the effect of storage periods on the shelf life of schefflera branches, extending storage periods ultimately have adverse effect and may be increase microbial proliferation. These results are in agreement with those obtained by Bayleyegn *et al.* [51] on cut rose and Baidya and Chakrabarty [52] on *Polianthes tuberosa* and Skutnik *et al.* [53] on poeny flowers. The shelf life influenced by interaction between the packaging materials and storage periods, treated cut branches by kraft paper and stored it for five days gave the highest shelf life compared to control and other treatments. Bestwrapper after foil paper was butter paper then cellophane paper when stored cut branches for twenty and sixty days. Similar results are reported by Farooq *et al.* [54] pointed that flowers of *R. hybrida* L. cv. Kardinal were kept in aluminum lamination foil and stored in cold storage and had a maximum vase life days also, Jawaharlal *et al.* [55] on *Jasminum sambac*. The idealistic treatment after the foil paper was butter paper and the next one was the cellophane paper in both seasons. The results are in conformity with the findings of Sisodia *et al.* [40] found that cellophane paper gave longest shelf life of gladiolus spikes. These may be attributed to wrapped cut branches has higher moisture retention and further storing them at low temperature resulted in lower metabolic activities like respiration, transpiration and maintained high humidity. Moreover, the beneficial effect of cold storage was due to the fact that it not only affects metabolic and physical activities of microbes but also reduces the rate of ethylene biosynthesis as well as the effectiveness of ethylene in promoting deteriorative processes [29]. Analogous observations were also elicited by Archana *et al*. [56] on tuberose.

Photosynthetic Pigments

Chlorophyll (a), (b) Andcarotenoids: Data presented in Table (4) revealed that, the chlorophyll (a), (b) and the carotenoids contents increased as a result of wrapping the cut branches with various packaging materials before storing them in cold storage. It was found that foil paper had the greatest effect on plant pigments, as it preserved the pigment content of the cut branches of *Schefflera arboricola*. Wrapping in foil paper gained 0.677 and 0.679mg/g fwcompared to 0.388 and 0.401 mg/g fw from control in connection to the content ofchlorophyll (a) in the two seasons. In relation to chlorophyll(b), the same treatment gave the highest amount as 0.443 and 0.441mg/g fw compared to the lowest amount from control 0.228 and 0.230mg/g fw.in both seasons.Furthermore, the content ofthe carotenoids with the supreme as 0.275 and 0.274mg/g fw.compared to control which had 0.187mg/g in the two seasons.

These results are in accordance with those obtained by Rashed and Younis [28] they elicited that packaging materials are very useful for maintaining the content of chlorophylls. The superior were polypropylene andpolyvinyl chloride shrink than the other package delayed the degradation of chlorophyll may be due to the best modified effect of it on CO_2 and O_2 inside package in *Origanum syriacum*. Regarding the effect of storage periods, the results cleared that raising the levels of chlorophyll (a), (b) and the carotenoids contents were the highest during storage for a short period, while storage for a long period led to the degradation of a large part of the photosyntheticpigments content in both seasons. These findings go in line with those explored by Ferrante *et al.* [57] on eucalyptus and Amin [58] on some cut foliage. The interaction treatments improved all the packaging materials used in this experiment led to the preservation of the content of pigments in the cut branches, but with an increase in the storage period, this effect decreased. Utilize the kraft paper during cold storage for five days gave the highest contents of photosynthetic pigments as chlorophyll (a), (b) and carotenoids in the two seasons.

Total Sugars: It is obvious from data averaged in Table (5) that all packaging materials had a great influence in total sugars content of cut branches in both seasons. Wrapping cut branches in foil paper scored the highest content of total sugars (1.075 and 1.079%) in comparison with control (0.115 and 0.114%) in the first and second seasons, respectively. This may be attributed to packing leading to the evolution of beneficial balance of modified atmosphere with high CO_2 and low O_2 and high relative humidity within the package, which further might have caused closure of stomata and minimized the respiration loss of water as well as loss of carbohydrates [59]. Regarding the effect of storage periods on total sugars it cleared the arrangement of storage periods in ascending order increases sugar content in descending order in both

Table 4: Influence of packaging materials on chlorophyll (a), (b) and the carotenoids (mg/g f.w)of*Schefflera arboricola*cut branches under three cold storage periods during 2019 and 2020 seasons

	Chlorophyll a				Chlorophyll b				Carotenoids			
	Storage periods				Storage periods				Storage periods			
Packaging materials	St.$_1$	St.$_2$	St.$_3$	Mean	St.$_1$	St.$_2$	St.$_3$	Mean	St.$_1$	St.$_2$	St.$_3$	Mean
First season												
T_0	0.492	0.400	0.273	0.388	0.285	0.206	0.194	0.228	0.201	0.197	0.164	0.187
T_1	0.641	0.600	0.385	0.542	0.405	0.388	0.310	0.367	0.254	0.236	0.200	0.230
T_2	0.694	0.541	0.316	0.517	0.442	0.357	0.296	0.365	0.275	0.210	0.177	0.220
T_3	0.857	0.592	0.342	0.597	0.490	0.364	0.292	0.382	0.316	0.224	0.189	0.243
T_4	0.832	0.789	0.411	0.677	0.483	0.462	0.384	0.443	0.310	0.285	0.231	0.275
T_5	0.780	0.740	0.401	0.640	0.467	0.431	0.379	0.425	0.301	0.274	0.216	0.263
Mean	0.716	0.610	0.354		0.428	0.368	0.309		0.276	0.237	0.196	
Second season												
T_0	0.496	0.430	0.277	0.401	0.286	0.210	0.196	0.230	0.200	0.194	0.169	0.187
T_1	0.645	0.607	0.386	0.546	0.411	0.381	0.309	0.367	0.256	0.237	0.203	0.232
T_2	0.697	0.542	0.318	0.519	0.448	0.352	0.297	0.365	0.274	0.218	0.181	0.224
T_3	0.861	0.590	0.340	0.597	0.495	0.360	0.285	0.380	0.314	0.229	0.188	0.243
T_4	0.838	0.784	0.415	0.679	0.488	0.457	0.380	0.441	0.308	0.287	0.229	0.274
T_5	0.784	0.752	0.395	0.643	0.462	0.429	0.372	0.421	0.300	0.279	0.211	0.263
Mean	0.720	0.617	0.355		0.431	0.364	0.306		0.275	0.240	0.196	

(T_0):control. (T_1):cellophane paper. (T_2):news paper. (T_3):kraft paper. (T_4):foil paper. (T_5):butter paper (St.$_1$): five days. (St.$_2$): twenty days. (St.$_3$): sixty days

Table 5: Influence of packaging materials on total sugars (%)andtotal phenols (%) of *Schefflera arboricola*cut branches under three cold storage periodsduring 2019 and 2020 seasons

	Total sugars				Total phenols			
	Storage periods				Storage periods			
Packaging materials	St.$_1$	St.$_2$	St.$_3$	Mean	St.$_1$	St.$_2$	St.$_3$	Mean
First season								
T_0	0.136	0.113	0.098	0.115	0.067	0.052	0.028	0.049
T_1	1.085	1.000	0.761	0.948	0.164	0.155	0.116	0.145
T_2	1.115	1.042	0.252	0.803	0.171	0.144	0.057	0.124
T_3	1.135	1.080	0.640	0.951	0.289	0.151	0.097	0.179
T_4	1.130	1.103	0.993	1.075	0.275	0.250	0.174	0.233
T_5	1.122	1.099	0.950	1.057	0.242	0.182	0.125	0.183
Mean	0.953	0.906	0.615		0.201	0.155	0.099	
Second season								
T_0	0.139	0.117	0.088	0.114	0.073	0.048	0.020	0.047
T_1	1.087	1.046	0.766	0.966	0.158	0.142	0.101	0.133
T_2	1.119	1.039	0.246	0.801	0.165	0.152	0.053	0.123
T_3	1.142	1.083	0.689	0.971	0.281	0.160	0.095	0.178
T_4	1.140	1.108	0.990	1.079	0.277	0.247	0.163	0.229
T_5	1.136	1.102	0.953	1.063	0.234	0.183	0.120	0.179
Mean	0.960	0.915	0.622		0.198	0.155	0.092	

(T_0):control. (T_1):cellophane paper. (T_2):news paper. (T_3):kraft paper. (T_4):foil paper. (T_5):butter paper (St.$_1$): five days. (St.$_2$): twenty days. (St.$_3$): sixty days

seasons whereas, in the three storage period under study for five , twenty and sixty days gave 0.953, 0.906 and 0.615 % in parallel with 0.960, 0.915 and 0.622 % in the first and second seasons, respectively. It has been established thatlow temperature storage for short period is often the best method for maintaining the content of sugars in compare with long periods. The results were in line with Amin [58] on some cut foliage. Concerning the interaction treatment, kraft paper gave 1.135 and 1.142 % comparing with control which gave 0.136 and 0.139 % in the first and second seasons, respectively. In general, wrapping the cut branches was a strong helper in maintaining the level of sugars. These findings go in line with those explored by Punetha and Srivastava [37] pointed out that minimum total sugar content was observed when rose cv. Naranja. flowers unwrapped compared to newspaper, LDPE (100 gauge), LDPE (200 µ) and butter paper. This might be due to the reason that maintaining high relative humidity and high CO_2 and low O_2 levels, which keep respiration low and thus maintains high sugar content.

Total Phenols: Data presented in Table (5) cleared the influence of packaging materials on total phenols of *Schefflera arboricola*. The results showed that total phenols % were positively progressive as a result of different wrapping materials The highest percentages were pronounced with 0.233 and 0.229 % in the cut branches treated with foil paper with great difference from the control which gave 0.049 and 0.047% in the first and second seasons, respectively. Regarding the effect of storage periods on total phenols content in cut branches, it could be concluded that the highest content obtained by stored cut branches for five days comparing to stored it for sixty days which led to increasing vase life after take out of storage and held in vase solution. The present finding also got support from finding of Mwangi *et al.* [60] found that, a higher content of phenols has been found to be associated with longer vase life in cut roses. As for the interaction between treatments, wrapping cut branches in kraft papermost influential 0.289 and 0.281% compared to 0.067 and 0.073% from control when it stored for five days in cold storage in the first and second seasons, respectively. Generally the interaction treatments exhibited as well a pronounced improving effect of the various packaging materials on total phenols content of cut branches.

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