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A Study on the Effect of Storage Periods and Some Packaging Materials on Some Cut Branches of Plants A-*Euonymus japonicus*

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Abstract: Cut foliage production has become an industry with great value and an impact on national income. This study was conducted in the Postharvest Laboratory of Ornamental Plants and Landscape Gardening Research Department, Horticulture Research Institute, Giza, Egypt at two successive seasons; 2019 and 2020 to investigate the influence of different packaging materialsduring the long periods of storage on keeping the quality and extending the shelf life of cut *Euonymus japonicus* branches and get ready to export as a new cut foliage. The used packaging materials were cellophane paper, news paper, kraft paper, foil paper and butter paper aside from control (without packaging materials) andthree cold storage periods for five, twenty and sixty days at 5°C using holding solution containing citric acid at 0.2g/l + sucrose at25g/l. The results emphasized that; packaging materials had a positive effect on the all measurements that were taken whereas unwrapping cut branches, which recorded the highest percentage of physiological loss (PLW)whilst kraft paper recorded the lowest PLW value. In addition, the highestpercentage of moisture retention wasregistered from warped bykraft paper, however through the long term of cold storage as sixty days, the foil paperwas the superior. Wrapped cut branches by news paper gave the greatest rate of water loss compared to other tested materials still less than control whilst the lowest level of water loss was obtained from wrapped cut branches by krakt paper. Cut euonymus branches that wrapped in foil paper achieved the maximum amount of water uptake and enhanced the relative fresh weight percentage comparing with other treatments and control, meanwhile packing cut branches inbutter paper came in the second rank in this concern. Utilizingthe cellophane paper stored the cut foliage of euonymus for five days at cold storageincreasedthe values of the general appearance and the quality. Wrapped cut branches by butter paper maximize the days of shelf life of cut branches and prolonged it comparison with rest of treatments and control. It retarded the degradation of chlorophyll (a) and (b) also increased the carotenoids contents, total sugars as well as total phenols compared to unwrapping cut branches. The gradually increasing the storage period led to a decrease in almost the traits that were measured in the experiment. Hence, it could be recommended to use the packaging materials in order to maintain good physiological characteristics and chemical constituents of cut foliage.

Key words: *Euonymus japonicus* · Packaging materials · Physiological loss · Shelf life · Storage

INTRODUCTION

Cut foliage occupies an important position in the local and foreign markets. Cut foliage (florists' greens) is important fillers because of the shelf life is long that leaves or branches and long lasting and their charming color in floral arrangements and bouquetsto satisfy the consumer's needs. Cut foliage production has been increasing rapidly inrecent years. Flowers and foliage plant are some of the most colorful and attractive horticultural plants.

Evünymus (ancient Greek name) often spelled Euonymus (*Euonymus japonicus*), family Celastraceae, spindle tree is a common name, it is a woody plants and deciduous or evergreen shrub or small tree with usually more or less angled branches mostly erect, rarely creeping

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or climbing by rootlets, winter buds usually conspicuous with imbricate scales: lvs, opposite, petioled, usually serrate and mostly glabrous: fls, small, in axillary cymes, 4-5 merous, generally perfect [1]. The wood is tough, close-grained and light colored, often almost white. Orwa *et al.* [2] found that the bark of euonymus is considered to be tonic, anti-rheumatic, an anhidoritic and a diuretic.

Storage and packaging are the two main factors in the post harvest life of flowers and foliages. Cold storage is one of the methods of storage of cut flowers and cut foliages which enables to accumulate large quantities of them after harvesting. Moreover, treatment of low temperature during the period of shipment and storage minimizes the entire tissue metabolism, slows down the rate of respiration and delay senescence of the cut flowers as well as cut foliage.Giving consideration to low temperature controls the metabolism: it limits respiration and thus the depletion of storage compounds, it reduces transpirational water losses and ethylene biosynthesis and limits pathogen development [3].

Packaging has a great role on extension of the shelf life of cut foliage and cut flowers. Packaging materials are imperative to maintain flower freshness and original colour of flower for a longer period which is chiefly governed by internal mechanism that includes balance between water uptake and water loss, stem plugging, respiration rate and production of toxic substances like ethylene and external factors that include environmental conditions and microbial attack on the cut ends of fresh quality of packaged products whether cut foliage or any else. Vijayabhaskar [4] observed a marked differences in catalase and peroxidase (POD) activities when cut roses were packed with different packaging materials during vase life period. The early increase in the enzyme activities exhibited by news paper + corrugated fibre board (cfb) packaging registered least vase life. The anthocyanin content significantly increased with news paper + cfb followed by kraft paper + cfb compared with the remaining treatments, probably due to early senescence which led to blackening of petals. Singh *et al.* [5] investigated the effect of different wrapping materials and cold storage on cut spikes of gladiolus and found that, various packing materials i.e, cellophane, polypropylene, news paper, butter paper, brown paper and plastic coated paper kept the quality of cut flowers or cut foliages under cold storage. Different types of the packaging materials like polythene sheet and aluminium lamination foil are used to enhance the shelf life of flowers under different temperature conditions [6]. Hence, there is an urgent need to use an appropriate packaging materials and storage technique for cut flowers as well as cut foliages during periods of decline, to facilitate long term sea-shipment for export.

The main objective of this study was to ascertain the packaging materials for improve the postharvest characteristics for cut foliage of *Euonymus japonicus* and gave an explanation of their effect on the survival period of the cut branches in the vase.

MATERIALS AND METHODS

The present study was conducted at to the Postharvest Laboratory of Ornamental Plants and Landscape Gardening Res. Dept., Hort. Res. Inst., ARC, Giza, Egypt during the two successive seasons 2019 and 2020 to elicit the response of cut branches of spindle tree (*Euonymus japonicas*) to wrap with some wrapping materials under cold storage at long periods and conducted to retain their quality for longer storage durations.

Plant Material: Cut branches of *Euonymus japonicus* were freshly obtained from a local commercial farm at 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 one hour. As soon as arrived to the Lab., they 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 (about 30 cmlength). 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 $m^{-2}S^{-1}$, from natural light and fluorescent cool light 12h/day.

Experimental Design and Treatments: The cut branches of spindle tree were pulsed for half an hour in solution contained sucrose at 25 g/l + citric acid at 0.2g/l and subjected to 5 types of packaging materialsin addition to control with 3 replications under 3 storage periods that: Storage for five days ($St._1$); Storage for twenty days ($St._2$) and Storage for sixty days ($St._3$).

All cut branches were stored at 5°C after wrapped and at the end of storage period, it arranged in a completely randomized design and stems were inserted in glass bottles (500 ml) containing 400 ml of citric acid at 0.2g/l + sucrose at 25g/l, after that, each bottle mouthwas completely covered 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 Lossin Weight (PLW): Expressed as percentage of weight loss relative after storage to the initial weight.

PLW (%) = $\frac{IWa - FWa}{IWa}$ x100, where IWa: initial fresh weight of cut foliage and FWa : final weight [7].

Moisture Retention Ratio (MRR): 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 [8].

Water Uptake: 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 [7].

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 [9].

General Appearance: It was 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.* [10].

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

Chemical Analysis:

Photosynthetic Pigments: The contents chlorophyll (a), (b) and carotenoids were determined (mg/g fw) [11].

Total Sugars: Determination of total sugars (%) in leaves [12].

Total Phenols: Determination of total phenols percentage in leaves [13].

Statistical Analysis: Data were tabulated and subjected to analysis of variance as a factorial experiment using MSTAT-C statistical software [14]. Means of treatments were compared by Duncan's Multiple Range Test at 5% level as indicated by Waller and Duncan [15].

RESULTS AND DISCUSSION

Physiological Lossin Weight (PLW%): It is evident from data presented in Table (1) that all tested packaging materials in this study decreased the physiological loss (PLW) percentage compared to control of cut branches (without packaging). Wrapping cut euonymus branches in kraft paper recorded the minimum loss 23.15and 22.98 % compared to control which gave 47.02 and 46.69% in the first and second seasons, respectively.Using the foil paper as wrapping materialoccupied the second rank as it reduced the percentage of loss without significant difference from the first one in the first season. Theminimum percentage of PLW record in the flowers packedin some the various packaging materials in the study. Through a group of research conducted that in parallel results were also obtained by Madaiah and Reddy [16] who studied the influence of polyethylene packing on the post harvest vase life of tuberose (cv. Single) florets and found significantly reduction inphysiological loss of weight that maintained freshness and extended the shelf life. Also, Prashanth and Chandrasekar [17] mentioned that, packing whole stalks of *Gerbera jamesonii* via plastic sleeves with noventilationrestricted the moisture loss and reducedthe PLW.

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

	Physiological loss(%)				Moisture retention ratio(%)			
	Storage periods				Storage periods			
Packaging materials	$St._1$	$St._2$	$St._3$	Mean	$St._1$	$St._2$	$St._3$	Mean
				First season				
T_0	32.15f	48.31b	60.59a	47.02A	67.85k	51.69o	39.41p	52.98E
T_1	8.77p	28.32i	34.27d	23.79D	91.23a	71.68h	65.73m	76.21B
T_2	28.29i	33.30e	41.23c	34.27B	71.71h	66.70l	58.77n	65.73D
T_3	13.30o	24.77k	31.39g	23.15E	86.70b	75.23f	68.61j	76.85A
T_4	22.49m	22.37m	25.30j	23.39E	77.51d	77.63d	74.37g	76.50B
T_5	20.26n	23.33l	30.21h	24.60C	79.53c	76.67e	69.79i	75.33C
Mean	20.88C	30.07B	37.17A		79.09A	69.93B	62.78C	
				Second season				
T_0	33.37de	48.46b	58.25a	46.69A	66.63kl	51.54n	41.39o	53.19E
T_1	8.93o	28.08h	33.57d	23.53D	91.07a	71.92h	66.43l	76.47B
T_2	29.37g	32.94e	40.49c	34.27B	70.63i	67.06k	59.51m	65.73D
T_3	13.74n	24.17j	31.04f	22.98E	86.26b	75.83f	68.96j	77.02A
T_4	23.55k	22.12l	25.34i	23.67D	76.45e	77.88d	74.66g	76.33B
T_5	21.46m	23.31k	29.76g	24.84C	78.54c	76.55e	70.24i	75.11C
Mean	21.74C	29.85B	36.42A		78.26A	70.13B	63.53C	

(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

This confirms the importance of the packaging during the storage process. Hence, it can be said that, the packaging materials are an important tool to keep cut foliage more in good qualities for better marketing. Furthermore, the physiological loss values were significantly increased with prolonging the durations of the cold storage in both seasons whereas, after 5 days as storage period, the euonymuscut branches recorded the minimum values and achieved about 20.88 and 21.74% compared to the maximum values resulted from those of stored at the longest periodfor 60 days which were 37.17 and 36.42% in the first and second seasons, respectively. The promotion in physiological loss may be due tomoisture loss through transpiration and/or the consumption of the stored substances through respiration. These results are in agreement with the findings of Chanbisana and Banik [18] who declared that, the less of physiological loss weight (PLW) in refrigerated storage may be attributed to more RH within the refrigerated unit as compared to ambient atmosphere and slow rate of respiration and transpiration under low temperature condition.

In relation to the interaction between the packaging materials and cold storage periods, it is clear from the same Table (1) that the interactions were significant in the two consecutive seasons. The lowest value of the PLW was recorded by wrapping cut branches in cellophane paper at 5°C cold storage for 5 days, it achieved 8.77 and 8.93% compared to the control 32.15 and 33.37% in both seasons respectively. Using of foil paper as packing material achievedthe minimum value of physiological loss in weight; it recorded 25.30 and 25.34% compared to 60.59 and 58.25% from unwrapped cut branches in the first and second seasons, respectively.The middle period of storage such 20 days with wrapping the cut euonymus branches in foil paper gave 22.37 and 22.12 % PLW compared to 48.31 and 48.46 % in cut branches without packaging in the first and second seasons, respectively. The result confirmed the great role of packaging during cold storage in reducing the percentage of physiological loss in weight in cut euonymus branches.This finding was demonstrated before by Thakur [19] whostudied the effect of packing of gladiolus on physiological loss in weight, vase life and floret size of gladiolus cv. 'Sylvia' and found that the low temperature with a very and high relative humidity is favorable for decreasing the post-harvest losses in most of the cut flowers. Moreover, Sharma *et al.* [20] found that, the minimum weight loss was observed when flowers of marigold were stored under cold storage for 3 days compared to 6 days and some packing materials were beneficial in reducing the moisture losssuch as cellophane whichgave 11.98% weight loss compared to 13.64% from the newspaper. The results indicated that packagingprocess maintains humidity, which slows down the process of moisture loss and suitable balance of oxygen (O_2) and carbon dioxide (CO_2) concentrations in turn reduces the process of respiration and this may be the reason for recording the least PLW.

Moisture Retention Ratio (MRR%): According to Table (1), data indicated that, all tested packaging materials in this study increased the moisture retention ratio percentage compared to control (without packaging). Wrapping cut euonymus branches in kraft paper was the best treatment, it increased the parentage of moistureretention and it attained 76.85 and 77.02 % in comparison to 52.98 and 53.19 % from thecut branches without packaging, in the first and second seasons, respectively, with a little difference with treated cut branches by packed with foil paper before stored them at different cold storage periods that may be due to the different packaging systems would create different permeability and balanced the air component inside the packagingmaterials. These results are in accordance with observations made by Patil and Singh [21] who affirmed that, the selection of a suitable packaging material creates an optimal passive modification of CO_2 and O_2 levels utmost importance for storage of cut flowers. Therefore packaging adjust the atmosphere enclitic the plant mainly due to respiration resulted a preferablemodified atmosphere. High metabolic activitiesinside the packaging such as transpiration and respiration processes contribute to the loss of water as described by [22, 23]. In the same manner, Sharma *et al.* [20] observed that, when the flowers of marigold were packed in cellophane gave 77.42% of moisture content while in newspaper it had 74.58%. This confirms the necessity of choosing the appropriate packing materials for the different type of plants.

With increasing the durations of cold storage of the cut branches, the percentage of moisture retentionwithin the tissues were decreased. Moreover, the percentage of moisture retention values were significantly decreased with extending the cold storage periods in both seasons whereas, after 5 days as storage period, the moister retention ratio reached maximum values giving 79.09 and 78.26 % compared to the minimum values from those of stored at longest period for 60 days which were 62.78 and 63.53 % in the first and second seasons, respectively.

In relation to the interaction among treatments, it is clear from the same Table (1) that the interaction between the tested packaging materials and the cold storage periods was significant in the two consecutive seasons. The greatest values were recorded cellophane paper at 5°C cold storage for 5 days, it achieved 91.23 and 91.07 % against 67.85 and 66.63 % for control in the first and second seasons, respectively. This may be due to the fact that the cut branches that packed by several packaging materials had higher moisture retention and at cold storage had lower metabolic activities as respiration, transpiration and maintained high humidity depend on the types of packaging; the gaseous components will be modified automatically through the respiration process that improving cut flowers and greens. These results agreed with Sharma and Srivastava [24] and Dhalsamant *et al*. [25]. Dastagiri *et al.* [26] observed that, the cellophane paper as a wrapping material prevents moisture loss and increase the relative humidity inside the wrapped cut stems of *Ornithogalum thyrsoides* helps to maintain turgidity of cut stems by retaining the moisture level in the tissue and minimize moisture loss is maintenance appearance and extended vase life of cut stems.

Water Loss: Data presented in Table (2) clearedthat, all the treatments decreased the level of water losswith significant differences among almost all of the studied treatments in comparing with the control. It obviously that, the lowest level of water loss was observed in the cut *Euonymus japonicas*branches which was wrapped in kraft paper (1.79 and 1.72ml.gfw^{-1}) followed by cut branches wrapped by butter paper (1.99 and 1.98ml.gfw^{-1}) compared to control (3.35 and 3.65 ml.gfw^{-1}). The highest level of water loss was found in the control treatment in both seasons. These findings were also in agreement with the results of Patel and Dhaduk [27] who found that wrapping minimized the transpirational loss of water and deceased permeability for water and CO_2 in cut flowers of tuberose, which maintained humidity in wrapping material. As far as duration of storage is concerned, the loss of water after storage were 4.37 and 4.57ml.gfw^{-1} for the cut branches which stored for 5 days at cold storage and reached to 0.85 and 0.92ml.gfw^{-1} with 60 days cold storage. Storage is important key for slowing down the transpirational loss of water as well as loss of carbohydrates which reduces the loss of weight during storage and leading to stomatal closure resulted for minimum loss of water also, increase the relative humidity to within 90 to 95 percent so as to prevent water loss in cut flowers [24, 28]. Kim and Seo [29] stated that, the porous and breathable (film packaging) decreased the metabolic activity from anaerobic respiration, CO_2 inside packaging.

Regarding to the interaction between the tested packaging materials and the cold storage periods, it can be seen in Table (2) that, stored cut branches for 60 days as a longest storage period was more effective by providing the foil, butter and then krakt paper for wrapping them during cold storage. The reduction in loss of water which emerged through the packaging process by foil, butter and krakt paper (sequentially) decreased the

Table 2: Influence of packaging materials on water loss(ml.gfw^{-1}) and water uptake (g) of *Euonymus japonicus* cut branches under three cold storage periods during 2019 and 2020 seasons

	Water loss (ml.gfw^{-})				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	5.57a	2.04f	2.43e	3.35A	38.44f	13.13l	6.34p	19.30E
T_1	3.52d	1.47gh	1.35gi	2.11BC	59.73b	17.35j	8.21o	28.43C
T_2	4.98b	1.31hi	0.45j	2.25B	46.46e	16.43k	7.07p	23.32D
T_3	3.97c	1.07i	0.34j	1.79D	56.29d	20.51i	9.22n	28.67C
T_4	4.20c	1.61gh	0.21j	2.01C	68.49a	23.78g	10.14m	34.14A
T_5	3.98c	1.68g	0.31j	1.99C	58.05c	22.00h	9.77mn	29.94B
Mean	4.37A	1.53B	0.85C		54.58A	18.87B	8.46C	
				Second season				
T_0	6.25a	2.17f	2.53e	3.65A	37.79f	13.59k	6.71n	19.36F
T_1	3.57d	1.60gh	1.50gh	2.22C	59.40b	18.49i	5.79o	27.89D
T_2	5.55b	1.51gh	0.56i	2.54B	45.31e	16.28j	7.12n	22.90E
T_3	3.58d	1.24h	0.35i	1.72E	55.03d	22.25h	9.41m	28.89C
T_4	4.59c	1.68g	0.25i	2.17C	68.06a	23.94g	10.40l	34.13A
T_5	3.87d	1.74g	0.33i	1.98D	57.62c	22.70h	9.93lm	30.08B
Mean	4.57A	1.66B	0.92C		53.87A	19.54B	8.23C	

(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

level of water loss to give 0.21, 0.31 and 0.34ml.gfw^{-1} in the first season, while it gave 0.25, 0.33 and 0.35ml.gfw^{-1} in the second one with no significant differences in both seasons, in the same time, the control recorded the highest value 2.43 and 2.53ml.gfw^{-1}. This confirms the preference of using packaging materials for cut branches at cold storage to reduce transpirational loss of water resulting in increased water balance and highest fresh weight change. In this concern, Pranuthi *et al.* [30] found that, the modest transpirational loss of water has been recorded by packing *Dianthus caryophyllus* in polypropylene at 5°C cold storage.

Water Uptake: Regardless shown in Table (2) data revealed that, the euonymus cut branches wrapped in foil paper, cold storage periods, gave the utmost amount of water uptake 34.14and 34.13g in comparison to the rest of other transactionsespecially with comprise to the control treatment was19.30 and 19.36g in the first and second seasons, respectively. Wrapped cut branches by cellophane caused a better result without significant difference with wrapped by kraft paper in the first season in compared to the lower rate of absorption from unwrapped cut branches.

Regarding the effect of storage periods on the water uptake of euonymus. It cleared from data in Table (2) thatthere was obviously different between the amounts of water uptake meantime at three cold storage periods in this study. Maximum amount of water uptake obtained by cut branches which stored at 5°C for five days in cold storage. The rates of water absorbed through the cut branches took a decreasing form when exposed to prolongingthe storage duration. The amount of uptake at the three periods of storage were 54.58, 18.87 and 8.46 g and 53.87, 19.54 and 8.23 gin the first and second seasons, respectively. These effects of long storage periods on cut foliage agreed with Punetha and Srivastava [31] who reported that, the ability to absorb water decreased with increase in storage duration which also affected postharvest life.

In relation to the interaction between the packaging materials and the cold storage periods, there was a significant effect on improving water uptake which can be seen from the combination of wrap cut branches in foil paper as advantageous wrapping material (68.49 and 68.06 g) and stored it for 5 days in a cold storage period compared to control treatment (38.44 and 37.79 g) in the first and second seasons, respectively.Packaging cut branches in various packaging materials enhanced the rate of absorbance after get out from storage conditions and periods. In a study done by Sharma and Srivastava [24], who mentioned that, a significant effect of wrapping material and storage condition were observed on percent weight loss, total water absorbed and vase life in cut chrysanthemum cultivars. Likewise, Makhwana *et al.* [32] who cleared that rose cut flowers packaged in the PP (polypropylene) atlow temperature stored showed the maximum water uptake. Similar findings were reported by Punetha and Srivastava [31] they found that the water uptake was higher in the rose flower buds wrapped in low density polyethylene (LDPE) under cold storage.

Relative Fresh Weight: From the obtained data in Table (3) it can be concluded that, the relative fresh weight of euonymus cut branches was affected by all treatments. The highest relative fresh weight percentage (121.2 and 121.1 %) was recorded whencut branches were wrapped in foil paper, whilst unwrapped cut foliage recorded the lowest values (85.60 and 82.90 %) in the first and second seasons, respectively. Also it can be seen wrapping euonymus cut branches in butter paper was in the second rank as a result of its great influence and it gave 118.8 and 119.3 % in the two seasons followed by wrapping cut branches in kraft and cellophane papers.

The effect of storage periods on the relative fresh weight, the data showed that, the relative fresh weight percentage decreased gradually with prolonging the durations of storage. As storage for short period (5 days) it recorded 116.8 and 117.3 % at the moderate period (20days) it had 106.2 and 106.9% however the least percentage 103.3 and 101.1% recorded for the longest period of storage (60days). The reduction in relative fresh weight may be attributed to the loss in moisture through transpiration and/or the consumption of the stored substances through respiration. These results were consistent with the observations of Daj and Paul [34] on *Protea nerifolia* cv. Pink Wink, Vinod and Bhattacharjee [35] on rose cv. Mercedes flowers, Badawy *et al.* [36]on cutrose cv. First Red and Chore *et al.* [37] on *Gladiolus grandiflorus*.

In regard to the responsiveness of the cut branches under study to the interaction among all factors, it can be reported from data in Table (3) that, the packaging materials alone with cold storage had a significant influence on relative fresh weight after storage aseuonymus cut branches wrapped in foil paper and stored under refrigerated cold storage (5°C) for 5 days then subjected to pulsing and holding of sucrose and citric acid solutions were found to gave the increment in the percent of relative fresh weight. Combined effect of pulsing and holding cut branches in sucrose and citric acid solutions with packaging materials may be caused a positive increment in this concern.In confirmation of the current experiment, He *et al.* [9] found that, bagging of whole grevillea stems or inflorescences increased the RFW (relative fresh weight) on day-3 of vase-life of cut stems compared with intact unbagged stems. Moreover, Sisodia *et al.* [33] declared that, the maximum weight of gladiolus was observed with spikes stored in cellophane paper followed by brown paper and news paper treatments.

Similarly, Sharma and Srivastava [24] obtained the same results on chrysanthemum cultivars. That corresponds to Baidya and Chakrabarty [38] who suggested that packaging material with the storage had a significant influence on changes in fresh weight after storage of tuberose flower strings.

General Appearance: It cleared from data in Table (3) that, the values of general appearance increased by using almost all packaging materials and the topmost was achieved by wrapping cut branches in foil paper andbutter paper without significant difference between them and they were the best wrappers for maintaining the quality of euonymus cut branches compared to control and the rest of the wrappers. This indicates an important fact that effective packaging systems wouldhelps to maintain the turgidity by retaining the moisture apart from lack of photosynthesis led to preserve carbohydrates thereby decreasing the deterioration rate. So, packaging is a fundamental tool for postharvest management of highly perishable commodities and adequate packaging protects the produce from physical, physiological and pathological deterioration during transport and marketing by retaining their attractiveness in *Polianthes tuberosa* and *Jasminum sambac* [39-41].

With regarding to effect of the cold storage periods, the same Table (3) showed that, extending of storage periods(5, 20 and 60 days) minimize the value of general appearance and had a negative effect recording 2.76, 2.61 and 2.16 in the first season and 2.87, 2.57 and 2.37 in the second one on the quality and general appetence of cut branches. This may be attributed to the role of the microbial damage occurring in the cut branches during storage that seems to be influenced much by long storage periods, the benefits of storage appear more achievable at 5 days. Results are in close agreement with the findings of Nelofar and Paul [42] who mentioned that, increasing storage duration decreased significantly the quality and vase life of gladiolus. Agree with this, Chand *et al*. [43] noticed thatthe post-harvest quality of gladiolus deteriorated with increasing in storage duration.

Table 3: Influence of packaging materials on relative fresh weight (%), general appearance and shelf life (days) of *Euonymus japonicus* cut branches under three cold storage periods during 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	87.89k	80.63m	85.30l	85.60E	1.44g	1.22h	1.11h	1.26D	20.33l	17.00o	15.00p	17.44F
T_1	119.6d	108.4gh	107.3h	111.8C	3.89a	2.33e	1.89f	2.70B	35.00a	20.33l	20.00m	25.11C
T_2	114.4e	100.1j	98.35j	104.3D	1.77f	1.89f	1.77f	1.81C	21.67j	18.67n	17.00o	19.11E
T_3	121.9c	109.6fg	104.5i	112.0C	3.44bc	3.33bc	2.33e	3.03A	29.00d	24.33h	21.33k	24.89D
T_4	130.1a	120.0cd	113.6e	121.2A	2.67d	3.55b	3.22c	3.15A	26.67f	29.33c	24.67g	26.89B
T_5	127.1b	118.3d	110.9f	118.8B	3.33bc	3.33bc	2.67d	3.11A	32.00b	27.33e	22.33i	27.22A
Mean	116.8A	106.2B	103.3C		2.76A	2.61B	2.16C		27.44A	22.83B	20.06C	
					Second season							
T_0	86.49l	81.67m	80.53m	82.90E	1.55j	1.22k	1.22k	1.33D	19.33m	17.33o	15.33p	17.33F
T_1	119.6d	109.3g	103.3h	110.7C	3.00f	3.78b	2.33gh	3.04B	34.67a	21.00k	20.00l	25.22C
T_2	117.0e	100.3j	97.81k	105.1D	2.15hi	1.66j	2.00i	1.94C	21.33j	19.33m	17.67n	19.44E
T_3	122.3c	110.1g	102.6i	111.7C	3.11ef	3.33cd	2.44g	2.96B	28.00d	24.67g	21.67i	24.78D
T_4	130.4a	120.3d	112.5f	121.1A	4.00a	2.22h	3.22de	3.15A	25.00f	29.67c	25.00f	26.56B
T_5	128.3b	119.5d	110.1g	119.3B	3.44c	3.22de	3.00f	3.22A	31.67b	27.67e	23.00h	27.44A
Mean	117.3A	106.9B	101.1C		2.87A	2.57B	2.37C		26.67A	23.28B	20.44C	

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

Interaction treatments showedthat significantly highest value of general appearancewas resulted from euonymus cut branches which treated by almost all wrapping treatments then stored in the three different storage periods. These findings were supported by those found by Jawaharlal *et al.* [44] on packing *Jasminum sambac* in aluminum-foil thermocol boxes under gel-ice cold condition as they recorded maximum freshness index. Moreover, Ahmad *et al*. [45] suggested that, polyethylene (PE) packaging maintained the external appearance of fruits irrespective of storage systems. The results confirmed that the beneficial effect of wrapping under cold storage might be due to the reason that it helps in providing a modified atmosphere for flowers and also slows down respiration, transpiration and cell division processes [31].

Shelf Life: According to data in Table (3) there wasa significant improvement in shelf life of cut branches of euonymus was obtained from various packaging materialstreatments in this study. All materials induced an increase in the shelf life of the studied cut branches particularly, the ones wrapped in butter paper (27.22 and 27.44 days in the first and second seasons, respectively) compared to unwrapped cut branches (17.44 and 17.33 days in the first and second seasons, respectively). This great effect of butter paper as a wrapper agreed with Dastagiri *et al.* [46] who found that the cut flowers of *Ornithogalum thyrsoides* Jacq which wrapped by polyethylene and butter paper had a long vase life as compared to unwrapped ones.Although, cut branches wrapped incellophane paper had the least transaction but it gained 25.11 and 25.22days until reaching to the senescenceas best result compared to control which was 17.33 and 17.44 days in the first and second seasons, respectively. As discussed earlier Phanindra [47] stated that, cellophane paper was the best packaging material for prolonging vase life in cut flowers. Recently, Sisodia *et al.* [33] clarified that cellophane paper treatment was also resulted in the longest shelf life of gladiolus spikes, also, Happy *et al.* [48] indicated that, butter paper as wrapper for cut spikes of *Polianthes tuberosa* performed better floret longevity, marketable vase life as noting data in the same Table (3) there was superiority of usage some packing materialsto another, so using of the kraft paper was better than newspaper paper, which agrees with the results of Bhaskar and Rao [49] who pointed out that, among the different packaging materials kraft paper gave higher vase life than news paper in cut rose.

By studying the effect ofprotraction of the storage periods on the cut branches survival period, the results obtained reflect the reality of the negative impact on prolonging the storage periods, as it declined the shelf life of euonymus cut branches. Storing cut branches for five days at cold storage then holding them in citric acid at 0.2g/l + sucrose at 25g/l gained the optimum first position among all storage treatments, it gave 27.44 and 26.67days while stored cut branches for twenty days gave 22.83 and 23.28 days. The last one was the storage for sixty days, which gave minimal value 20.06 and 20.44 days in the first and second seasons, respectively. This finding was demonstrated by Finger *et al*. [50] who postulated that, the vase life of *Strelitzia reginae* continuously reduced when they were stored at 10°C and the storage period was extended from seven to 28 days. Storage at low temperatures, reserve cut flowers and cut foliage, remained turgid and recorded reduced moisture loss thereby increased shelf life. Teixeira [3] mentioned that dehydration produced by transpiration is an important process during postharvest because it is closely related to the loss of quality in fresh products, particularly in cut flowers also, cut flowers of gloriosa in cold storage at 4°C for 7 days has the potential to be used for delaying inflorescence senescence, prolonging vase life and postharvest quality [51]. Nelofar and Paul [42] reported that, by increasing storage duration the quality and vase life of gladiolus decreased significantly. It has been established that long periods of storage ultimately have negative effects on the ultimate vase life of the rose [52]. Chand *et al.* [43] found that, low density polyethylene (LDPE-100) gave the maximum vase life of gladiolus (6.77 days) and storage significantly reduced the vase life of gladiolus spikes with increase in storage duration. It can be inferred that shorter storage duration maximized the benefits valuable for wrapping materials than longer durations.

Interaction treatments also utilize a pronounced effect on shelf life of cut branches aswrapping the cut branches in cellophane paper and storing them for 5 days was the optimum treatment (35.00 and 34.67 days in the first and second seasons, respectively) and provided the best result compared to other treatments, while wrapping them in foil paper and then storing them for 20 and 60 days showed impressive results for the control and the rest of the treatments, In detail, the harvested branches were wrapped in foil paper and stored for 20 days gave 29.33 and 29.67 days whilst when it stored for 60 days gave 24.67 and 25.00 days in the first and second seasons, respectively. This effect is primarily due to initially continued metabolic activities (specially respiration and transpiration) of flowers, might have led to the evolution of beneficial equilibrium of modified atmosphere with high CO_2 and low O_2 and high relative humidity within the package. This further might have caused closure of stomata and minimized the respirational loss of carbohydrates as well as transpirational loss of water from flowers [53]. Varu and Barad [54] found that polyethylene sheet and metal paper increased vase life of *Polianthes tuberosa* and that attributed to provided modified atmosphere, which increased the CO_2 concentration as well as humidity and slow down the transpiration inside the package leading to slow down the respiration process. The obtained results coincided with the findings of Punetha and Srivastava [31] who found that the beneficial effect of wrapping in LDPE(low density polyethylene) might be due to the reason that it helps in providing a modified atmosphere for flowers and also slows down respiration, transpiration and cell division processes, but these conditions remain only up to a specific period of time. Vase life decreased with increase in storage duration and this might be due to the fact that process pertaining to development and senescence, continue slowly, leading to rapid senescence after storage so it decrease shelf life. Furthermore, Choudhury *et al.* [41] determined that the flowers treated with 4% boric acid, packed in 60-micron polyethylene bags without ventilation and stored under 7°C significantly extended the shelf life of *Jasminum sambac.* Kumar *et al.* [55] found that, polythene bag packaging significantly influencedthe shelf life of tuberose flowers.

Photosynthetic Pigments

Chlorophyll (a), (b) and Carotenoids: From the recorded data in Table (4), it can be concluded that, almost all treatments reduced the degradation of chlorophyll (a), (b) and the carotenoids contents in the cut branches. Wrapping cut branches in butter paper was superior, it recorded a highest amount of chlorophyll (a) and gave 0.418 and 0.396 mg /g f. w.compared to control (0.365 and 0.348 mg /g f. w.), the corresponding values of chlorophyllof (b) were 0.268 and 0.253mg /g f. w.compared to control (0.218 and 0.202 mg /g f. w.).Wrapping cut branches in butter paper had the uppermost amount of the carotenoids content 0.160 and 0.152mg /g fresh weight and the lowest amount 0.130 and 0.127mg /g f. w. from control in the first and second seasons, respectively. That may be due to atmospheric air leads to senescence and loss of green color. Hence, the natural biological variance and the packaging technology used lead to different respiration rates and thus color changes in packaged wild rocket [56, 57].

It was observed in Table (4) the chlorophyll contents showed a decreasing trend during the prolonging of storage periods. Chlorophyll (a)content recorded a highest content at 5 days cold storage (0.506 and 0.502 mg /g f. w.) while stored cut branches at 20 days in cold storage recorded 0.394 and 0.375 mg /g f. w. in the first and second seasons respectively. The lowest contents of

Table 4: Influence of packaging materials on chlorophyll (a), (b) and the carotenoids (mg/g f.w) of *Euonymus japonicus* 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	0.440	0.352	0.304	0.365	0.235	0.220	0.199	0.218	0.147	0.130	0.114	0.130
T_1	0.528	0.401	0.312	0.413	0.311	0.269	0.219	0.266	0.192	0.158	0.119	0.156
T_2	0.515	0.388	0.310	0.404	0.286	0.263	0.216	0.255	0.170	0.153	0.116	0.146
T_3	0.518	0.402	0.316	0412	0.298	0.274	0.220	0.264	0.186	0.160	0.120	0.155
T_4	0.516	0.413	0.322	0.417	0.292	0.285	0.226	0.267	0.179	0.166	0.128	0.157
T_5	0.523	0.410	0.320	0.418	0.301	0.281	0.224	0.268	0.190	0.164	0.126	0.160
Mean	0.506	0.394	0.314		0.287	0.265	0.217		0.177	0.155	0.120	
					Second season							
T_0	0.439	0.348	0.258	0.348	0.214	0.201	0.191	0.202	0.140	0.131	0.110	0.127
T_1	0.522	0.387	0.264	0.391	0.296	0.250	0.204	0.250	0.185	0.148	0.115	0.149
T_2	0.508	0.360	0.258	0.375	0.262	0.247	0.200	0.236	0.168	0.140	0.102	0.136
T_3	0.514	0.379	0.273	0.388	0.285	0.254	0.207	0.248	0.177	0.152	0.117	0.148
T_4	0.510	0.389	0.281	0.393	0.277	0.262	0.214	0.251	0.173	0.160	0.121	0.151
T_5	0.519	0.390	0.280	0.396	0.290	0.258	0.211	0.253	0.181	0.157	0.119	0.152
Mean	0.502	0.375	0.269		0.270	0.245	0.204		0.170	0.148	0.114	

(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

chlorophyll (a) obtained by storing cut branches for 60 days cold storage which was 0.314 and 0.269 mg /g fresh weight in the first and second seasons respectively. In the same pattern, the amount of chlorophyll (b) and carotenoids decreased with increasing storage periods. These results are in accordance with the findings obtained by Byun *et al*. [58] on *Dianthus caryophyllus* cvs. Desio and Fillandero they gave the lowest carotenoids contents with the longest storage period. Also, Badawy *et al.* [36] found that the total chlorophylls and the carotenoids content in the leaves of rose flowers were significantly decreased with increasing storage periods. These may be due to the rapid decline in chlorophyll content indicates high oxidative damage that in high temperatures is more rapid than in low temperature [59].

Regarding interactions effect, wrapped euonymus cut branches by cellophane paper and stored for short storage period (5days) recorded the highest amount of chlorophyll (a), (b) and the carotenoids content with highly difference from control. On other hand, wrapped cut branches by foil recorded the uppermost of amount from chlorophyll (a), (b) and the carotenoids contents after store for long duration (60days).

Total Sugars: Data in Table (5) illustrated that, showed that the highest total sugars concentration was recorded in cut branches held in citric acid at0.2g/l + sucrose at 20g/l, after wrapping in butter paper (0.732 and 0.708 % in the first and second seasons respectively) followed by cellophane paper (0.717 and 0.689 % in the first and second seasons respectively). These may be due to that wrapped cut branches gave minimum SOD and the MDA content enzyme activity as compared was found in control as a positive relation was found between unpackaged and packaged materials in terms of SOD activity and MDA contents [60]. In this regard, an inverse relationship between sugar content levels and long storage periods has been confirmed, storing the cut branches for a period of 5 days gave the largest percentage of sugars compared to storing them for the other two storage periods in the two seasons. The obtained results coincided with the findings of Badawy *et al*. [36] on *Rosa hybrida* and results showed the importance of storage for an appropriate period. Gul and Tahir [61]attributed the increment in concentration of various sugar fractions such as glucose, fructose and sucrose at low temperature regimes in *Nerine* to enhancement of influx water and osmolytes into cells. Skutnik *et al*. [62] found that, the total soluble and reducing sugars increased in senescing flowers in both non-stored and stored of cut herbaceouspeony flowers and they were lower after storage. In this regard, cut branches wrapped in cellophane paper and stored at five days recorded the highest percentage of total sugars (0.851 and 0.842 % in the first and second seasons, respectively).

Table 5: Influence of packaging materials on total sugars (%) andtotal phenols (%) of *Euonymus japonicus* 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	0.621	0.598	0.423	0.547	0.46	0.43	0.28	0.39
T_1	0.851	0.712	0.588	0.717	0.92	0.67	0.47	0.68
T_2	0.745	0.685	0.512	0.647	0.71	0.55	0.43	0.56
T_3	0.810	0.716	0.603	0.709	0.83	0.68	0.50	0.67
T_4	0.766	0.729	0.641	0.712	0.77	0.72	0.59	0.69
T_5	0.842	0.721	0.634	0.732	0.90	0.71	0.56	0.72
Mean	0.772	0.693	0.566		0.76	0.62	0.47	
				Second season				
T_0	0.618	0.584	0.411	0.537	0.53	0.47	0.30	0.43
T_1	0.842	0.653	0.573	0.689	0.88	0.58	0.43	0.63
T_2	0.734	0.627	0.548	0.636	0.69	0.51	0.38	0.52
T_3	0.802	0.669	0.575	0.682	0.80	0.63	0.46	0.63
T_4	0.740	0.685	0.628	0.684	0.72	0.69	0.54	0.65
T_5	0.829	0.680	0.615	0.708	0.84	0.64	0.51	0.66
Mean	0.760	0.649	0.558		0.74	0.58	0.43	

(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

Total Phenols: It can be seen from data averaged in Table (5) that, wrappingeuonymus cut branches in butter paper recorded the highest amount of total phenols in comparison with other wrapping materials. This effect of packing materials agrees with the findings of Amin [63] who showed that packing some cut foliages by kraft paper gave higher content of phenols than freely packed ones. With the long storage period, it was found that the percentage of phenol decreased after storing the branches for 5, 20 and 60 periods, where after storage they were in order 0.76, 0.62 and 0.47 % in the first season, whilst 0.74, 0.58 and 0.43 in the second one. These results are in harmony with Ahmad *et al.* [64] who mentioned that, storage of iris scapes at low temperature resulted in a decrease in the tissue content of phenols. In this regard, wrapped cut branches by cellophane paper and stored it at five days recorded maximum percentage of total phenols (0.92 and 0.88 % in the first and second seasons, respectively). Results may be due to modified atmosphere, which increases the CO_2 concentration as well as humidity and slow down the transpiration inside the package leading to slow down the respiration process [39]. That shows the effect of packaging with the appropriate materials and the usage of a short period of storage to obtain cut branches in good condition.

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