USE OF CHITOSAN TO IMPROVE THE TOLERABILITY OF *CODIAEUM VARIEGATUM* PLANTS TO TRANSPORT PERIODS

NAGLAA M. MOSTAFA, MAGD EL DIN F. RIDA AND ASMAA M. TAHA

Alexandria, Ornamental Plants Research and Landscape Antoniades Research Branch Gardening Department, Horticulture Research Institute, ARC, Egypt.

(Manuscript received 9 December 2018)

Abstract

The aim of this study was to improve the tolerability of *Codiaeum variegatum* plants to transport and postharvest handling by using chitosan. It was conducted at Antoniades Research Branch, during the seasons of 2017 and 2018. Three concentrations of chitosan (0.0 ,500 and 750 ppm) were used as a foliar spray on the plants, then packing in carton box and stored at 15.5 ° C and 73%RH for different periods (0-time, 5, 10, 15 and 20 days).The results cleared that the foliar spray of chitosan at 500 ppm recorded the highest decrease in water loss rate (WLR), relative water loss (RWL), intensity of transpiration, leaves drop percentage (LDP) , proline and reducing sugars content. Also this treatment gave the highest chlorophyll a and b content. However RWL, LDP and proline content were increased by increasing the storage period. The lowest intensity of transpiration was recorded after the 10^{th} day of storage. Also chlorophyll a and b were decreased by increasing storage period.

Key wards: Chitosan - *Codiaeum variegatum*- croton – storage periods

INTRODUCTION

Codiaeum variegatum L. (croton) belongs to the Family Euphorbiaceae. It is a popular plant. It has tough, leathery leaves with many colors, largely yellows and green modified or veined with rosy, or orange. Their shapes vary enormously from long and pointed to short and broad, from slender, way-edged ribbons and deeply lobed and fiddle – shaped. The plant forms small, sturdy shrub, often with a bare lower stem (Jane and Graham 1997).

The production of the pot plant in most time is under high relative humidity and frequent irrigation. However, during shipping and retailing, these plants may be exposed to high temperature and infrequent irrigation (Besufkad and Woltering, 2015). These unfavorable conditions often cause leaves drop, excessive elongation of shoots, discoloration of leaves, and infection of plants with gray mold. To reduce this deteriorating effect, application of anti–transpiration is one of the integral measures to implement. One of these anti- transpiration is chitosan.

Chitosan is an important and ubiquitous polysaccharide biopolymer. It is produced by partial alkaline N-deacetylation of chitin commercially extracted from shrimp and crab shells, (Hein 2004). It is a low toxic and inexpensive compound that is biodegradable and environmentally friendly with various applications in agriculture (New *et al.,* 2004). The coating with chitosan can form a semi–permeable film which may modify the internal atmosphere and decrease the transpiration loses of the leaves (El Ghaouth, *et al.,* 1991; Olivas and Barbosa-Ca´novas, 2005). Also, chitosan has been found to exhibit potent antimicrobial activity (Ramírez *et al.,* 2010).

The aim of this study was to improve the tolerability of *Codiaeum variegatum* plants to transport and postharvest handling by using chitosan.

MATERIALS AND METHODS

The experiment was carried out during the two successive seasons of 2017 and 2018 at Antoniades Research Branch, Horticulture Research Institute, A.R.C. Alexandria.

Two years of croton (*Codiaeum variegatum* L var. "Gold Star") rooted cuttings were planted in 16 cm diameter plastic pots using peatmoss media.

The plants were homogenized. The trial began on January 28th, 2017, in the first season and January 19th, 2018, in the second season. Three chitosan concentrations (0.0, 500 or 750 ppm) were prepared and sprayed on the leaves of plants by using a hand-sprayer until the leaves were wet to run off. Twenty four hours prior to storage, the plants were watered well and left to drain excess the water. After that, The plants were packed in cardboard boxes and stored at average temperature of 15.5 ^{o}C and relative humidity 73% for five storage periods (0-time, 5, 10, 15 or 20 days)

The following data were recorded:

1) Water loss rate (WLR) %

The WLR was measured according to the formula below

$$\textbf{WLR} = \frac{Wt-(Wt+5)}{Wt} \times 100$$

Where (Wt) is the weight of the pot (g),(Wt+5) is the weight of the same pot (g) after five days of storage .

2) Relative water loss (RWL) %

The RWL was measured according to the formula below

$$\textbf{RWL} = \frac{WI-WS}{WI} \times 100$$

Where WI is the initial pot weight (g) and (WS) is the weight of the pot (g) after the storage period.

3) The intensity of transpiration (mg cm^{-2} min^{-1})

It was determined according to the method of Nguyen *et al.*(2011). Three leaves of three plants of each plot were collected and kept in the plant's conditions. After 30, 60, 90, 120 min, the leaves were weighed to measure the loss of their weight. The intensity of transpiration was determined as follows:

$$I = (W0 - Wt)\ S^{-1}\ t^{-1}$$

Where **I**: is an intensity of transpiration (unit: mg cm^{-2} min^{-1}); **S**: is the leaf area (cm^2); **W0**: the weight of the leaves after cutting; **Wt**: the weight of the leaves after **t** min in the plant's condition.

The average of the intensity of transpiration was determined by calculating the mean of four times and analyzed.

4) Leaves drop percentage (LDP) %

It was determined at the end of the storage period according to the following formula

$$\textbf{LDP (\%)} = \frac{\text{Initial leaves number} - \text{Final leaves number}}{\text{Initial leaves number}} \times 100$$

5) Chemical analysis:

Chlorophyll a and b content (mg/100 g fresh weight) was determined in leaves according to Moran, (1982) and carotene (mg /100 g fresh weight) acrc0rding to Wellburn (1994). Proline content (µg/g dray weight) was determined according to Bates *et al.* (1973) and reducing sugars content (mg/g dray weight) was determined according to Miller (1959).

Statistical Analysis

The experimental layout was designed to provide a complete randomized block design in a factorial experiment, which contained three replicates, each replicate contained fifteen treatments (three treatment for chitosan X five treatments for storage period). Three pots were used as an experimental unit for each treatment in each replicate. The means of the individual factors and their interactions were compared by L.S.D. at 5% level of probability according to Snedecor and Cochran , (1989).

RESULTS

1. Water loss rate (WLR) %

Data presented in Table (1) cleared that foliar spray of chitosan at 500 ppm (2.32 and 2.59 %) or plant storage for 10 days (2.27 and 2.31%) in the first and second seasons respectively caused the lowest WLR compared with the other treatments. Moreover, there was no significant difference in the WLR for the interaction between chitosan treatment and storage period in both seasons.

Fig.(1) illustrated that the lowest WLR was recorded by application of chitosan at 500 ppm and the third storage period (10 days). While the highest WLR was obtained after storage of the plants for five days compared with the untreated plants in both seasons.

Table 1. The mean of water loss rate (WLR) % of *Codiaeum variegatum* L as influenced by foliar spray of chitosan (ppm), storage period (days) and interaction between them during the two successive seasons of 2017 and 2018.

	Storage Period (days)	2017				2018			
		Chitosan (ppm)			Mean	Chitosan (ppm)			Mean
		0	500	750		0	500	750	
WLR (%)	0-time	0.00	0.00	0.00	**0.00 e**	0.00	0.00	0.00	**0.00 c**
	5	3.48	2.48	3.07	**3.01 a**	4.19	3.16	3.31	**3.55 a**
	10	2.75	2.47	2.49	**2.57 c**	2.52	2.36	2.44	**2.44 b**
	15	2.51	2.14	2.17	**2.27 d**	2.33	2.20	2.39	**2.31 b**
	20	3.14	2.20	2.91	**2.75 b**	3.11	2.62	2.67	**2.80 ab**
	Mean	**2.97 a**	**2.32c**	**2.66 b**		**3.04 a**	**2.59 a**	**2.70 a**	
	L.S.D.at 0.05			D	0.11	L.S.D.at 0.05		D	1.07
				Ch	0.09			Ch	0.83
				D x Ch	N.S.			D x Ch	N.S.

L.S.D. = Least significant different at 0.05 level of probability
D :: Days , Ch : Chitosan
N.S.= not significant

2. Relative water loss (RWL) %

Table (2) and Fig. (2) cleared that highest significant decrease in RWL was recorded after application of chitosan at 500 ppm (4.77 and 5.23 %) in the first and second season respectively compared with the other treatments. RWL is increased by increasing storage periods. Moreover, there was an insignificant difference in the interaction between chitosan as foliar spray and storage periods.

3. The intensity of transpiration (mg cm^{-2} min^{-1})

Table (2) showed that the highest significant value of the intensity of transpiration (0.015 and 0.014 mg cm^{-2} min^{-1}) was obtained by the untreated plants in the first and second seasons, respectively. This value decreased after foliar spray of chitosan and the lowest value of an intensity of transpiration (0.011 mg cm^{-2} min^{-1}) was obtained after foliar spray of chitosan at 500 ppm in both seasons. Also, Table (2) cleared that the lowest transpiration rate (0.010 mg cm^{-2} min^{-1}) was obtained after 10 days of storage in both seasons. Moreover, there was insignificant difference in the interaction between chitosan as a foliar spray and storage period in both seasons.

Fig. (3) cleared that foliar spray of chitosan at 500 ppm caused decrement in the intensity of transpiration for all storage periods. The intensity of transpiration decreased by increasing the storage period until the 10^{th} day of storage then it increased moderately after 15 and 20 days of storage in both seasons.

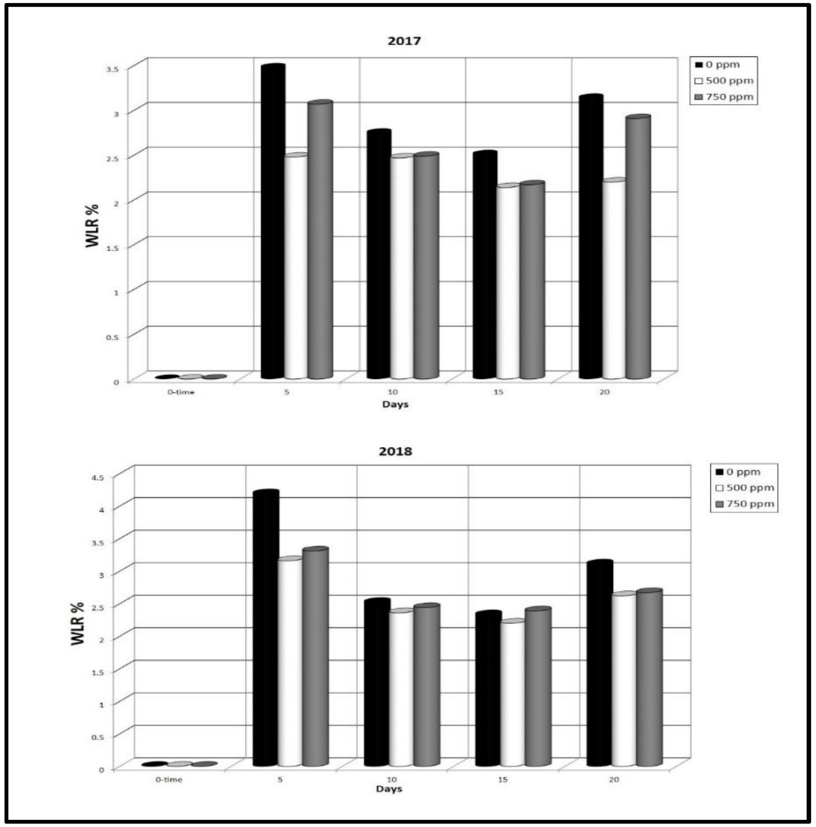

Fig. 1. Effect of the interaction between chitosan and storage period on the water lose rate (WLR) % of *Codiaeum variegatum* during the two seasons (2017-2018)

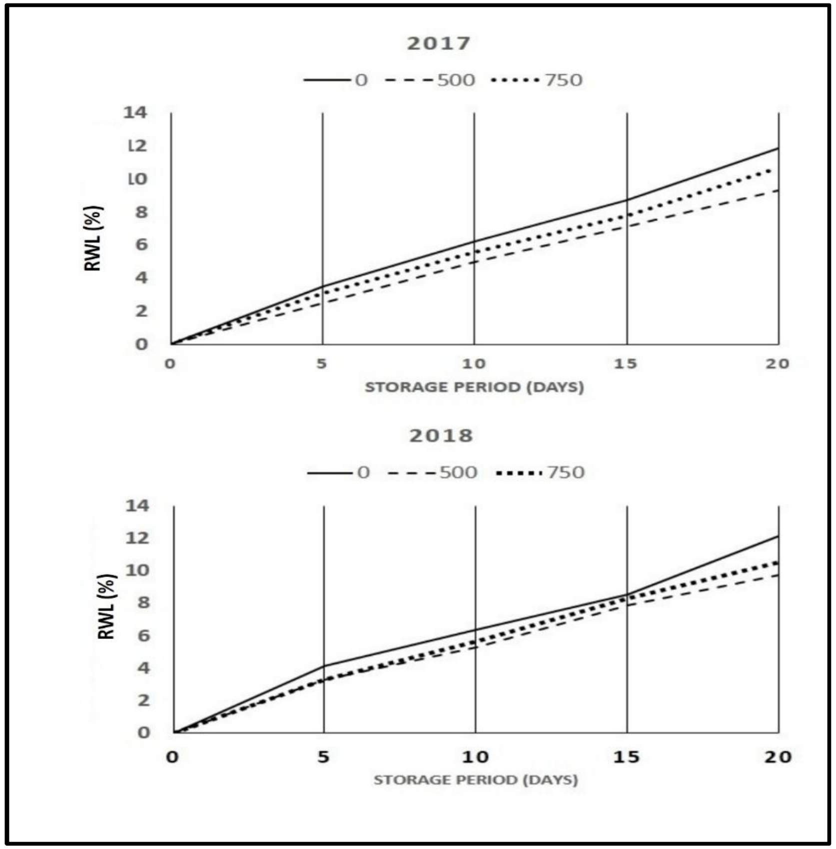

Fig. 2. Effect of the interaction between chitosan and storage period on the relative water lose(RWL) % of *Codiaeum variegatum* during the two seasons (2017-2018)

4. Leaves drop percentage (LDP) %

Data presented in Table (2) showed that croton plants can be stored untill 20 days with a foliar spray of chitosan at 500 ppm without significant effect on LDP compared with control plants

Also, Table (2) showed that the least LDP (0.61 and 0.73 %) in the first and second seasons, respectively was obtained by the treatment of chitosan at 500 ppm. LDP was increased by increasing the storage period in both seasons.

5. Chemical analysis

5.1 Chlorophyll a (mg/100 g fresh weight)

Data presented in Table (3) cleared that the highest value of chlorophyll a (104.33 and 112.08 mg/100 g fresh weight) in the first and second seasons, respectively was obtained by foliar spray of chitosan at 500 ppm. Also, Table(3) cleared that the value of chlorophyll a decreased by increasing the storage periods. There was insignificant difference for the interaction between storage periods and foliar spray of chitosan in both seasons.

5.2 Chlorophyll b (mg/100 g fresh weight)

Table (3) showed that there was a significantly increased of Chlorophyll b after foliar spray of chitosan at 500 or 750 ppm with the same level of significance in both seasons. Also, the value of chlorophyll b decreased by increasing the storage period and there was an insignificant difference for the interaction between storage periods and chitosan treatments in both seasons.

5.3 Carotenoids (mg/100 g fresh weight)

Data presented in Table (3) indicated that, there was no significant, difference in carotenoids amount between using 10 or 15 days storage compared with the control treatment in both seasons. However there was insignificant difference between treatments of chitosan and the interaction between chitosan and storage period treatments.

5.4 Proline (µg/g dray weight)

Data presented in Table (4) showed that using chitosan led to a significant decrease in proline. The lowest decrease was obtained by foliar spray of chitosan at 500 ppm (160.45 and 131.93 µg/g) in the first and second seasons, respectively . Also Table (4) cleared that the value of proline increased by increasing the storage period and the highest proline value was obtained after 20 days of storage (248.97 and 193.76 µg/g) in the first and second seasons respectively compared with the other treatments. Moreover, there was insignificant difference for the interaction between chitosan and storage period treatments.

Table 2. The means of relative water lose (RWL) % , intensity of transpiration(mg cm^{-2} min^{-1}) and leaves drop percentage (LDP) of *Codiaeum variegatum* L as influenced by foliar spray of chitosan (ppm) , storage period (days) and interaction between them during the two seasons of 2017 and 2018.

	Storage Period (days)	2017				2018			
		Chitosan (ppm)			Mean	Chitosan (ppm)			Mean
		0	500	750		0	500	750	
RWL %	0-time	0.00	0.00	0.00	**0.00 e**	0.00	0.00	0.00	**0.00 e**
	5	3.48	2.48	3.07	**3.01d**	4.13	3.29	3.31	**3.57 d**
	10	6.23	4.95	5.56	**5.58 c**	6.38	5.29	5.63	**5.77 c**
	15	8.73	7.10	7.73	**7.85 b**	8.52	7.87	8.27	**8.22 b**
	20	11.87	9.30	10.64	**10.60 a**	12.15	9.71	10.53	**10.80 a**
	Mean	**6.06 a**	**4.77 c**	**5.40 b**		**6.24 a**	**5.23 c**	**5.55 b**	
	L.S.D.at 0.05			D	0.32	L.S.D.at 0.05		D	0.36
				Ch	0.24			Ch	0.28
				D x Ch	N.S.			D x Ch	N.S.
Intensity of transpiration (mg cm^{-2} min^{-1})	0-time	0.017	0.013	0.015	**0.015a**	0.015	0.012	0.015	**0.014a**
	5	0.014	0.012	0.012	**0.013b**	0.015	0.012	0.010	**0.012b**
	10	0.013	0.009	0.009	**0.010d**	0.012	0.009	0.010	**0.010d**
	15	0.016	0.011	0.012	**0.013a**	0.016	0.012	0.013	**0.014a**
	20	0.014	0.010	0.011	**0.012c**	0.012	0.01	0.011	**0.011c**
	Mean	**0.015a**	**0.011c**	**0.012b**		**0.014a**	**0.011c**	**0.012b**	
	L.S.D.at 0.05			D	0.002	L.S.D.at 0.05		D	0.001
				Ch	0.001			Ch	0.001
				D x Ch	N.S.			D x Ch	N.S.
LDP	0-time	0.00c	0.00c	0.00c	**0.00c**	0.00d	0.00d	0.00d	**0.00b**
	5	0.00c	0.00c	0.00c	**0.00c**	0.00d	0.00d	0.00d	**0.00b**
	10	1.14c	0.00c	0.38 c	**0.51bc**	1.08cd	0.00d	0.00d	**0.36b**
	15	3.82b	0.68c	1.56c	**2.02b**	3.13abc	0.71cd	2.23bcd	**2.02a**
	20	6.84a	2.36bc	3.29b	**4.16a**	5.19a	2.50bcd	4.03ab	**3.91a**
	Mean	**2.36 a**	**0.61b**	**0.97b**		**1.88 a**	**0.64 b**	**1.25ab**	
	L.S.D.at 0.05			D	1.01	L.S.D.at 0.05		D	1.47
				Ch	0.78			Ch	1.14
				D x Ch	1.74			D x Ch	2.54

L.S.D. = Least significant different at 0.05 level of probability
D :: Days , Ch : Chitosan
N.S.= not significant

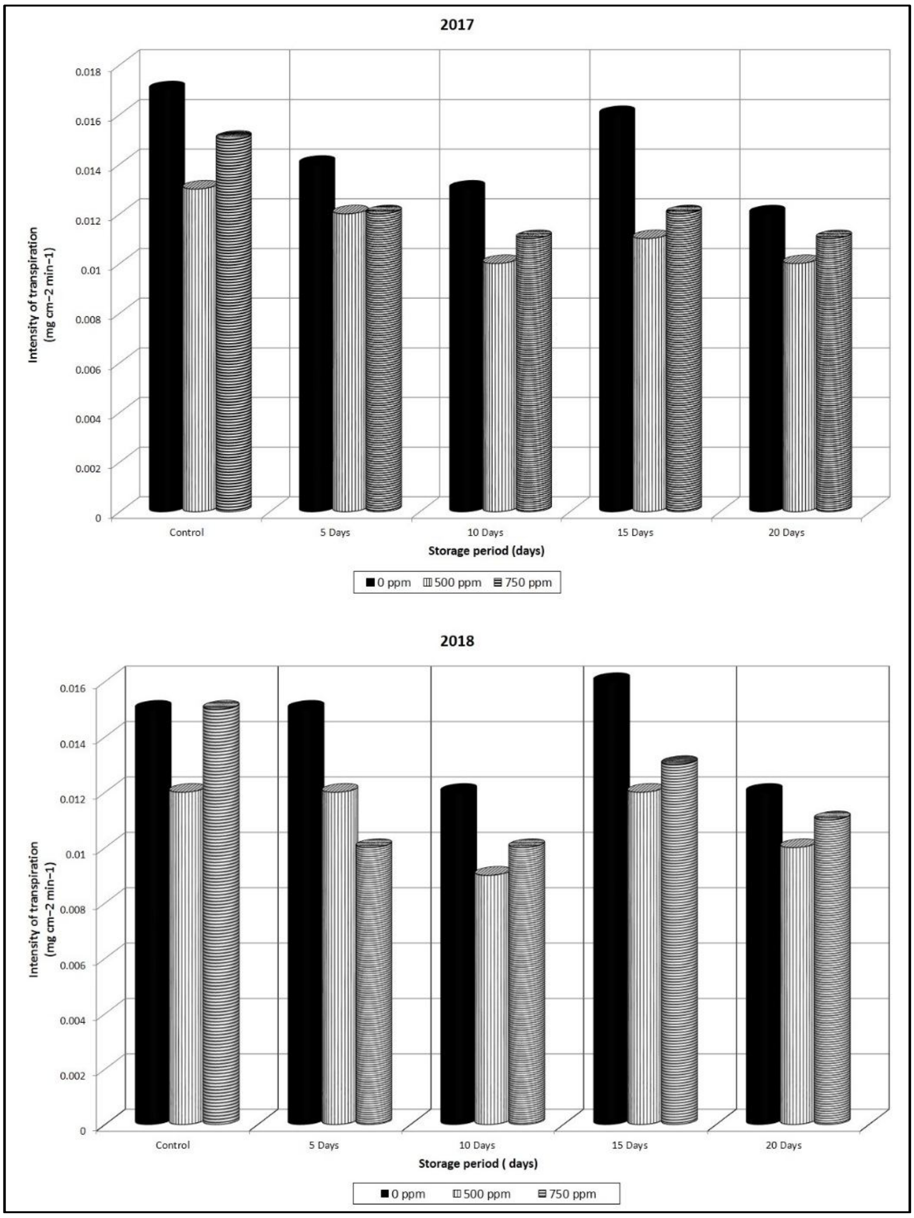

Fig. 3. Effect of the interaction between chitosan and storage period on the intensity of transpiration of *Codiaeum variegatum* during the two seasons (2017-2018)

5.5 Reducing sugar (mg/g dray weight)

Table (4) showed that storage of croton plants for 5 days with foliar spray of chitosan at the rate of 500 ppm caused the highest decrease in reducing sugars content (2.496 and 2.239 mg) in the first and second seasons, respectively . Also, Table (4) cleared that foliar spray of chitosan at the rate of 500 ppm caused the highest decrease of reducing sugars content (3.874 and 3.266 mg) in the first and second seasons respectively. Moreover, the significantly highest decrease in reducing sugar content was observed after 5 days of storage (3.231 and 2.776 mg) in the first and second seasons, respectively .

Table 3. Means of Chlorophyll a , b and Carotenoids (mg/100 g leaves fresh weight) in the leaves of *Codiaeum variegatum* L as influenced by foliar spray of chitosan (ppm), storage period (days) and the interaction between them during the two seasons of 2017 and 2018.

	Storage Period (days)	2017				2018			
		Chitosan (ppm)			Mean	Chitosan (ppm)			Mean
		0	500	750		0	500	750	
Chlorophyll a (mg/100 g)	0	116.23	120.97	116.98	**118.06a**	116.69	119.94	118.68	**118.44a**
	5	69.81	115.60	114.95	**100.12ab**	91.37	122.67	110.35	**108.13a**
	10	56.21	101.21	98.56	**85.32bc**	83.65	116.50	116.12	**105.42a**
	15	56.77	93.99	91.84	**80.86bc**	64.08	110.41	87.81	**87.43b**
	20	39.59	89.89	70.90	**66.80c**	40.18	90.90	65.88	**65.65c**
	Mean	**67.72 b**	**104.33 a**	**98.64 a**		**79.19 c**	**112.08a**	**99.77 b**	
	L.S.D.at 0.05			**D**	**21.70**	**L.S.D.at 0.05**		**D**	**15.54**
				Ch	**16.81**			**Ch**	**12.04**
				D x Ch	**N.S.**			**D x Ch**	**N.S.**
Chlorophyll b (mg/100 g)	0	36.30	54.26	57.49	**49.35a**	42.91	53.91	43.59	**46.80a**
	5	35.10	49.69	48.51	**44.43a**	33.50	47.76	45.15	**42.14a**
	10	31.03	41.08	40.06	**37.39ab**	35.25	49.15	45.49	**43.30a**
	15	19.91	33.74	32.07	**28.57bc**	23.89	23.89	30.92	**30.24b**
	20	15.00	33.29	24.89	**24.39c**	15.10	34.67	23.83	**24.53b**
	Mean	**27.47b**	**42.41a**	**40.60a**		**30.13 b**	**44.28a**	**37.80a**	
	L.S.D.at 0.05			**D**	**12.34**	**L.S.D.at 0.05**		**D**	**9.76**
				Ch	**9.56**			**Ch**	**7.56**
				D x Ch	**N.S.**			**D x Ch**	**N.S.**
Carotene(mg/100 g)	0	33.12	36.12	31.61	**33.62ab**	31.86	31.64	31.82	**31.77a**
	5	23.27	22.33	25.44	**23.68c**	25.57	22.23	26.24	**24.68b**
	10	26.06	41.26	42.27	**36.53a**	25.28	28.83	29.46	**27.86ab**
	15	28.48	32.81	30.14	**30.48abc**	27.62	27.90	26.92	**27.48ab**
	20	25.31	24.92	23.37	**24.53bc**	22.91	21.29	23.14	**22.44b**
	Mean	**27.25**	**31.49**	**30.57**		**26.65**	**26.38**	**27.52**	
	L.S.D.at 0.05			**D**	**9.36**	**L.S.D.at 0.05**		**D**	**5.81**
				Ch	**N.S.**			**Ch**	**N.S.**
				D x Ch	**N.S.**			**D x Ch**	**N.S.**

L.S.D. = Least significant different at 0.05 level of probability
D :: Days , Ch : Chitosan
N.S.= not significant

Table 4. Means of proline content (µg/g dray weight) and reducing sugar (mg/ g dray weight) of *Codiaeum variegatum* L as influenced by foliar spray of chitosan (ppm) , storage period (days) and the interaction between them during the two seasons of 2017 and 2018.

	Storage Period (days)	2017				2018			
		Chitosan (ppm)			Mean	Chitosan (ppm)			Mean
		0	500	750		0	500	750	
Prolin content (µg/g)	0-time	131.07	126.88	108.49	**122.15 b**	116.98	117.64	101.03	**111.88 b**
	5	157.93	132.53	129.17	**139.88 b**	132.58	98.33	117.83	**116.25 b**
	10	156.12	135.60	141.55	**144.42 b**	142.71	113.13	136.89	**130.91 b**
	15	282.49	188.58	203.44	**224.84 a**	210.64	157.03	146.08	**171.25 a**
	20	288.81	218.67	239.42	**248.97 a**	216.44	173.51	191.33	**193.76 a**
	Mean	**203.29 a**	**160.45b**	**164.41 b**		**163.87 a**	**131.93 b**	**138.63 b**	
	L.S.D.at 0.05			D	38.33	L.S.D.at 0.05		D	27.65
				Ch	29.69			Ch	21.42
				D x Ch	N.S.			D x Ch	N.S.
Reducing sugar (mg/g)	0-time	3.994 de	3.797 ef	3.904 de	**3.898 b**	3.531e	3.067 f	3.536 e	3.378 b
	5	4.510 bcd	2.496g	2.685g	**3.231 c**	3.739 d	2.239 g	2.349g	2.776 c
	10	4.663 abc	3.182 f	4.148 cd	**3.997 b**	3.805 d	2.573 fg	3.560 e	3.312 b
	15	5.096 ab	4.825 ab	4.988 ab	**4.969 a**	4.785 ab	4.153 bcd	4.148 bcd	4.362 a
	20	5.177 a	5.069 ab	5.069 ab	**5.105 a**	4.805 a	4.297 b	4.399 abc	4.500 a
	Mean	4.688 a	3.874 b	4.159 b		4.133 a	3.266 c	3.598 b	
	L.S.D.at 0.05			D	0.373	L.S.D.at 0.05		D	0.289
				Ch	0.289			Ch	0.223
				D x Ch	0.646			D x Ch	0.500

L.S.D. = Least significant different at 0.05 level of probability
D :: Days , Ch : Chitosan
N.S.= not significant

DISCUSSION

The decrease of leaves drop percentage (LDP) , water loss rate (WLR) % and the intensity of transpiration after application of chitosan could be explained due to the ability for chitosan in improving the storage of croton plants under water lack by inducing stomatal closure and reducing transpiration rates in plants (Bittelli *et al .,* 2001) or that chitosan coating acts as a semi-permeable barrier against oxygen, carbon dioxide and moisture, thereby reducing respiration and water loss (Velickova *et al.,* 2013).

The increase in chlorophyll content after foliar spray of chitosan may be due to the fact that the application of chitosan is able to restrain the activity of chlorophyllsse enzyme in degrading chlorophyll. (Anggarwulan *et al.,* 2015). The decrease of leaves proline content after application of chitosan may be due to the decrease in intensity of transpiration and water loss rate (WLR) which resulted in a decrease in plant stress. The decrease in reducing sugar after foliar spray of chitosan at 500 ppm cleared that chitosan inhibited the plant metabolism and gave extended storage life.

For the effect of storage periods the increase of leaves drop after 20 days of storage may be due to ethylene, the lack of light intensity or water stress (Starman *et al.,* 2007)

The decrease of chlorophyll content by increasing storage period may be due to darkness during storage as light is necessary for chlorophyll biosynthesis and reduce a loss of color (Ferrante *et al.,* 2015)

By increasing the storage period the plants are exposed to stress conditions like lack of light and water stress which resulted in increment of reducing sugars.

In conclusion, chitosan can be used as a foliar spray on croton plants at 500 ppm. This treatment decreases water loss , leaves drop percentage and increase chlorophyll content which increases the tolerability of *Codiaeum variegatum* plants to transport and retail conditions. Moreover, croton plants can be stored until 20 days with foliar spray of chitosan at 500 ppm without significant effect on leaves drop percentage .

REFERENCES

1. Anggarwulan,E.; W. Mudyantini and I. Jati Asiyah. 2015. Chitosan treatment and storage temperature in the retardation of fruit ripening of red guava (*Psidium guajava*) The Nusantara Bioscience, 7 (2):153-159.
2. Bates, L.; R. Waldern and I. Teare. 1973. Rapid determination of free proline for water stress studies. Plant and Soil, 39: 205 – 207.
3. Besufkad , A. and E. Woltering. 2015. Efficacy of physiologically active anti-transpirants on excised leaves of potted plants .Malaysian Journal of Medical and Biological Research, 2 (5): 167-174.
4. Bittelli, M.; M. Flury ; G.S. Campbell and E.J. Nichols. 2001. Reduction of transpiration through foliar application of chitosan. Agricultural and Forest Meteorology Journal, 107: 167–175.
5. El Ghaouth, A., J. Arul and R. Ponnampalam. 1991. Use of chitosan coating to reduce water loss and maintain quality of cucumbers and bell pepper fruits. Journal of Food Process and Preservation, 15: 359–368
6. Ferrante A.; A. Trivellini; D. Scuderi and D. Romano. 2015. Post-production physiology and handling of ornamental potted plants. Postharvest Biology and Technology, 100: 99–108

7. Hein, NQ. 2004. Radiation Degradation of Chitosan and Some Biological Effects.Vietnam Atomic Energy Authority, Ho Chi Minh City, Viet Nam.
8. Jane C., and C. Garaham. 1997. Indoor Plants The Essential Guide to Choosing and Caring for Houseplants . Reader's Digest Association ,Inc . Italy.
9. Miller, G.L. 1959. Use of dinitrosalicylic acid reagent for determination of reducing sugar Anal. Chem., 31 (3): 426-428.
10. Moran, R. 1982. Formula for determination of chlorophyll pigment extracted with N,N diethyl formamide. Plant Physiology, 69 : 1376-1381.
11. New N, S. Chandrkrachang and WF Stevens. 2004. Application of chitosan in Myanmar's agriculture sector, in: Proceedings of the 6th Asia Pacific Chitin and Chitosan Symposium, May 23–26, The National University of Singapore, Singapore.
12. Nguyen, A.D.; V.T.P. Khanh and T.T. Dzungc. 2011. Research on impact of chitosan oligomers on biophysical characteristics, growth, development and drought resistance of coffee. Carbohydrate Polymers, 84: 751–755
13. Olivas, G. I., and G.V. Barbosa-Ca´novas. 2005. Edible coatings for fresh-cut fruits. Critical Reviews in Food Science and Nutrition, 45: 657–670.
14. Ramírez, M.Á.; A. T. Rodriguez, L. Alfonso and C. Peniche. 2010. Chitin and its derivatives as biopolymers with potential agricultural applications. Biotecnol. Apl., 27: 270–276.
15. Snedecor , G. W. and W. Cochran. 1989. Statistical Methods, 8th Ed. Iowa State University Press.
16. Starman,T.W., S. E. Beach, and K. I. ,Eixmann. 2007. Postharvest decline symptoms after simulated shipping and during shelf life of 21 cultivars of vegetative annuals. HortTechnology, 17: 544–551.
17. Velickova, E.; E. Winkelhausen.; S. Kuzmanova, ; V.D. Alves, ; Moldão and M. Martins. 2013. Impact of chitosan beeswax edible coatings on the quality of fresh strawberries (*Fragaria ananassa*, cv "Camarosa") under commercial storage conditions. Food Science Technology, 52: 80–92.
18. Wellburn, A.R. 1994. The spectral determination of chlorophylls *a* and *b,* as well as total carotenoids, using various solvents with spectrophotometers of different resolution. Journal of Plant Physiology , 144(3): 307-313.

إستخدام الشيتوزان لتحسين قدرة تحمل نباتات الكروتون لفترات الشحن

نجلاء محمد مصطفى ، مجد الدين فؤاد رضا ، أسماء محمد طه

فرع بحوث نباتات الزينة بأنطونيادس – الإسكندرية – قسم بحوث الزينة وتنسيق الحدائق-– معهد بحوث البساتين – مركز البحوث الزراعية – جمهورية مصر العربية

أجريت هذه الدراسة بفرع بحوث الزينة بانطونيادس خلال الموسمين (2017 – 2018) لتحسين قدرة نبات الكروتون على تحمل فترات النقل والتداول باستخدام الشيتوزان . تم رش نباتات الكروتون بثلاثة تركيزات من الشيتوزان (صفر– 500 – 750 جزء في المليون) وتم تعبئة النباتات في عبوات من الكرتون وخزنت على درجة حرارة 15.5 م° ومتوسط الرطوبة النسبية 73 % . لفترات تخزين مختلفة (بدون تخزين – 5 –10 –15 – 20 يوما) .اظهرت النتائج أن رش اوراق الكروتون ب 500 جزء قي المليون أدي إلى نقص في معدلات فقد الماء – الفقد النسبي للماء – كثافة النتح – تساقط الأوراق –تركيز البرولين – السكريات المختزله . اعلى تركيز من كلورفيللي أ و ب بعد هذه المعاملة . كما اظهرت النتائج أنه مع زيادة فترة التخزين يزداد كل من الفقد النسبي للماء – معدل تساقط الأوراق – تركيز البرولين . أقل كثافة نتح تم الحصول عليها بعد 10 أيام من التخزين وكذلك قل كلورفيل أ و كلورفيل ب بزيادة فترة التخزين.