World Applied Sciences Journal 17 (4): 509-515, 2012
ISSN 1818-4952

UV-C Treatments on Fresh-Cut Garden Cress (*Lepidium sativum* L.) Enhanced Chlorophyll Content and Prevent Leaf Yellowing

Rezzan Kasim and M.Ufuk Kasim

Department of Postharvest Technology, Kocaeli University, 41285, Kartepe, Kocaeli, Türkiye

Abstract: The effect of UV-C treatments at different doses, on color attributes (L* and b* values), chlorophyll content and also electrolyte leakage was investigated. Garden cress leaves harvested, trimmed, washed and the stem of leaves was cut. After that UV-C irradiation was treated for different time such as 10 min, 20 min or 30 min. Quality attributes of samples evaluated at the begining of storage and after seven days of storage at 5°C temperature and 95% relative humidity. Total chlorophyll content of garden cress leaves was increased with increasing UV-C doses but it was the higher in samples treated with UV-C for 30 min (C) compared to other treatments. In the same way lightness (L* value) was high and b* values of samples were low in C treatment, an also number of yellowing leaves was low in C treatment. Electrolyte leakage of samples, however, was the high in samples in all UV-C irradiation treatments compared with control group. As a results of study, UV-C treatment on fresh-cut garden cress leaves was prevented leaf yellowing, increased chlorophyll content and also prevent chlorophyll degradation but increased electrolyte leakage due to tissue damage.

Key words: *Lepidium sativum* L. • Garden cress • UV-C • B*value • Color • Chlorophyll • Yellowing

INTRODUCTION

Cress (*Lepidium sativum* L.), otherwise known as garden cress, gardencress pepperweed or garden pepperworth, is a fast growing annual herb belonging to the *Brassicaceae* family that is native to Egypt and west Asia but is widely cultivated in temperate climates throughout the world for various culinary and medicinal uses [1]. The garden cress is an annual herb. The seedlings are consumed in Europe as salad and spice [2].

Since people are encouraged to increase their salad consumption, there is also a need to divesify the vegetables to be used in salads, Adams *et al.* [3] showed that variety in salads tend to increase the salad intake in elementary school students. Recently garden cress has gained more interest from consumers and producers [4] and can be a good choice for salads with its peppery taste and health promoting substances suc as glucotropaeolin, a glucosinolate compound and precursor of benzyl isothiocyanate [5] and sterols [6].

The consumer demand for high quality foods requiring only minimum amount of effort and time for preparation has led to the introduction of ready-to-use, convenience foods pereserved by mild methods (so called minimal processing method, fresh-cut method) only. Minimally processed fruits and vegetables consist of raw fresh cut produce, which have undergo a minimal processing such as peeling, slicing or shredding to make them ready-to-use [7].

Minimal processing of raw fruits and vegetables has two purposes. First, it is important to keep the produce fresh, but convenient without losing its nutritional quality. Second, the product should have a shelf life sufficient to make distribution feasible within the region of consumption. The microbiological, sensory and nutritional shelf life of minimally processed vegetables or fruits should be at least 4-7 days, but preferably even longer, up to 21 days depending on the market [7].

The fresh-cut vegetable industry commonly uses sodium hypochlorite (NaOCl) and acidification top H 6-7 in a washing step as sanitisation treatment. However, certain by products of this procedure, such as chloroform, haloacetic acids and other trihalomethanes, are potentially harmful to humans [8] so alternative disingectant agents need to be investigated. Among the possibilities, disinfectionby non-ionising UV-C radiation is interesting, because no residues are released and the cost is relatively low [9].

Corresponding Author: Rezzan Kasim, Department of Postharvest Technology, Kocaeli University, 41285, Kartepe, Kocaeli, Türkiye.

The effectiveness of UV-C seems to be independent of temperature in the range 5-37°C, but it depends on the incident irratiation determined by the structure and surface topography of the treated product [10]. In addition, UV-C light acts indirectly against micro-organisms by stimulating defence mechanisms in treated produce, retarding decay and delaying senescence. The crucial point is whether a safe dose could be found that would greatly impair pathogen growth without damaging the product [11]. Studies on the application of UV-C in leafy vegetables are scarce.

The purpose this work was to evaluate the effects of various UV-C treatments on fresh-cut garden cress quality during storage at 5°C temperature for 7 days.

MATERIALS AND METHODS

Plant Material: Garden cress (*Lepidium sativum* L.), produced under usual cultivation practices in the greenhouse of the Arslanbey Vocational School, Kocaeli University, Türkiye were hand harvested by plowing the plants from the soil, when 90% of plant reached to 7 to 10 leaf stage. After harvest, roots of garden cress were trimmed, had the decayed leaves removed and washed with the tap water and stem part of leaves was cut.

Packaging and Storage: For each replicates 50 g of garden cress leaves were placed into polystyrene foam dishes and wrapped with polyethylene (PE) stretch film. Leaves of fresh cut garden cress were stored at 5°C temperature and 95% relative humidity for seven days. Changes in quality of leaves of garden cress were determined at the beginning of storage and seven days after storage. Three replication from each treatment were evaluated for chlorophyll a, b and total chlorophyll content, color changes, number of yellowing leaves and electrolyte leakage.

UV-C Irradiation Methods and Treatments: The UV-C irradiation treatments were applied using unfiltered germicidial emitting lamps (TL 60 W/10R SLV, Philips, Holland). Packaged garden cress leaves were placed on a wide mesh screen and irradiated with lamps on upper surfaces at a distance of 30 cm, from screen. UV-C treatments were applied to leaves as follows: control (Non-treated, K), UV-C for 10 min (A), UV-C for 20 min (B) and UV-C for 30 min (C).

Chlorophyll Determination: Chlorophyll a and b were exracted by grinding 2 g of leaf tissue of garden cress with 30 mL 80% acetone, followed filtering through Whatman No.2 paper. The filtered solution volume was adjusted to 100 mL with 80% acetone. Chlorophyll content was measured spectrophotometrically at 645 and 663 nm according to Mencarelli and Saltveit [12].

Color Measurements: Superficial color was determined with a chromameter (Minolta CR-400, Minolta Camera, Co., Osaka, Japan) equipped with as 8-mm measuring head and a D65 illuminant. The chromameter was calibrated with manufacturer's standart white plate. Color changes were quantified in the L* and b* color space. The color of fresh-cut garden cress leaf was objectively measured at three point over the leaf surface.

Yellow Leaf Number: Number of yellowing leaves was scored at the end of the storage.

Electrolyte Leakage: Electrolyte leakage (EL) was measurad as 1 cm leaf parts of garden cress. The leaf parts were washed several times in distilled water and were then incubated in distilled water. Conductivity was measured after 2 h of incubetion. Total electrolyte conductivity in the leaf parts was measurad after they had been frozen and thawed. EL was calculated as a percentage of the conductivity after 2 h of total [13].

Statistical Analysis: Experiments were conducted as completely randomized designs with thee replications. Data analysis was dona by two-way analysis of variance and means were seperated by Duncan's multiple range test ($p \leq 0.05$)

RESULTS AND DISCUSSIONS

Chlorophyll Content: Chlorophyll is considered as the source of green vegetable color. It is fragile and can be easily altered or destroyed this makes green vegetables fade easily during storage and processing, which affects the fresh green leafy vegetables quality the color change from bright green to olive brown during the storage and processing which is mainly due to the degradation of chlorophyll [14]. Changes in the level of chlorophyll in photosynthetic tissues may represent a good index of senescence, occuring in green vegetables after harvest;

chlorophyll degradation is strongly connected with senescence associated peroxidase activity on cell membrane lipids [15].

Effect of different doses of UV-C radiation (10, 20 or 30 min) on chlorophyll a (chl a), chlorophyll b (chl b) and total chlorophyll content is showed in Fig. 1. The content of chlorophyll a+b was highest in leaves of garden cress treated with UV-C for 30 min (601.84 mg g^{-1}) and followed by A (586.69 mg g^{-1}), B (479.68 mg g^{-1}) or K (477,88 mg g^{-1}) treatment, respectively at the end of the storage. Chlorophyll content of *Lepidium sativum* was affected by various levels of UV-C radiation doses but differences among the treatments were not to be statistically significant. Exposure of leaves to different doses of UV-C, however, was altered chlorophyll contents. And also, the parameters under consideration were positively influenced by a dose level of 30 min UV-C which increased chlorophyll a by 26.14%, chlorophyll b 25.69% and total chlorophyll by 23.93% over control. The present study revealed considerable effects of UV-C doses (especially 30 min UV-C treatment) on chlorophyll content of garden cress leaves which exhibited increasing trend with increasing intensity level.

Color change during selling period is very important because it affects produce attractiveness to consumers [16]. Chlorophyll and carotenoid very common pigment, their content start to decline a few days after harvest [17]. But in our study, UV-C treatments on fresh-cut garden cress leaves were increased chlorophyll content and we did not recorded degredation of chlorophyll. It was said by Ben-Yehoshua and Mercier [11] that UV-C light acts indirectly against micro-organisms by stimulating defence mechanisms in treated produce, retarding decay and delaying senescence. So in present study increasing in chlorophyll content may be depends on defence mechanism of garden cress leaves against to UV-C treatments.

Harvesting of green leafy vegetables induces senescence which has detrimental effect on their postharvest quality though accelerated chlorophyll degradation [18] and degradation of chlorophyll most evident symptom of senescence at harvested vegetable [19]. In present work, chl a content of fresh-cut garden cress leaves was 359.68 mg g^{-1}, chl b content was 156.56 mg g^{-1} and total chl content was 516.14 mg g^{-1} at the beginning of storage and chl a value was decreased in K and B treatments while it was increased in A and C treatments. The same trend was found for total chl content but chl b content of samples was increased both in control and in all UV-C treatments. Therefore, UV-C treatments on leaves of garden cress were delayed chl degratadion especially at 10 min and 30 min treatments. Normally chlorophyll content of green vegetables was decreased and yellowing was occured but in present study the chl content of leaves was not decreased contrarily it was increased in leaves treated 10 min and 30 min treatments and this increase was higher than the treatment of UV-C for 20 min and control. In previous work it was showed that UV-C treatments can delay chlorophyll degradation, effect normal catabolism of chlorophyll and maintain green color in broccoli [20,21]. We did not find any literature about the effect of UV-C on postharvest quality including color and chlorophyll content of garden cress leaves. So, in present work UV-C treatments were increased chl a, chl b and total chlorophyll content of garden cress with the increased UV-C doses and was mainly maintained throughout the seventh days storage period under MAP and refrigerated storage condition confirming by previous reports [20, 21]. Also like our study Artez-Hernandez *et al* [22] was reported that UV-C treatment on spinach was maintained the initial chlorophyll content during shelf life.

Color Changes: Consumer take product appearance into consideration as a primary criterion, color has been considered to have a key role in food choice, food preference and acceptability and may even influence taste thresholds, sweetness, perception and pleasantness. Color is one of the main attributes, along with texture, that characterises the freshness of most vegetables. The retention of the inherent color of fresh vegetables is often used as a quality indicator and has a substantial impact on consumer acceptance [23]. As shown in b* values (Fig. 2) yellowing of leaves was decreased with increasing UV-C doses. b*values of fresh-cut garden cress leaves were the highest in K (24.77) and followed by A (24.15) and B(23.38) treatments and were lowest in C (22.82) treatment and also differences between C treatment and conrol group were statistically important ($p \leq 0.05$). The green colors of most vegetables are contributed by chlorophyll and anthocyanins [24]. In our study, results of chlorophyll measurements (Fig. 1) indicated that likewise b* values, chl a, chl b and total chlorophyll content of fresh cut garden cress were the high in C treatment than the other two UV-C treatments and control. In a previous study [25], it was found that the green color

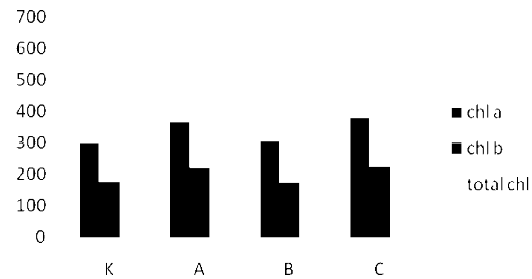

Fig. 1: Chlorophyll a, chlorophyll b and total chlorophyll content of fresh-cut garden cresss at 7thday of storage (K: control, A: UV-C for 10 min, B: UV-C for 20 min, C: UV-C for 30 min), Chlorophyll a, b and total chlorophyll content of garden cress leaves at the beginning of the storage: 359.68; 156.56 and 516.24, respectively

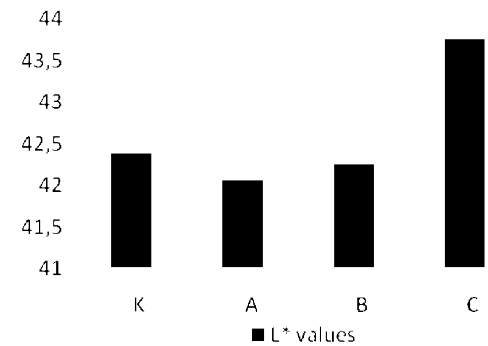

Fig. 3: L* values of fresh-cut garden cresss at 7thday of storage (K: control, A: UV-C for 10 min, B: UV-C for 20 min, C: UV-C for 30 min), L* value of garden cress leaves at the beginning of the storage: 44.48

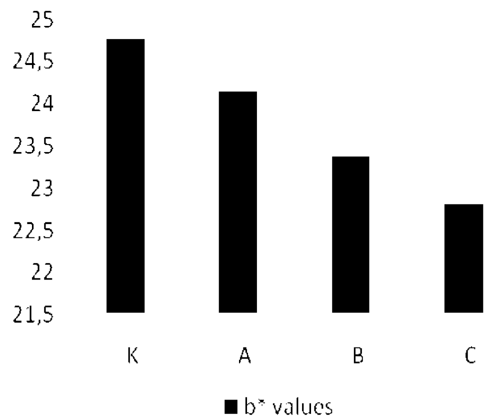

Fig. 2: b* values of fresh-cut garden cresss at 7thday of storage (K: control, A: UV-C for 10 min, B: UV-C for 20 min, C: UV-C for 30 min), b* value of garden cress leaves at the beginning of the storage: 21.40

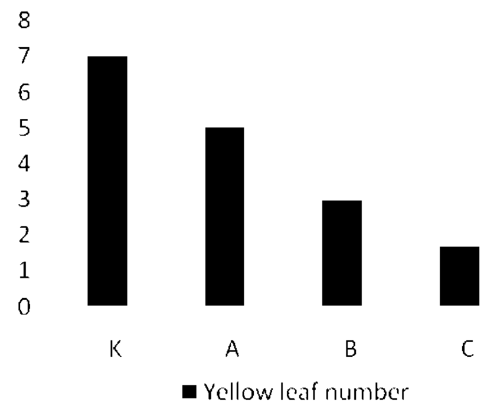

Fig. 4: Yellow leaf number of fresh-cut garden cresss at 7thday of storage (K: control, A: UV-C for 10 min, B: UV-C for 20 min, C: UV-C for 30 min), L* value of garden cress leaves at the beginning of the storage: 0

of cucumer treated with UV-C was maintain better than the control. The present work agreement with this result.

UV-C treatment for 30 min on fresh-cut garden cress leaves had a significant effect on color L* values and followed by control, UV-C for 20 min and UV-C for 10 min treatments, respectiveliy. The differences between C and K treatment were found (Fig. 3) significant statistically ($p \leq 0.05$). Also, L* values were supported to b* values because, in C treatment, yellowing of leaves were low and lightness of this samples was high and number of yellowing leaves was low compared with other two UV-C treatments. Furthermore total chlorophyll content of fresh-cut garden cress leaves treated with UV-C for 30 min was increased during the storage. Therefore, UV-C treatments especially higher doses on garden cress leaves were positively effect on color b* and L* values and chlorophyll content compared with control.

Number of Yellow Leaf: Number of yellow leaf was performed by panelists and it was shown in Fig. 4. According to this evaluation, number of yellow leaf of fresh-cut garden cress was the highest in control (K) and followed by A, B and C treatments, respectively during the storage. Green color of leaves was retained best in samples treated with UV-C for 30 min (C) than in control and the other two UV-C treatments. An important quality loss of fresh green product is leaf yellow during storage.

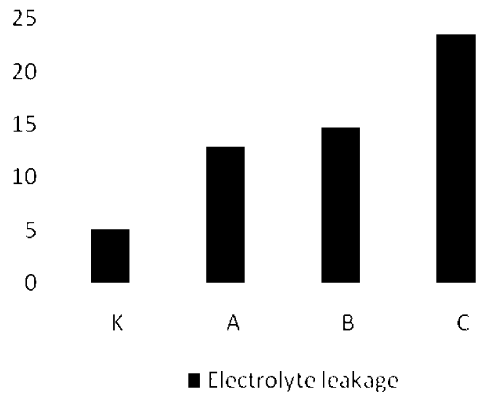

Fig. 5: Electrolyte leakage of fresh-cut garden cresss at 7th day of storage (K: control, A: UV-C for 10 min, B: UV-C for 20 min, C: UV-C for 30 min), L* value of garden cress leaves at the beginning of the storage: 4.87%

The decrease of green pigmentation is loss of chlorophyll during storage. We found that total chlorophyll content and number of yellow leaf negatively correlated (data not shown). The total chlorophyll content of fresh-cut garden cress leaves was increased at the end of the storage on the contrary the number of green leaves was the lowest in C treatment. So UV-C treatments were decreased leaf yellowing in all doses compared with control.

Electrolyte Leakage (EL): Electrolyte leakage expressed as a percent of total electrolyte leakage was 4.87% at harvest and had increased at the end of the storage (Fig. 5). But thes increase was the highest in garden cress leaves treated with UV-C for 30 min (23.53%) and followed by UV-C for 20 min (14.76%), UV-C treatment for 10 min (12.93%) and control (5.07%) samples, respectively. EL of leaves in control group was the lower than those of UV-C treated samples and differences among the treatments were significant ($p \le 0.05$) and EL rate of UV-C treated leaves after 7 d of storage was changed between 12.93% and 23.53%, twice or five fold the rate seen at harvest. EL, can be used determine changes in membrane permeability caused by environmental stres [26]. In the present study minimally processing used for garden cress leaves was damaged plant tissue because the EL rate of control group was higher at the end of the storage compared with harvest. Furthermore, UV-C treatments on fresh-cut leaves is a the other stres affecting membrane permeability.

UV-C treatment is effective for inactivation of food borne pathogen and parasite in various vegetables [27] while it can be detrimental for tissue especially higher doses. In our study EL of UV-C treated leaves was increased with increasing UV-C doses (Fig 5) confirming previous work. The rate of EL was the lowest in control samples and the highest in samples in UV-C treatment for 30 min. Higher rates of increase in EL as function of higher doses of UV-C was suggested that garden cress leaves were sensitive to UV-C damage.

CONCLUSIONS

UV-C treatments on fresh cut garden cress leaves were studied. In carden cress leaves that fresh cut and treated with UV-C for 30 min, lightness (L* values) was retained best than the other two UV-C treatments at the end of the storage. In the same way, b* values of samples were decreased in all UV-C treatments, especially UV-C treatment for 30 min, so UV-C treatments were prevent or at least delayed yellowing of fresh-cut garden cress for the seven days of storage. Also, UV-C treatments were delayed chlorophyll degradation of leaves in fact the total chlorophyll content of UV-C treated garden cress leaves were increased. Likewise number of yellow leaf was lowest in the sample tretaed with UV-C for 30 min. But EL of UV-C treated leaves was getting increase with the increasing UV-C doses. consequently, it was said that UV-C treatments on fresh-cut garden cress leaves could prevent yellowing but increase tissue damage. So for the maintain of quality of fresh-cut garden cress the lower UV-C doses could be used.

REFERENCES

1. Gokavi, S.S., N.G. Malleshi and M. Guo, 2004. Chemical Composition of Garden Cress (*Lepidium sativum*) Seeds and Its Fractions and use of Bran as a Functional Ingredient. Plant Foods for Human Nutrition, 59: 105-111.
2. Maier, U.H., H. Gundlach and M.H. Zenk, 1998. Seven Imidazole alkoloids from *Lepidium sativum*. Phytochemistry. 49(6): 1791-95.
3. Adams, M., R. Pelletier, M. Zive and J. Sallis, 2005. Salads Bars and Fruit and Vegetable Consumption in Elementary Schools: A Plate Waste Study. J. Am. Diet. Assoc., 105(11): 1789-92.

4. Zhan, L.J., E. Fontana, G. Tibaldi and S. Nicola, 2009. Qualitative and Physiological Response of Minimally Processed Garden Cress (*Lepidium sativum* L.) to Harvest Handling and Storage Conditions. J.Food Agric. Environ., 7 (3&4): 43-50.
5. Kassie, F., S. Rabot, M. Uhl, W. Huber, H.M. Qin, C. Helma, R. Schulte-Herman and S. Knasmüller, 2002. Chemoperative Effects of Garden Cress (*Lepidium sativum*) and Its Constituents towards 2-amino-3-methiyl-imidazo (4.5.-f) quinoline (IQ)-Induced Genotoxic Effects and Colonic Affects and Colonic Preneoplastic Lesions. Carcinogenesis. 23(7): 1155-66.
6. Conforti, F., S. Sosa, M. Mairelle, F. Menichini, G.A., Statti, D. Uzunov, A. Tubaro and F. Menichini, 2009. The Protective Ability of Mediterranean Dietary Plants Againts the Oxidative Damage: The Role of Radical Oxgen Species in Inflammation and the Polyphenol, flavonoid and Sterol Contents. Food Chem., 112(3): 587-594.
7. Ahvenainen, R., 2000. Ready-to-use Fruits and Vegetables. FLAIR-FLOW EUROPE Technical Manual. 376A/00. (Ed.,Gormley, R., The National Food Centre, Dublin), pp: 32.
8. Nieuwenhuijsen, M.J., M.B. Toledano and P. Elliot, 2000. Uptake of Chlorination Disinfection Byproducts; A Review and a Discussion of Its Implications for Exposure Assessment in Epidemiological Studies. J. Exp. Anal. Envion. Epidemiol., 10: 586-589.
9. Artés, F., A. Conesa, V. López-Rubira and F. Artés-Hernández, 2006. UV-C Treatments for Improving Microbial Quality in Whole and Minimally Processed Bell Peppers, In: The Use of UV as a Postharvest Treatment: Status and Prospects, ed.by Ben-Yehoshua, S., D'Hallewin, G., Erkan, M., Rodov, V. and Lagunas, M. Kros Ofset-Yakup Kublay, Antalya, pp: 12-17.
10. Gardner, D.W. and G. Shama, 2000. Modeling UV-Induced Inactivation of Microorganisms on Surfaces. J. Food Protect. 63: 63-70.
11. Ben-Yehoshua, S. and J. Mercier, 2005. UV Irratiotion, Biological Agents and Natural Compounds for Controlling Postharvest Decay in Fresh Fruits and Vegetables, In: Environmentally Friendly Technologies for Agricultural Produce Quality. Ed. By Ben-YehoshuaS., CRC/Taylor and Francis, Boca Raton, FL, pp: 265-299.
12. Mencarelli, F. and M.E. Saltveit, 1988. Ripening of Mature-Green Tomato Fruit Slices. Journal of the American Society for Horticultural Sci., 113: 742-745.
13. Kasım, M.U., 2009. The Effect of Harvesting Onions at Different Diameter on Color and Weight Loss in Fresh Cut Green Onions. World Applied Science J., 6(6): 728-733.
14. Martínez-Sánchez, A., A. Allende, R.N. Ferreres and M.I. Gil, 2006. Microbial, Nutritional and Sensory Quality of rocket Leaves as Affected by Different Sanitizers. Postharv. Biol. Technol., 42: 86-97.
15. Deschene, A., G. Paliyath, E.C. Lougheed, E.B. Dumbroff and J.E. Thompsan, 1994. Membrane Deterioration during Postharvest Senescence of Broccoli Florets: Modulation by Temperature and Controlled Atmosphere Storage, Postharv. Biol. Technol., 1: 19-31.
16. Biswall, B., 1995. Carotenoid catabolism during leaf senescence and its control by light, Photochem. Photobiol., B 30: 3-14
17. Ferrante, A., L. Incrocci, R. Maggini, G. Serra and F. Tognoni, 2004. Colour Changes of Fresh-Cut Leafy Vegetables during Storage. J. Food Agric. Environ., 2(3&4): 40-44.
18. Koukounaras, D.A., 2009. Senescence and Quality of Green Leafy Vegetables. Stewart Postharvest Review. 5(2): 1-5.
19. Hui, Y.H., 2004. Handbook of Vegetable Preservation and Processing. Markel Dekker. pp: 739.
20. Costa, L., A.R. Vicente, P.M. Civello, A.R. Chaves and G.A. Martinéz, 2006. UV-C Treatment Delays Postharvest Senescece in Broccoli Florets. Postharvest Biol.Technol., 39: 204-210.
21. Lemoine, M.L., P.M. Civelo, A.R. Chaves and G.A. Martinéz, 2008. Effect of Combined Treatment with Hot Air and UV-C on Senescence and Quality Parameters of Minimally Processed Broccoli (*Brassica oleraceae* L. var. *Italica*). Postharvest Biol. Technol., 48: 15-21.
22. Artez-Hernandez, F., V.H. Escalona, P.A. Robles, G.B. Martinez and F. Artés, 2008. Effect of UV-C Radiation on Quality of Minimally Processed Spinach Leaves. www. interscience.wiley.com DOI 10.1002/jsfa, 3460.
23. Roura, S.I., L.A. Davidovich and C.E. Valle, 2000. Quality Loss in Minimally Processed Swiss Chard Related to Amount of Damaged Area. Lesensmittel-Wissenschaft Und-Technologie-Food Science and Technol., 33: 53-59.

24. Lazcano, C.A., K.S. Yao and L.M. Pike, 2001. A Method for Measuring Anthocyanins after Removing Carotenoids in Purple Colored Carrots. Sci. Hort., 90: 321-324.
25. Kasım R. and M.U. Kasım, 2008. The Effect of Ultraviolet Irradiation (UV-C) on Chilling Injury of Cucumbers During Cold Storage. J. Food Agric. Environ., 6(1): 50-54.
26. Knowles, L., M.R. Trimble and D.R. Knowles, 2000. Phosphorus Status Affects Postharvest Respiration, Membrane Permeability and Lipid Chemistry of Europen Seedless Cucumber Fruit (*Cucumis sativus* L.). Post. Biol. Technol., 21: 179-188.
27. Kasım, M.U. R. Kasım and S. Erkal, 2008. UV-C Treatments on Fresh-Cut Green Onions Enhanced Antioxidant Activity, Maintained Green Color and Controlled ‘Telescoping”. J. Food Agric. Environ., 6(3&4): 63-67.