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One Sided UV-C Treatments Maintain Quality of Fresh-Cut Green Onions

Rezzan Kasım[1], M. Ufuk Kasım[1]

[1]Kocaeli University Vocational School of Arslanbey, 41285 Arslanbey, Kocaeli, Türkiye.
e-mail: rkasim@kocaeli.edu.tr

Abstract: Storage quality of fresh-cut green onions as affected by UV-C treatments, so in this research the effect of UV-C treatments on quality was investigated in fresh-cut green onions. Four different UV-C treatments were used for ultraviole radiation to onions, and non-treated samples as evaluated control group. After UV-C treatments onions were stored at 5^{o}C and 85-90% RH for 15 days. Quality attributes of samples were evaluated periodically in terms of antioxidant activity, electroliyte leakage, color, weight loss, decay percentage and inner leaf extension. Electrolyte leakage of fresh-cut green onions was getting high with the higher doses of UV-C so, the lower doses can be used for controlled pathogen growth because of both lower electrolyte leakage and lower decay percentage at the day 10th. L* value of white stem tissues maintain best in UV-C_5 treatment whereas green color of hollow green tissues was retained best in UV-C_3 treatment. Onions in UV-C_{15} treatment were shown noticeable yellowing however inner leaf extension of onions was effectively controlled by the UV-C_{15} treatment. Antioxidant activity of fresh-cut green onion was enhanced higher doses of UV-C treatments, especially UV-C_{15}.

Key Words: UV-C treatment, fresh-cut green onions, electrolyte leakage, antioxidant activity.

Minimal İşlenmiş Taze Soğanlarda Tek Yönlü UV-C Uygulaması Kaliteyi Korur

Özet: Minimal işlenmiş soğanların depolama kalitesi UV-C uygulamalarından etkilenmektedir dolayısıyla bu çalışmada UV-C uygulamalarının minimal işlenmiş soğanların kalitesi üzerindeki etkileri araştırılmıştır. Soğanlara ultraviyole ışınlaması olarak dört farklı UV-C uygulaması yapılmış ve uygulama yapılmayan örnekler kontrol grubu olarak değerlendirilmiştir. UV-C uygulamalarından sonra soğanlar 5^{o}C sıcaklık ve %85-90 oransal nemde 15 gün depolanmıştır. Periyodik olarak depodan alınan soğanlarda kalite özellikleri olarak; antioksidant aktivite, elektrolit sızıntısı, renk, ağırlık kaybı, çürüme oranı ve iç yaprak uzaması incelenmiştir. Minimal işlenmiş taze soğanlarda elektrolit sızıntısı UV-C dozu arttıkça artmıştır. Depolamanın 10. gününde düşük UV-C dozu uygulanan soğanlarda hem elektrolit sızıntısı hem de çürüme oranı düşük bulunduğundan patojenlerin kontrol edilmesi için düşük dozlar kullanılabilir. Soğanın beyaz yapraklarında ölçülen L* değeri en yüksek UV-C_5 uygulamasına ait örneklerde bulunmuş fakat yeşil yaprakların rengi, UV-C_3 uygulamasında daha iyi korunmuştur. UV-C_{15} uygulaması yapılan soğanlar önemli oranda sararma gösterirken, UV-C_{15} iç yaprak uzamasını önemli ölçüde önlenmiştir. Antioksidant aktivite, uygulanan UV-C dozu arttıkça artmış, özellikle UV-C_{15} uygulamasında yüksek bulunmuştur.

Anahtar Sözcükler: UV-C uygulaması, Minimal işlenmiş taze soğan, elektrolit sızıntısı, antioksidant aktivite.

Introduction

Minimally processed fruits and vegetables are a relatively new and rapidly developing segment of the fresh food industry. These products will have been freshly trimmed, peeled and/or cut, washed, packaged and maintained with refrigeration to after consumers high nutrition, convenience and flavour (Hong and Kim 2004).

However, there are many limitations to post-cutting shelf life of the products due to undesirable physiological changes caused by the minimal processing. Green onions provide an interesting challenge as a minimally processed product. Green onions are comprised of roots, a compressed stem and leaves which consist of a lower white leaf sheath and the hollow upper green tissues. Minimal processing includes the trimming of the leaves, the cutting of the roots, and the removal of all part of the compressed stem. Although this results in a convenient fresh cut product, cutting damage, discoloration, dehydration and decay are common defects of the cut surfaces. These defects similar to those reported for other minimally processed vegetables (Hong et al 2000).

Although great interest in minimally processed vegetable and fruit products exist little commercial success has been achieved. Several preservation methods, including antioxidant treatment, modified atmosphere packaging (MAP), refrigeration, chlorine wash and irradiation have been applied to minimally processed produce (Ahn et al 2005). Exposure to low UV-C doses has been reported to reduce postharvest decay (Lu et al 1987) and also enhanced antioxidant activity, maintain green color and controlled inner leaf extension (Kasim et al 2008) of fresh-cut green onions.

The purpose of this study is to provide information to help determine what role irradiation, in combination with packaging, may have in improving and extending the quality of fresh-cut green onions.

Materials and Methods

Minimally processing of green onions

Green onions (*Allium cepa* L.) were grown in Arslanbey Vocational School of Kocaeli University under usual production practices (Vural et al 2000), harvesting by pulling. After harvest, green onions were sorted for obvious defects, trimmed (roots and leaf tips cut) and washed with tap water at about 20^{o}C. Trimmed stalks then were crosscut into 10 cm lenght.

UV-C radiation treatments and packaging

The UV-C radiation treatments were applied using unfiltered germicidal lamps (TUV 30 W/T8 Philips, Holland) located 30 cm above the radiation vessel. Prior to use the UV lamps were allowed to stabilize by turning them on at least 15 min. Fresh-cut green onions were placed over a tray for UV-C treatments (Allende et al 2006). The tray consisted in a glass that minimized blockage of the UV-C radiaton in a wooden frame. Radiation of the product was carried out in the cold room at 5^{o}C to avoid a temperature increase during treatments. UV-C treatments used were: control (K, non-treated), UV-C irradiation for 3

min (UV-C_3), UV-C irradiation for 5 min (UV-C_5), UV-C irradiation for 10 min (UV-C_{10}) and UV-C irradiation fr 15 min (UV-C_{15}). After radiation, fresh-cut onions (three onions per dishes for each replicate) were packaged into polystyrene foam dishes and wrapped in polyethylene stretch film.

Determination of DPPH free radical scavenging activity

The antioxidant activity using the DPPH assay was assesed by the method of Pieroni et al (2002). A sample of 20 g of mixed onion was extracted in 200 ml of methanol:water (4:1) at room temperature and protected from light for 7 days. A second batch of extracts was prepared extracting with 200 ml of the same solvent under reflux for 30 min. Of each extract 1.5 ml was added to 1.5 ml 51 0.1 mM DPPH dissolved methanol. Absorbance was read at 517 nm after 5 min. The free radical scavenging activity was calculated as [1-(A-B)/C]x 100, where A is the absorbance of 1.5 ml of the crude extract solution mixed with an egual volume of the DPPH solution:B the absorbance of 1.5 ml of the crude extract solution mixed with equal volume of methanol and C the absorbance of DPPH with an equal volume of methanol:water (4:1).

Determination of electrolyte leakage

Electrolyte leakage was measured as 5 mm discs cut of the onions. The discs were washed several times in distilled water and were then incubated in distilled water. Conductivity was measured after 2 h of incubation. Total electrolyte conductivity in the discs was measured after they had been frozen and thawed. Electrolyte leakage was calculated as the percentage of the conductivity after 2 h out of total (Friedman and Rot 2006).

Color measurement

Color readings of the fresh-cut onions were performed with a chromameter (Minolta CR-400, Minolta, Osaka, Japan), equipped with an 8-mm measuring head and a D65 illuminant. The meter was calibrated manufacturer's Standard white plate. Color changes were quantified in the L*, a* and b* color space. Hue angle ($h^o=tan^{-1}$ (b*/a*) when a*>0 and b*>0 or $h^o=180^o+tan^{-1}$ (b*/a*) when a*<0 and b*>0 was calculated from a* and b* values (Kasim et al 2008). The color of fresh-cut onions was determined both a lower white leaf sheath and the hollow green tissues.

Determination of inner leaf extension, decay percentage and weight losses

Inner leaf extension was measured with e Vernier caliper as lenght to the nearest 0.1 mm from cut surfaces at the white leaf base to the end of the most extended portion (Hong et al 2000).

Decay of fresh-cut green onions during storage was determined by the rate percent of decayed leaves to total percent of the leaces. A piece of leaf was counted as decayed if it exhibited a significant discoloration. Decay percentage was measured before all other tests were conducted.

Three replicates per treatment were weighed at the beginning of the storage and at a weekly interval during storage. The weight loss (%) was calculated in reference to the initial weight of the fresh-cut green onions.

Statical analyses

Statistical analyses performed on data included analysis of variance (ANOVA) and differences among means determined by the Duncan's multiple range test with significance defined at $P<0.05$. The experimental design used for analytical measurements was completely randomized and repeated three times.

Results and Discussion

DPPH free radical scavenging activity

Methanolic extracts were individually assessed for their possible antioxidative capacities by employing DPPH free radical-scavenging assay. Free radical scavenging capacities of fresh-cut green onion extracts were measured by DPPH assay and results are shown Figure 1. antioxidative potential of onion extracts decreased during the storage however, higher activity obtained in samples treated with UV-C_{15} (94.27%) at the end of the storage and followed by UV-C_3 (86.26%), UV-C_{10} (86.48%), UV-C_5 (83.84%) and onions in K had the lower activity (82.14%). But, differences among the treatments did not significantly important. In present study it was found that there was observable correlation between high radical scavenging activity and high UV-C treatments on fresh-cut green onions extracts and this result with agreed with our previously studies (Kasim et al 2008). So, according to our findings, UV-C treatments on fresh-cut green onions enhanced their antioxidant activity.

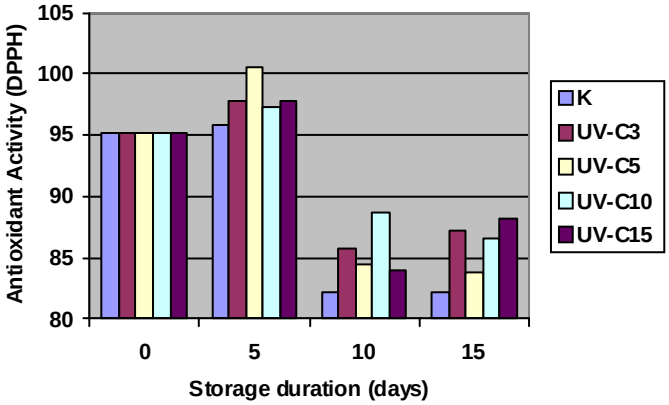

Figure 1. The effects of UV-C treatments on antioxidant activity (DPPH) of fresh-cut green onions

DPPH free radical scavenging activity of fresh-cut green onions varied between 82.14% and 94.27% at the end of the storage. According to Kevers et al. (2007), DPPH activity of onion bulbs was 60±4 µM TE 100^{-1} of FW, and also Nencini et al (2007) found that the antioxidant capacity of the bulbs was lower while the leaves were higher. The results presented here agreement with these results. In our study, DPPH radical scavenging activity decreased during the storage but Kevers et al (2007) found that the antioxidant activity in onion continuously increased during storage. These results disagree with our results and in our study decreasing antioxidant activity may be due to minimally processing. Because, minimally processed fruit and vegetables often differ from traditional intact fruits and physiology, handling and storage requirements.

Electrolyte leakage (EL)

Electrolyte leakage (EL), measures integrity of plant cells and tissues. An increase in EL, indicates deterioration in cellular membran systems. EL, expressed as a percent of total electrolyte leakage was between 7.73% and 16.29% at the 5^{th} days of storage and increased linearly ($P<0.05$) with higher UV-C doses during the storage (Figure. 2). The highest EL, was obtained from UV-C_{10} (23.37%), and followed by UV-C_5 (23..11%), UV-C_{15} (18.25%), UV-C_3 (13.66%) or K (11.93%), respectively at the end of the storage. There were significantly changes obtained between K, UV-C_3 and UV-C_5, UV-C_{10}, UV-C_{15} treatments at the day of 15^{th}.

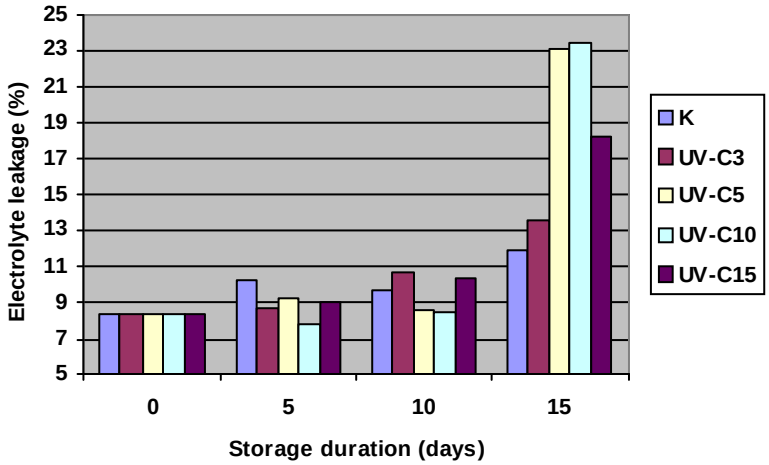

Figure 2. The effect of UV-C treatments on electrolyte leakage (%) of fresh-cut green onions

The membrane system of plant tissues in the boundary of all living cells and plays an important role in maintaining normal physiological processes. Many enzymes and proteins also are embedded on membranes. Therefore, changes in the membrane will lead to the alteration and loss of normal physiological processes, and even to the death of plant tissues. The loss of cytoplasm from the cell through the damaged membrane is known as electrolyte

leakage (Fan et al 2003). Electrolyte leakage can be used to determine changes membrane permeability caused by environmental stress (Whitlow et al 1991). The processing used for fresh-cut green onions severely damages plant tissues and providess nutrients and surfaces for pathogens to grow. Our results suggested that EL of UV-C treated green onions increased during the storage, particularly from day 10 to day 15 compared to control group, suggesting membrane deterioration of the tissues occured in the period. These results are generally in agreement with our quality observation on UV-C samples which deteriorated rapidly from d 10 and d 15 as indicated by overall visual quality and decay. Our results show that UV-C treatment increased EL, especially higher doses. So, for the control of pathogen of fresh-cut onions the lower UV-C doses can be used because of lower EL rates. But the decay percentage of fresh-cut onions treated with high UV-C doses were high at the day 15, it was said that UV-C treatments maintained quality of fresh-cut onions only 10^{th} day of storage period.

Decay percentage

Decay percentage (Figure.3) of fresh-cut green onions was increased samples in K (14.81%) and UV-C_3 (14.26%) than those of UV-C_5 (5.26%), UV-C_{10} (4.62%) and UV-C_{15} (1.52%). So, quality of fresh-cut green onion was the best in UV-C_{15} treatment ($P<0.05$) at the day 10, therefore it was said that the higher doses of UV-C was effectively control to pathogen growth in fresh-cut green onions. After 15 day of storage, however, decay percentage increased for all samples, and the quality of fresh-cut green onion in all treatments became unmarketable. It appears that maximum storage life for the green onions was about 10 day. UV-C radiation did not affect decay percentage at the end of the storage.

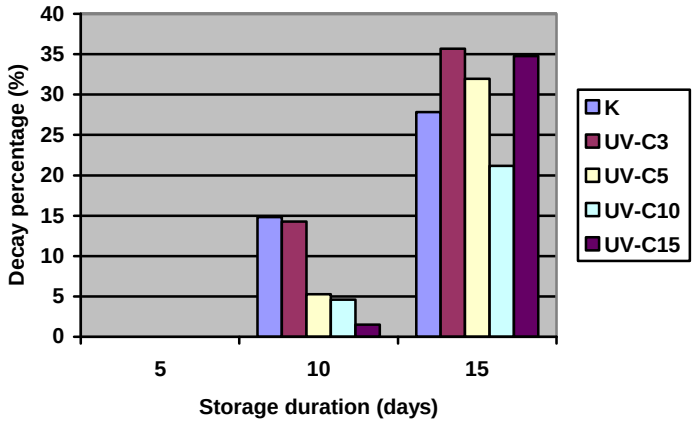

Figure 3. The effect of UV-C treatments on decay percentage (%) of fresh-cut green onions

Colour changes

Colour of fresh-cut green onions was not significantly influenced by different UV-C treatments. For white stem tissues (Figure 4) the L* value slightly decreased from the 77.95

to 71.71-76.09 and hue angle (h^o) value showed decreased in the limited range of 104.89-96.73 during storage. Among the UV-C treatments, UV-C_5 showed the least color changes in white stems almost constant L* value.

In the case of green leaf tissues (Figure 5) L* value slowly increased from 38.73 to 39.91-48.54 whereas hue angle value gradually decreased from 127.65 to 117.45-123.43, relying on UV-C treatments. Hue angle value of onions was maintained best in UV-C_3. The a* value of hollow green tissues of fresh-cut green onion was the highest in UV-C_{15} treatments similarly those of b*values and also hue angle values.

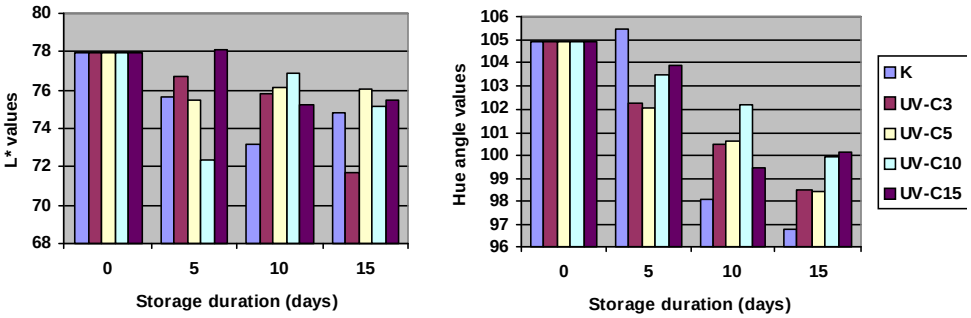

Figure 4. L* values and hue angle of white leaf sheath of fresh-cut green onions

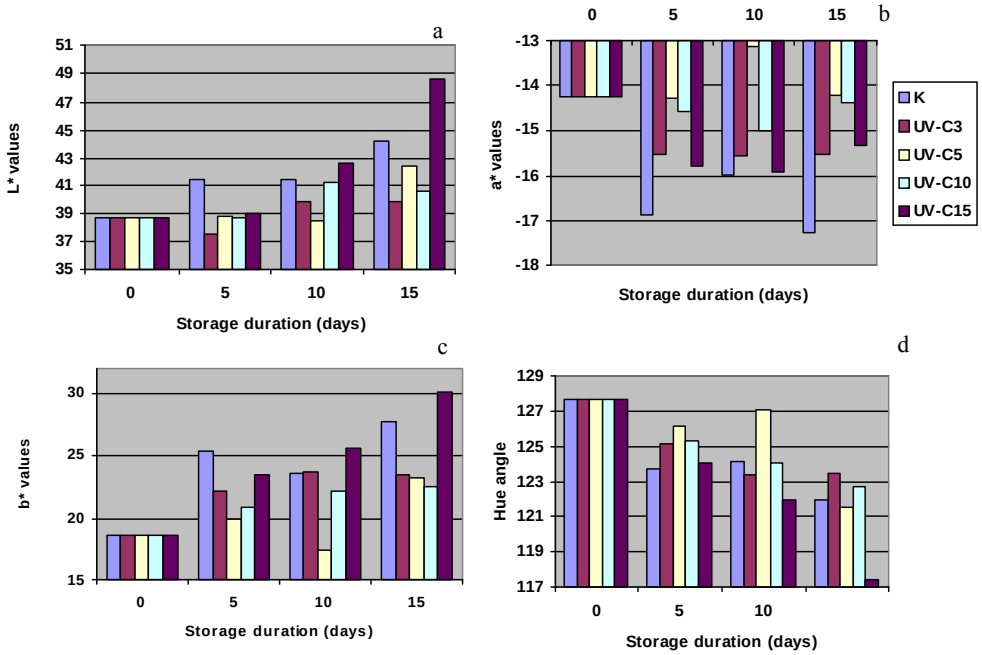

Figure 5. (a) L* values, (b) a* values, (c) b* values and (d) Hue angle values of hollow green tissues of fresh-cut green onions

So, after 15 days of storage, noticeable yellowing in green leaf tissues of fresh-cut onions treated with UV-C_{15}, this change probably led to marked decrease of hue angle values and increase of a* and b* values. Therefore UV-C treatments especially higher doses, accelerated yellowing of onions compared with lower doses of UV-C treatments and K. Loosing green pigment accompanied by the predominance of yellow pigments is a natural process in the senescence of many vegetables and such changes can be accelerated by ethylene. A stress to plant tissues increase ethylene production and respiration rate (Garcia and Barrett 2002) and there by increases yellow pigments. UV-C treatments as added stressed to plant tissues should have accelerated the color changes in fresh-cut onions toward more yellowish. As a results of our study, the best treatment for the maintain green color of fresh-cut green onions was the UV-C_{10}.

Inner leaf extension

The rate of extension growth was increased in all treatments during the storage but differences among the treatments were not significant (Figure 6). UV-C_{15} treatment effectively controlled extension growth with 0.56 mm of growing occured at the day 10^{th}. But after that time, UV-C treatments did not control inner leaf extension and it changed from 5.78 mm to 7.11 mm at the end of the storage. So, it was suggested that inner leaf extension effectively controlled by the UV-C_{15} at the 10 d of storage.

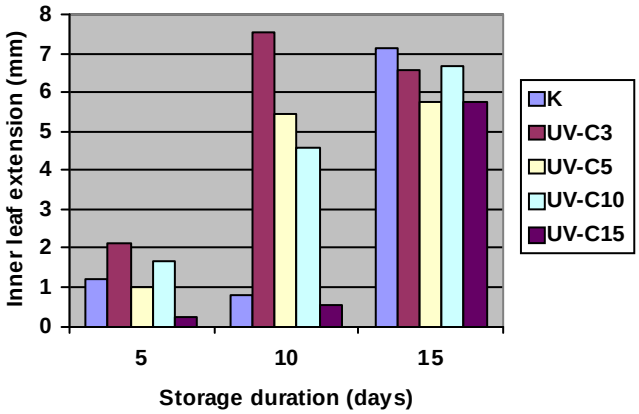

Figure 6. Inner leaf extension of fresh-cut green onions treated with different doses of UV-C

Weight Loss

Figure 7 shows the weight loss of fresh-cut green onions treated with different doses of UV-C after being stored for 15 day at 5°C. As expected, weight loss increased with a longer period and was noticeable in samples treated with UV-C_5, UV-C_{10} and UV-C_{15}. The higher UV-C treatments had higher weight losses than those of in K and UV-C_3 during the storage and also differences among the treatments were significant. In our previous studies, it was

observed that UV-C treatments increased weight loss in cucumbers (Kasım and Kasım 2008) and onions (Kasım et al 2008). Similar results were obtained in this research.

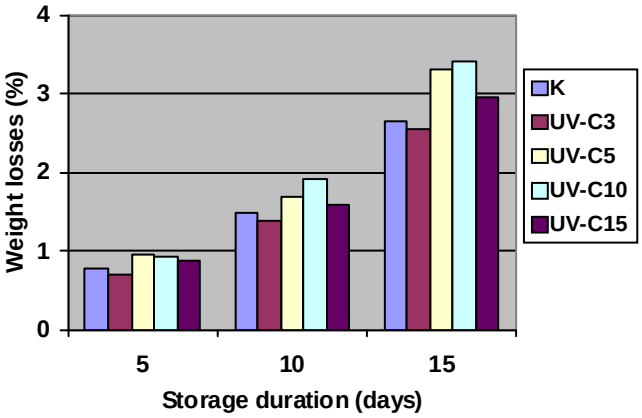

Figure 7. Weight losses of fresh-cut green onions treated with different doses of UV-C.

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