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Changes in Bioactive Compounds Contents of 'Maehyang' and 'Seolhyang' Strawberry Fruits by UV Light Illumination

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Abstract. The net photosynthetic rate of 'Seolhyang' strawberry plants was measured daily for 7 days after treatment at three UV illumination dosages (0, 9.8, and 29.5 $kJ \cdot m^{-2}$). The net photosynthetic rates of the strawberry plants with 9.8 and 29.5 $kJ \cdot m^{-2}$ UV light illumination decreased by 20.2 and 61.4%, respectively, at 7 days after UV light treatments. UV treatments with two illumination dosages (7.9 and 15.7 $kJ \cdot m^{-2}$) altered the phenolic compounds contents during the cultivation period when compared to those in the control fruits. The anthocyanin content with 7.9 $kJ \cdot m^{-2}$ UV light illumination of 'Seolhyang' increased by 18.7% compared with those in control fruits at the 11 DAT. However, the anthocyanin content of 'Maehyang' was not significantly different among treatments during experiment period. The highest level of ellagic acid was found with 7.9 $kJ \cdot m^{-2}$ UV light illumination in both cultivars at the 11 DAT. Our results showed that strawberries illuminated with UV light during cultivation period had higher bioactive compounds contents than control fruits. These results suggest that UV light treatments may be a useful non-chemical way of promoting strawberry fruits quality.

***Additional key words*:** anthocyanin, ascorbic acid, ellagic acid, *Fragaria* × *ananassa*, net photosynthetic rate, organic acid, sugar

Introduction

In recent years, consumers have been paying more attention to the health and nutritional aspects of horticultural products (Scalzo et al., 2005). Fruits and vegetables contain high levels of bioactive compounds that impact on health benefits apart from basic nutritional value (Oomah and Mazza, 2000). Antioxidants can inhibit the oxidation of lipids or other molecules by inhibiting oxidizing chain reactions therefore play an important role in health protection (Velioglu et al., 1998). Strawberry is one of the richest sources of natural antioxidants among fruits (Heinonen et al., 1998; Wang et al., 1996). Ascorbic acid is required for the prevention of scurvy and the maintenance of healthy skin, gums, and blood vessels (Harris, 1996). Aaby et al. (2007) reported that ascorbic acid was the single most important contributor to the electrochemical response in strawberries. Anthocyanins have been shown to protect cells against harmful free radicals and to be associated with lowering incidence and mortality rates of cancers and heart diseases, in addition to a number of other health benefits (Velioglu et al., 1998). Ellagic acid comprises 51% of the phenolic compounds in strawberries (Häkkien et al., 2000) and is found both in free form and esterifies to glucose in water soluble hydrolysable ellagitannins (Clifford and Scalbert, 2000). Ellagic acid is a promising inhibitor of certain chemically induced cancers (De Flora and Ramel, 1988; Hayatsu et al., 1988; Stoner, 1989). Additionally, sugars in food are of the major interests with regard to chronic diseases (Anderson et al., 1990; Terry et al., 2001; Weisburger, 2001). Different types of sugars give rise to different glycemic responses; the glycemic potential of glucose is, for example, higher than that of sucrose, which in turn is higher than that of fructose (Miller, 1994). Interestingly, different types of indigestible sugars give rise to different profiles of short-chain fatty acids (Parks, 2002). Thus, sugar type is of great importance from a nutritional point of view.

Recently, interest in the role of antioxidants in human health has promoted in the research field of horticulture and food science to determine how their content and activity can be enhanced through cultural practices or postharvest handling

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(Ayala-Zavala et al., 2004). UV light illumination as a postharvest treatment has proven beneficial to delay fruit senescence and especially control decay in different fruit and vegetable species (Allende and Artes, 2003; Allende et al., 2006; Baka et al., 1999; Erkan et al., 2001; Maharaj et al., 1999; Marquenie et al., 2003). The exposure to UV light illumination delays fruit softening, which is one of the main factors determining fruit postharvest shelf-life (Pan et al., 2004). In strawberry, UV light illumination reduced both natural rots (Nigro et al., 2000) and induced infections of *Botrytis cinerea* and *Monilinia fructigena* (Marquenine et al., 2002). Both the direct germicidal effect of UV light illumination on plant pathogens and the induction of disease resistance in tissue help to reduce rot development during storage (Ben-Yehoshua et al., 1992; Mercier et al., 1993, 2001; Nigro et al., 2000). Phenylalanine ammonia-lyase activity increases after UV light illumination (Ensminger, 1993; Hadwiger and Schwochau, 1971; Nigro et al., 2000). The enzyme plays a key role in the biosynthesis of phenolic compounds, many of which have antifungal and antioxidant activity (Chappel and Hahlbrock, 1984). A previous study (Perkins-Veazie et al., 2007) has indicated that postharvest application of UV light might be effective in stimulating the antioxidant content of blueberries. The effect of altering the level of UV light in growing systems has been found to affect the pigment and colorless phytochemical contents of some crop plants. Ordidge et al. (2010) found that the phenolic levels of strawberries, raspberries, and blueberries were unresponsive to the UV light transparency of the plastic film under which the crops were grown. However, little information is available on the effect of UV light illumination on the bioactive compound content in strawberry fruit during cultivation period. Therefore, the purpose of this study was to determine the changes in the bioactive compound contents in strawberry fruit illuminated with UV light at different dosages (illumination durations × UV light intensity) during cultivation period.

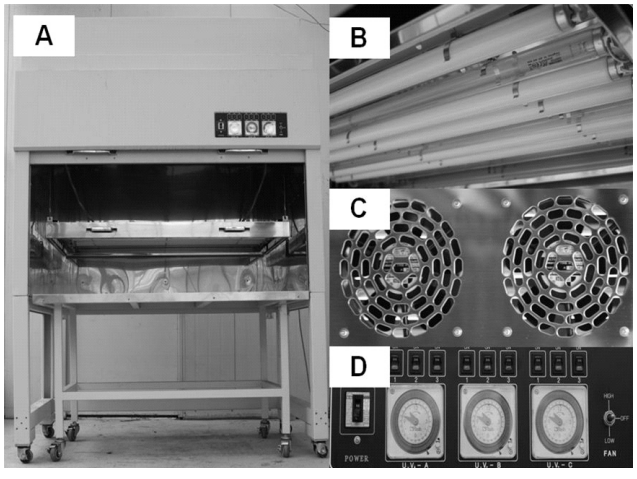

Fig. 1. The device developed for UV light illumination treatment (A), consisting of a lighting (B), ventilation (C), and control (D) modules.

Materials and Methods

Characteristics of UV Light Illumination Device

The UV light illumination device consisted of a lighting, ventilation, and time control modules (Fig. 1). That device [1150 × 1660 × 2000 mm (L × W × H, outside)] was equipped with nine 40-watt UV lamps, two pans, and three analog timers. The peak wavelengths of the UVs-A (G40TBL, Sankyo Denki, Co. Ltd., Kanagawa, Japan), B (G40T10E, Sankyo Denki, Co. Ltd., Kanagawa, Japan), and C (G40T10, Sankyo

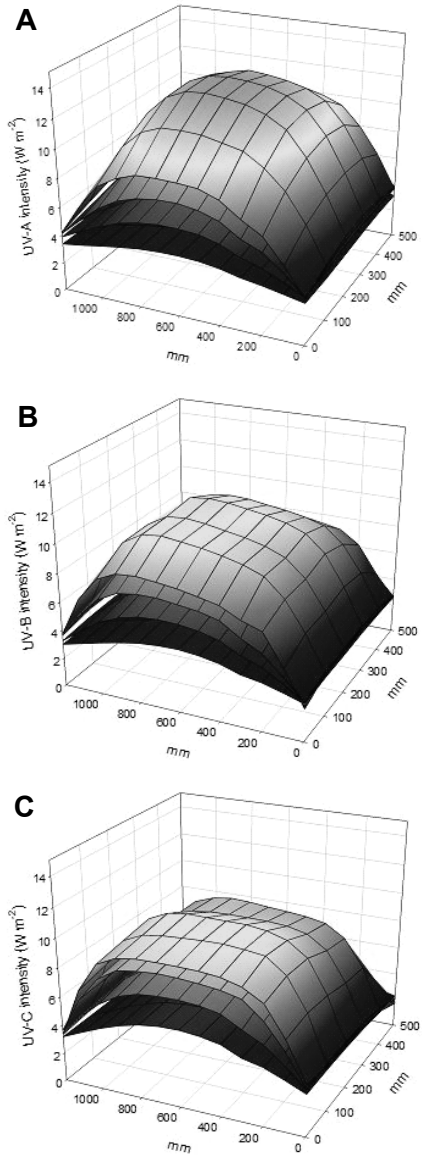

Fig. 2. The vertical and horizontal profiles of light intensity in UVs-A (A), B (B), and C (C).

Denki, Co. Ltd., Kanagawa, Japan) lamps were 352, 306, and 254 nm, respectively, which lamps equipped with three per each UV lamps. That UV light module can move in the vertical direction (maximum 940 mm and minimum 250 mm from bench ground). We measured UV light intensity using a digital radiometer (KH-97503, Cole-Parmer Instrument Company, Vernon Hills, IL, USA) and vertical (distance were 940, 600, and 400 mm, respectively, from light module) and horizontal [500 × 1000 mm (L × W)] profiles were obtained. UV-A, B, and C light intensities were 5.7 ± 1.1, 5.2 ± 1.3, and 5.5 ± 1.7 $W \cdot m^{-2}$, respectively, at 600 mm distance from light source (Fig. 2) and we used this position for all UV light illumination treatment.

Net Photosynthesis Measurement

For 7 days after the UV light illumination treatment, we measured the daily net photosynthetic rate of 'Seolhyang' strawberry plant that were exposed to 16.4 $W \cdot m^{-2}$ of UV radiation level for 0, 10, and 30 min once in two days, thus resulting in three different dosages (0.0, 9.8, and 29.5 $kJ \cdot m^{-2}$) using a portable gas exchange system (Li 6400-40, Li-Cor Co., Inc., Lincoln, NE, USA). Flow rate and photosynthetic photon flux was maintained at 500 $\mu mol \cdot s^{-2}$ and 500 $\mu mol \cdot m^{-2} \cdot s^{-1}$, respectively. Leaf temperature was also set at 25℃ and RH at 40-60%. The leaf area clipped by the leaf chamber was 200 mm^2. All the measurements were replicated three times.

Production of Strawberry Fruit and UV Light Illumination

Korean-bred cultivars 'Maehyang' and 'Seolhyang' strawberry plants were grown at the Experimental Farm of Seoul National University, located in Suwon, Korea (37 16 12N, 126 59 20E, and elevation 30 m). The cultivation type was hydroponic culture in a glasshouse. The strawberry plants were grown in 800 × 300 × 200 mm (L × W × H, outside) plastic containers filled with a mixture of peatmoss (BM-4, Berger Peat Moss Ltd, Quebec, Canada) and perlite (Parat No 3, Kyung Dong Ceratech Co., Ltd, Seoul, Korea) (1:1, v/v). The plants were fertigated with 450 mL/plant/day using Yamasaki nutrition solution (N; 5.5 $me \cdot L^{-1}$, P; 1.5 $me \cdot L^{-1}$, K; 3.0 $me \cdot L^{-1}$, Ca; 2.0 $me \cdot L^{-1}$, Mg; 1.0 $me \cdot L^{-1}$, S; 1.0 $me \cdot L^{-1}$) and an automatic drip fertigation system (Agro 5000, Agro Co. Ltd., Wonju, Korea). UV light illumination treatment was performed starting with full elongation of the third fruit cluster and ending with cluster harvest. Strawberry plants were subjected to two UV light illumination durations (8 and 16 min) at 16.4 $W \cdot m^{-2}$ of radiation level resulting two dosages (7.9 and 15.7 $kJ \cdot m^{-2}$) once in two days using the UV light illumination device. The plants in control treatment were not subjected to UV light illumination. Ripe secondary or tertiary strawberry fruits were harvested at the optimal fruit maturity, when about 90% of the fruit surface had reached a fully red color. The ripe strawberry fruits were harvested at three different times (harvesting date 11, 19, and 26 days after treatment). All the measurements were replicated three times.

Extraction and Analysis of Sugars and Organic Acids

Fruit samples (5 g) were homogenized with 20 mL of distilled water, filtered using No. 2 filter papers and filtered again through a 0.45 μm syringe filter. The filtrate was diluted and injected into a chromatography system (Dionex 2500, Dionex Co., New York, NY, USA). For sugar analysis, the solvent was 18 mM sodium hydroxide at a flow of 1 $mL \cdot min^{-1}$. CarboPac PA10 (4 × 250 mm: Dionex Co., New York, NY, USA), and an amperonmetry detector with an Au electrode were used. Fructose and glucose content were calculated using external standards. Total sugar content was calculated by summing the fructose and glucose contents. The same extract used in the sugar analysis was used in organic acid analysis. An IonPac ICE-AS6 column (9 × 250 mm; Dionex Co., New York, NY, USA) was used for separation of acids and 0.4 mM heptafluorobutyric acid was used as an eluent at a flow rate of 1 $mL \cdot min^{-1}$. A suppressed detector, with an anion-ICE micromembrane suppressor and 5 mN tetrabutylammonium hydroxide was used. An external standard was used to calculate organic acid content. Since citric and malic acids were predominantly found in the strawberry extract, the total organic acid content was calculated by summing the contents of those two acids.

Extraction and Analysis of Ascorbic Acid

The strawberry fruit samples (10 g) were homogenized with 50 mL of buffer solution (4% metaphosphoric acid) and filtered using NO. 2 filter paper. The mixture was filtered through a 0.45 μm syringe filter and injected into an HPLC system (Ultimate 3000, Dionex, Sunnyvale, CA, USA) for L-ascorbic acid analysis under the following conditions. The mobile phase was acetonitrile and 50 mM $NH_4H_2PO_4$ (70:30, v/v), and the flow rate was 1.0 $mL \cdot min^{-1}$. The components were detected at 254 nm. A C18 reverse phase column (4.6 × 250 mm, 0.5 μm; Supelcosil TM C-18, Supelco, Bellefonte, PA, USA) was used for analysis (Kim et al., 2006).

Extraction and Analysis of Anthocyanin

Anthocyanin was extracted from the epidermal fruit tissue (2 g), less than 2 mm thick, by homogenizing with 5 mL HCl (1%)-methanol solution. The extraction was filtered through No. 2 filter paper and measured with a spectrophotometer at 520 nm (UV-2550, Shimadzu, Kyoto, Japan). Total anthocyanin content was expressed as mg pelargonidin 3-glucoside

(ε = 36,000 L·mol^{-1}·cm^{-1}) 100 g^{-1} FW (Ferreyra et al., 2007).

Extraction and Analysis of Ellagic Acid

The strawberry fruit samples (2.5 g) were homogenized with 7.5 mL water and the mix was added to 12.5 mL methanol and 5.0 mL 6.0 M HCl. The mixture was then refluxed for 2 h at 85℃ and filtered through a 0.45 μm syringe filter prior to injection into an HPLC system (Ultimate 3000, Dionex, Sunnyvale, CA, USA). Solvent A was 1% formic acid and solvent B was acetonitrile with 0.5 mL·min^{-1} flow rate. The gradient was: 0-15 min, 10-55% of B in A; 15-20 min, 55-100% of B in A; 20-25 min, 100-10% of B in A; and 25-35 min, 10-10% of B in A. Using the gradient, the best purity and separation were achieved for the ellagic acid peak in strawberry. The peak was obtained using a UV/Vis detector at 260 nm with a C18 column (4.6 × 150 mm, 5 μm; Zorbax SB-C18, Agilent Co., New York, NY, USA).

Statistical Analysis

Statistical analysis was done to evaluate significant differences among treatments within same harvesting date and cultivar. ANOVA was used to assess differences in sugars, organic acids, anthocyanin, ascorbic acid, and ellagic acid contents. Differences were considered statistically significant with a $P \leq 0.05$.

Results and Discussion

Net Photosynthetic Rate

The initial net photosynthetic rates of strawberry plants with 9.8 and 29.5 kJ·m^{-2} UV light illumination were 20.3 and 22.3 μmol·CO_2·m^{-2}·s^{-1}, respectively, but the rates decreased by 20.2 and 61.4%, respectively, at 7 days after UV light treatment (Fig. 3). On the other hand, the net photosynthetic rate of strawberry plants in the control treatment was 20.7 μmol·CO_2·m^{-2}·s^{-1} at 7 days after treatment, which was 60.5% greater than the initial value. The effects of increased UV light radiation are manifold, with marked decreases in yields of agricultural crop plants (Mazza et al., 1999; Teramura, 1983), damage to photosystems II and I, disturbance in carboxylating enzyme, DNA damage, and oxidative stress (Mazza et al., 1999). Valkama et al. (2003) revealed that UV light-treated strawberry plants develop marginally thinner leaves with a reduced ratio of starch to chloroplast area in their cells, thus suggesting that there is a negative influence of UV light illumination treatment on the photosynthetic processes. Results indicated that suitable UV light illumination dosage could determine 9.8 kJ·m^{-2} without severe damage in related organ for photosynthesis.

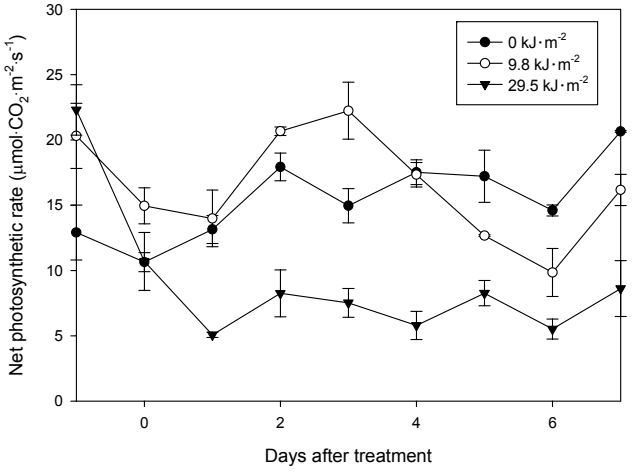

Fig. 3. Net photosynthetic rate of 'Seolhyang' strawberry plants as affected by UV illumination treatment. Vertical bars show standard deviation (n = 3).

Sugar and Organic Acid Content

The fructose, glucose, and total sugar contents of 'Maehyang' and 'Seolhyang' fruits were significantly different among treatments at the 11 DAT (Table 1). The mean fructose, glucose, and total sugar contents with 7.9 kJ·m^{-2} UV light illumination of 'Maehyang' were 30.7, 24.3, and 54.9 mg·g^{-1} FW, respectively, representing the highest values among all treatments. Our results revealed that the sugar content increased in the UV light-treated strawberry fruits of 'Maehyang' in an early period after UV light illumination. However, the mean fructose, glucose, and total sugar contents with 7.9 kJ·m^{-2} UV light illumination of 'Seolhyang' were 10.5, 11.3, and 21.9 mg·g^{-1} FW, respectively, representing the lowest value among all treatment. Those of 'Seolhyang' decreased by over 50% UV light treatment. The total sugar content of strawberry fruits decreased slightly immediately after UV light illumination treatment (Pan et al., 2004). There were different from response to sugars contents of strawberry fruits by UV light illumination dependent on cultivars and treatment periods. Citric and total acid contents of 'Seolhyang' were significantly different among treatments at the 11 and 19 DAT. The means of total organic acids content with 15.6 kJ·m^{-2} UV light illumination of 'Seolhyang' were 6.3 and 6.1 mg·g^{-1} FW, respectively, those were the lowest content among all treatments. Organic acids are minor components of strawberry fruit, but they are important attributes for flavor, which, in combination with sugars, have an impact on the sensory quality of the strawberry fruit (Wang et al., 2002). Application of UV light illumination increase total sugars/acid ratio of 'Seolhyang' fruits by decreasing organic acids contents without changing sugars contents, while it does not improve those

Table 1. The sugar and organic acid contents of 'Maehyang' and 'Seolhyang' strawberry fruits as affected by UV illumination treatment.

Cultivar	Dosage ($kJ \cdot m^{-2}$)	Sugar content ($mg \cdot g^{-1}$ FW)			Organic acid content ($mg \cdot g^{-1}$ FW)			TS/TO[z]
		Glucose	Fructose	Total	Citric acid	Malic acid	Total	
				11 DAT				
Maehyang	0	21.9 b	18.0 b	39.9 b	4.3 b	1.9 a	6.2 a	6.6 a
	7.9	30.7 a	24.3 a	54.9 a	5.6 ab	2.9 a	8.4 a	6.6 a
	15.6	24.0 b	19.9 b	43.9 b	6.2 a	2.4 a	8.6 a	5.3 a
Seolhyang	0	27.5 a	23.7 a	51.2 a	7.0 a	2.4 a	9.4 a	5.5 a
	7.9	10.5 c	11.3 c	21.9 c	8.2 a	1.0 b	9.1 a	2.4 b
	15.6	19.9 b	17.0 b	36.9 b	5.1 b	1.3 b	6.3 b	5.8 a
				19 DAT				
Maehyang	0	27.5 a	22.3 a	49.8 a	4.2 a	1.8 a	6.0 a	8.7 a
	7.9	20.5 b	17.1 b	37.6 b	5.6 a	2.3 a	7.8 a	4.9 b
	15.6	26.5 a	21.6 a	48.1 a	5.6 a	2.3 a	7.9 a	6.3 ab
Seolhyang	0	24.8 a	20.4 a	45.2 a	6.8 a	1.7 ab	8.4 a	5.4 a
	7.9	26.0 a	21.0 a	47.1 a	6.8 a	2.0 a	8.8 a	5.4 a
	15.6	24.0 a	19.6 a	43.6 a	5.0 b	1.1 b	6.1 b	7.4 a
				26 DAT				
Maehyang	0	19.5 a	16.6 a	36.1 a	5.3 ab	2.4 a	7.6 a	4.8 a
	7.9	19.9 a	16.8 a	36.7 a	4.9 b	2.4 a	7.3 a	5.0 a
	15.6	24.3 a	20.1 a	44.3 a	6.3 a	2.6 a	8.9 a	5.1 a
Seolhyang	0	17.6 b	15.2 b	32.8 b	4.9 a	1.7 a	6.6 a	5.0 a
	7.9	22.2 a	18.3 a	40.5 a	4.3 a	2.0 a	6.4 a	6.4 a
	15.6	22.6 a	18.8 a	41.4 a	5.2 a	1.6 a	6.8 a	6.2 a

[z]TS/TO: Total sugar/organic acid.
[y]Mean separation within columns by LSD test at 5% significance level.

of 'Maehyang' fruits, indicating that its effect may vary by cultivars.

Ascorbic Acid Content

Significant differences were found in ascorbic acid contents of 'Seolhyang' among treatments at the 11 and 19 DAT (Fig. 4). The ascorbic acid contents with 15.6 $kJ \cdot m^{-2}$ UV light illumination treatment of 'Seolhyang' were 52.4 and 58.6 $mg \cdot 100\ g^{-1}$ FW, respectively, which those decreased by 18.8 and 24.9%, respectively, compared with those in control fruits. However, the ascorbic acid contents of 'Maehyang' were not significantly different among treatment during experiment period. Lee and Kader (2000) have indicated that the ascorbic acid content could be modified by several preharvest factors. For example, higher light intensity increases the sugar production and ascorbic acid synthesis. Several studies have already focused on the UV light impact on nutritional constituents of fruits and vegetables (González-Barrio et al., 2006; Pan et al., 2004; Pérez et al., 1999). UV light elicits plant defense responses such as the production of phytoalexins (Maharaj et al., 1999), including ascorbic acids in strawberries (Pérez et al., 1999). Ascorbic acid is able to scavenge oxygen radicals, thus preventing oxidative stress (Klopotek et al., 2005). Thus, changes in the amount of ascorbic acid in UV light-treated strawberries can be attributed to the activation of an antioxidative system that promotes the biosynthesis of ascorbic acids from the carbohydrate pool (Pérez et al., 1999). However, Allende et al. (2007) found that the UV light illumination did not have a lasting effect on the synthesis of ascorbic acids or phenolic compounds of strawberries.

Anthocyanin Content

Significant differences were found in anthocyanin contents of 'Seolhyang' among treatments at the 11 and 26 DAT (Fig. 5). At the 11 DAT, the anthocyanin content with 7.9 $kJ \cdot m^{-2}$ UV light illumination of 'Seolhyang' was 55.0 $mg \cdot 100\ g^{-1}$ FW, which that increased by 18.7% compared with those in control fruits. At the 26 DAT, the anthocyanin content with 15.6 $kJ \cdot m^{-2}$ UV light illumination of 'Seolhyang' was 51.2 $mg \cdot 100\ g^{-1}$ FW, which increased by 19.5% compared

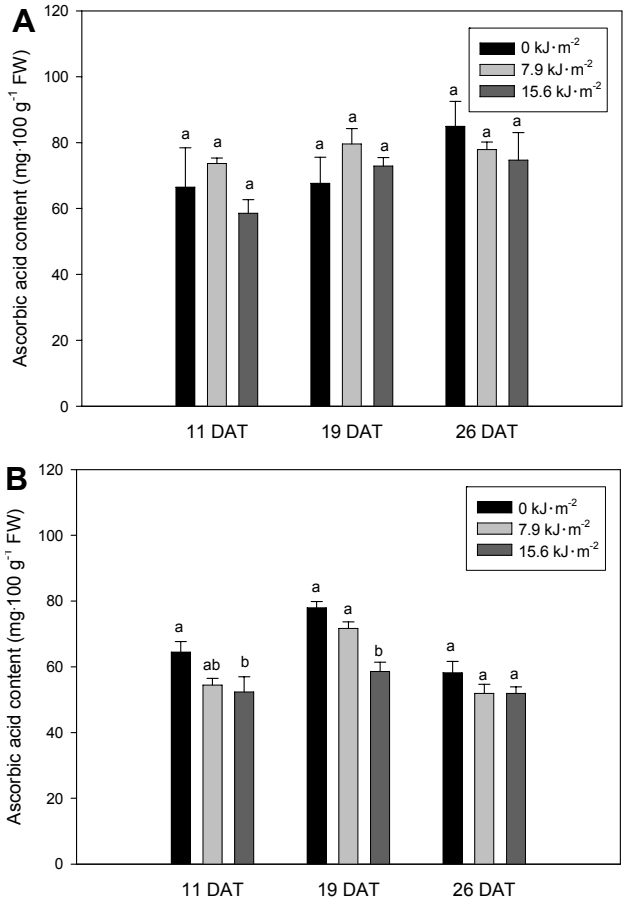

Fig. 4. The ascorbic acid content of 'Maehyang' (A) and 'Seolhyang' (B) strawberry fruits as affected by UV illumination treatment. Vertical bars show standard deviation (n = 3). Different letters indicate statistically significant differences at $P \leq 0.05$.

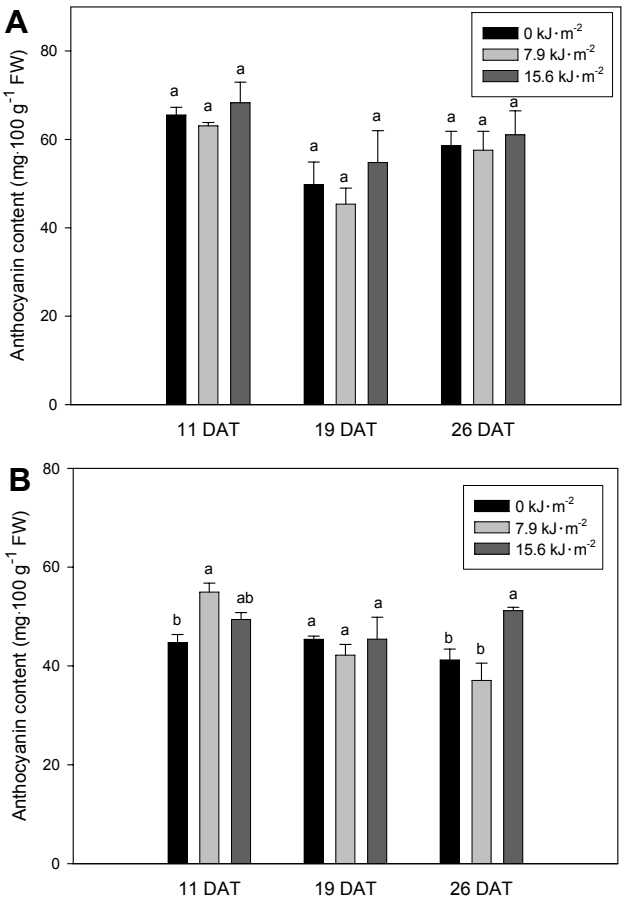

Fig. 5. The anthocyanin content of 'Maehyang' (A) and 'Seolhyang' (B) strawberry fruits as affected by UV illumination treatment. Vertical bars show standard deviation (n = 3). Different letters indicate statistically significant differences at $P \leq 0.05$.

with those in control fruits. However, the anthocyanin contents of 'Maehyang' were not significantly different among treatments during experiment period. Several reports have indicated that UV light exposure promotes anthocyanin synthesis in other fruits, including apples (Dong et al., 1995), sweet cherries (Kataoka et al., 1996), grapes (Kataoka et al., 2003), and boysenberries (Vicente et al., 2004). Enhancement of anthocyanin levels by UV light illumination also has been reported in strawberries and sweet cherries (Baka et al., 1999; Kataoka et al., 1996). The increase in total phenols and anthocyanins in blueberries by UV light illumination appears to be dose-dependent at lower doses (0.43-2.15 kJ·m^{-2}) (Wang et al., 2009); however, higher doses (4.30-6.45 kJ·m^{-2}) tend to suppress these increases. On the other hand, Pan et al. (2004) has reported a delay in the accumulation of anthocyanin by UV light illumination in strawberry fruit. This phenomenon has also been reported in strawberries where high doses of UV light exposure are thought to cause too much stress and possibly result in injury (Baka et al., 1999). Phenylalanine ammonia-lyase (PAL) activity increases after UV light irradiation (Ensminger, 1993; Hadwiger and Schwochau, 1971; Nigro et al., 2000). The enzyme plays a key role in the biosynthesis of phenolic compounds, many of which have flavonoids and anthocyanins (Chappel and Hahlbrock, 1984). Nigro et al. (2000) reported that low doses of UV light (0.5 kJ·m^{-2}) increase PAL activity, whereas higher doses (2.50 kJ·m^{-2}) cause a smaller increase the activity. The amount of anthocyanins in fruit treated with a dose of 4.1 kJm^{-2} of UV light was similar or slightly lower than that in the controls, probably because the activity of PAL is not significantly increased at this dose. However, our results suggest that anthocyanin content of strawberry fruits increased in relatively higher dosage of UV light illumination; it could be range 7.9-15.6 kJ·m^{-2} during cultivation period.

Ellagic Acid Content

We found large differences in the ellagic acid content of 'Maehyang' among treatments at 11 DAT (Fig. 6). The highest level of ellagic acid was found with 7.9 kJ·m^{-2} UV light illumination in both cultivars. We revealed that the ellagic

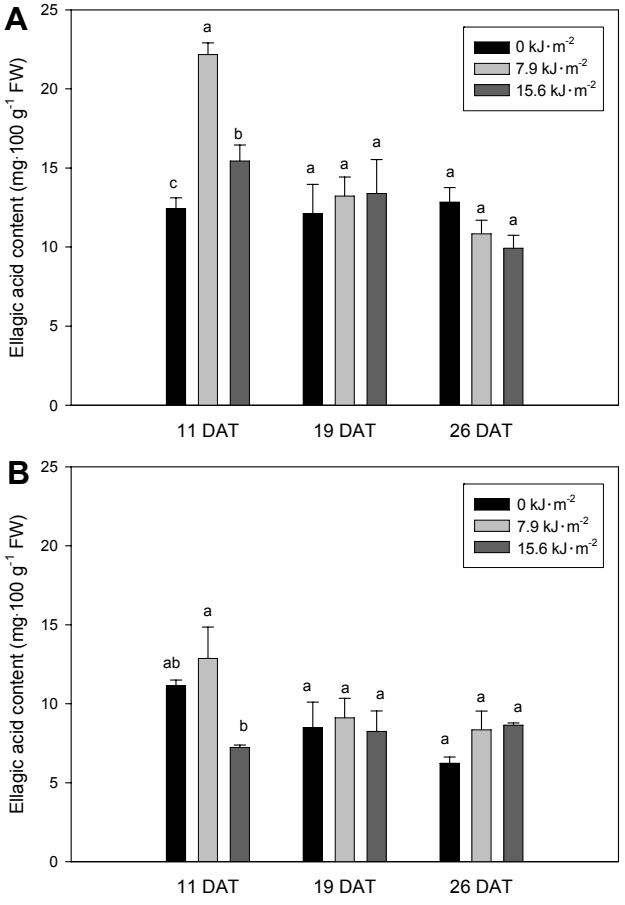

Fig. 6. The ellagic acid content of 'Maehyang' (A) and 'Seolhyang' (B) strawberry fruits as affected by UV illumination treatment. Vertical bars show standard deviation (n = 3). Different letters indicate statistically significant differences at $P \leq 0.05$.

acid content of strawberry fruit was enhanced by an adequate dosage of UV light illumination during cultivation periods. The levels of secondary compounds in soft fruit have previously been shown to be influenced by environmental factors during storage periods (Kalt et al., 2001; Wang and Zheng, 2001), but the effect of cultivation under different UV regimes is not known. With both cultivars of strawberry tested, the June-bearer 'Elsanta' and the ever-bearer 'Everest', UV-blocking film reduced total phenolics, anthocyanin and ellagic acid in some of the crops but the effect was not observed with all crops under all conditions. When crops were grown under polyethylene film that partially or completely block UV light or UV-transparent film the amount of health-beneficial phenolics was similar compared with each other (Ordidge et al., 2010).

UV illumination on strawberry plants cultivated in greenhouse for a few minutes in night time may increase contents of bioactive compounds such as anthocyanin and ellagic acid dependant cultivars and treatment periods. However, it is not clear, yet that tendency of response to UV light stress. Insensitiveness of strawberry to environmental stresses might be the major reason of the small influence on bioactive compounds contents of fruits by applying UV light treatment.

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