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EFFICACY OF ULTRAVIOLET-C IRRADIATION TO SUPPRESS FRUIT DECAY AND RETAIN THE POSTHARVEST QUALITY OF DRAGON FRUIT (*Hylocereus polyrhizus*)

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ABSTRACT

Dragon fruit (*Hylocereus* sp.) is a non-climacteric fruit with a short shelf-life and is easily susceptible to diseases. Chemical pesticides are commonly used to control disease in dragon fruit. However, the efficacy of Ultraviolet-C (UV-C) irradiation at low concentrations as effective germicidal to control fruit decay and prolong the shelf-life on dragon fruit is still unexplored. This study aimed to evaluate the efficacy of UV-C irradiation at lower rates (0, 0.25, 0.5, 0.75, 1.0 kJ m^{-2}) to control the postharvest decay and maintain the quality of dragon fruit. Results revealed that the quality of dragon fruit is dose-dependent. UV-C irradiated dragon fruits at 0.75 and 1.0 kJ m^{-2} were significantly reduced in fruit body decay, delayed bract yellowing, and prolonged shelf-life. These dosages synergistically slowed down the depletion of total soluble solids and fruit firmness during storage. Also, dragon fruit treated with 1.0 kJ m^{-2} UV-C exhibited the lowest pH value after the 6th day in storage. UV-C irradiation at this dosage indicated no significant adverse effects in titratable acidity and total water loss. These results indicated that UV-C irradiation at 1.0 kJ m^{-2} was effective to reduce post-harvest decay and hence prolong the post-harvest quality of dragon fruit storage under ambient conditions.

Key words: Fruit rot, pitaya, post-harvest quality, UV-C irradiation

INTRODUCTION

Dragon fruit belongs to the *Hylocereus* genus, a climbing vine cactus commonly known as pitaya. There are two widely cultivated dragon fruit species: *Hylocereus polyrhizus* (red pulp and black seeds), and *Hylocereus undatus* (white pulp & black seeds) that successfully attained for both commercial and ornamental purposes. The size and shape of the fruits are also various with variety (Nurliyana *et al*., 2010). In Malaysia, the *H. polyrhizus* was reported to be the consumer preference owing to its sweetness compared to the other types of dragon fruits (Chik *et al*., 2011). Dragon fruit is one of the non-climacteric fruits that will not continue to ripen after harvesting and thereafter the postharvest quality is decreased during storage. Moreover, dragon fruit is also very susceptible to pests, diseases, and various postharvest injuries: chilling, mechanical, and water loss. Splitting can also occur to fruits that received excessive rainfall or irrigation during ripening at the harvesting stage. Refrigeration of dragon fruit at 10 ºC is highly suggested to retain the postharvest quality for up to 45 days with the relative humidity of 85-90% (Paull, 2014). Low storage temperature at 6 ºC and below can induce chilling injury (Paull, 2014), however, it also depends on the species, maturity level at harvest, and the growing location (Jalgaonkar *et al*., 2020).

Ultraviolet germicidal irradiation (UVGI) is commonly used as an effective method to disinfect microorganisms using short-wavelength ultraviolet (UV) light to destroy their nucleic acids and disrupt their DNA. Ultraviolet radiation is commonly categorized with wavelengths: UV-A (320-400 nm), UV-B (280-320 nm) and UV-C (200-280 nm) based on the electromagnetic spectrum used' (Guerrero-Beltrán & Barbosa-Cánovas, 2004). The application of UVGI as an effective postharvest treatment to disinfect microorganisms in food, air, and water purification industries. Recently, the application of UV irradiation (A range) as a post-harvest treatment of tomato was reported to increase the antioxidant activity (Dyshlyuk *et al*., 2020).

However, UV-C irradiation obtained from 250-270 nm was reported as the most effective germicidal towards various microorganisms (Bintsis *et al*., 2000). The application of UV-C light as an alternative to chemical pesticides in postharvest diseases management and to prolong the quality of horticultural crops has been applied for the last two decades (Rodov *et al*., 1992). Besides, UV-C irradiation was reported to prolong the shelf-life quality of agricultural produces by increasing their resistance against rotting and delaying the ripening process during post-harvest storage (Darvishi *et al*., 2012). The application of UV-C light on agricultural produces attained international recognition in the food industry. This is because UV-C treatment is safe, without leaving any residue in treated food, convenient in the application method, without implementing extensive safety equipment, and effective to most all kinds of microorganisms (Bintsis *et al*., 2000).

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The application of fungicides on the postharvest treatment of dragon fruit has been banned by the EU or US authorities since 2011 (Sergio *et al*., 2011). However, there is still limited study documented regarding the potential application of UV-C as an alternative to chemical fungicides on dragon fruit to disinfect the postharvest pathogens and also to prolong the shelf-life quality. Therefore, this study aimed to gauge the bio-efficacy of UV-C irradiation at lower dosage on dragon fruit to control the postharvest decay and prolong the postharvest quality during storage at ambient conditions.

MATERIALS AND METHODS

Fruit material

The dragon fruit (*Hylocereus polyrhizus*) was freshly obtained from the commercial orchard in Triang, Pahang, Malaysia. Fruits with uniform size, similar maturity index (stage 6), and shape without physical and microbial damage were carefully selected and packed. The dragon fruits were packed in corrugated cardboard boxes and brought back on the same day to the Laboratory of Postharvest, Faculty of Fisheries and Food Science, University Malaysia Terengganu. The fruit was washed with running tap water before surface-sterilized by submerging it into the sodium hypochlorite solution 1% (v/v) for 3 min at 28 ± 2 ºC. The fruit was rinsed with sterile distilled water before allowing for air drying in the laminar airflow. The air-dried dragon fruit was UV-C irradiated at the various dosages and dragon fruit without UV-C irradiation served as the negative control. Dragon fruit surface sterilized with sodium hypochlorite solution 5% (v/v) served as a positive control.

UV-C irradiation treatment

There are six treatments: positive control [surface sterilized with 5% (v/v) sodium hypochlorite alone], 0 kJ m^{-2} (negative control, without UV-C irradiation), 0.25, 0.50, 0.75 and 1.0 kJ m^{-2} were applied with five replicates per sampling time. Fruits for each treatment were packed separately in a polypropylene box. UV-C light was switched on for 20 min for irradiation stabilization. The UV-C light meter (Model: Lutron UVC-254SD) was used to determine the dosage of UV-C irradiation. UV-C was irradiated to dragon fruits with the same wavelength and distance but differs in irradiation timing in the fuming chamber. The calculation of UV-C dosage was performed as described by Stevens *et al*. (1990) and expressed in kJ m^{-2}. The formulation was utilized to calculate the UV-C dose (kJ m^{-2}) as in Equation 1.

$$UV\text{-}C\ dose\ (kJ\ m^{-2}) = Rate\ (W\ m^{-2}) \times Irradiation\ timing\ (s) \times 10^{-3} \quad \text{-Equation 1}$$

After the treatments, each fruit was packed into an individual polypropylene box to ease the sampling and reduce the possibility of cross-contamination. All fruit were stored at ambient temperature (28 ± 2 ºC) for further assessment until day 10^{th}.

Inoculation of *Fusarium proliferatum* dan determination of decay development on dragon fruit body

All dragon fruits were injured with a sterilized needle with 4 points on the fruit body before being inoculated with the mycelium plug of *Fusarium proliferatum*. Fruit body rotting lesions developed during storage were evaluated by using a 0 to 3 scale as described by Wall and Khan (2008). The rotting lesion present on the fruit body was rated visualize based on the total infected surface area, where 0 indicating healthy, 1 indicating 5% to 10% of the infected surface area, 2 indicating 16% to 25% of the infected surface area, and 3 indicating greater than 50% of the infected surface area. The sampling was conducted at 2 days intervals until day 10^{th}, each fruit was carefully observed for the fruit decay development by measuring and recording the size of the lesion formed on the fruit body before being expressed into an infected percentage.

Determination of bract appearance

The bract appearance of dragon fruit was accessed visually based on the 0 to 5 scale as according to Wall and Khan (2008). The browning severity was rated based on the color change, where 0 = no browning or blackening detected, 3 = bract margin with color changing from green to yellowing/browning, and 5 = bracts are 100% turned into the black in color and desiccated. Each scale was confirmed when more than 50% of the total bracts in fruit were indicating changes of color.

Effect of UV-C irradiation on physicochemical properties

Determination of weight loss

The total weight loss of dragon fruit was determined by the weight differences at each sampling time and expressed in percentage as described by Zahid *et al*. (2012). All dragon fruit was weighed at a two days interval from 0 to 10 days using an electronic balance. The weight loss was calculated using the formula in Equation 2.

$$= \frac{Initial\ weight - Final\ weight}{Initial\ weight} \times 100\% \quad \text{- Equation 2}$$

Determination of external firmness

External flesh firmness was performed using a Stable Micro Systems texture analyzer (Model: TA-XT Plus). The external fruit firmness measurements were spotted at the three locations around the middle of the fruit body. The maximum compressing force required for 3 mm depth into the fruit was performed in Newton (N) (Wall & Khan, 2008).

Determination of total soluble solids (TSS)

The total soluble solids in dragon fruit were measured using a composite sample that formed from the flesh of the fruits at three different parts (top, middle, & bottom). Ten grams of the flesh samples from the fruit were pressed and homogenized by using a mortar and pestle before being filtered with a muslin cloth. The fruit juice filtrate obtained was used to measure the total soluble solid using a digital

hand refractometer (General Tools, Model: REF103) and expressed in % Brix. The temperature of the juice was maintained at 28 ± 2 ºC for maximum accuracy reading (Wall and Khan, 2008).

Determination of pH value and titratable acidity

The remaining juice filtrate prepared for TSS was used to measure the pH and titratable acidity of dragon fruit. To prepare the diluted solution, the fruit juice filtrate (10 mL) was added into distilled water (90 mL) and mixed thoroughly. The pH value of the fruit juice mixture was determined using a pH meter (Orion 910500) with electrodes designed for purees (Perkins-Veazie *et al*., 2008). Titratable acid was measured by further drawing out the diluted solution (5 mL) into a conical flask to be titrated with 0.1 N NaOH. The volume of NaOH used to neutralize the aliquot was recorded after the pH of the aliquot reached 8.1 (Wall & Khan 2008). The results were expressed in the percentage of oxalic acid as the formula in Equation 3.

$$Oxalic\ acid\ (\%) = \frac{0.0045 \times (mL\ of\ NaOH) \times (made\ up\ volume)}{(mL\ of\ juice\ used) \times (volume\ of\ aliquot\ taken)} \times 100\%$$

- Equation 3

Experimental design and data analysis

This experiment was conducted in a complete randomized design with six treatments and five replicates per sampling time. Destructive sampling was conducted where each of the treatments comprised a total of 30 fruits allowed for six sampling times. Data collected were subjected to one-way ANOVA using IBM SPSS statistics 20 software. The mean comparison was further separated by the Tukey test at a significance level of 5% using SPSS software.

RESULTS

Effect of UV-C irradiation on the severity of dragon fruit body decay

Dragon fruit body decay severity was increased with storage timing (Figure 1 & Figure 2). The UV-C radiation at the highest dosages (0.75 & 1.00 kJ m^{-2}) indicated a significant reduction in fruit decay compared with the dragon fruit treated with 5% sodium hydrochloride (positive control), UV-C irradiation at 0.25 and 0.50 kJ m^{-2} from days 8th in storage at 28 ± 2 ºC. Meanwhile, dragon fruit treated with only 5% sodium hydrochloride, without any UV-C irradiation (positive control) exhibited a delay in the onset of fruit decay over all other treatments until day 6th in storage before having a drastic rise. The onset of the rotting lesion on dragon fruits irradiated with UV-C at 0.75 kJ m^{-2} was also delayed to the 4th day in storage at 28 ± 2 ºC.

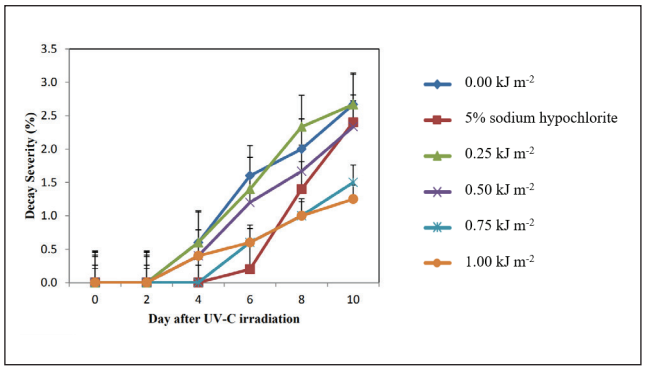

Fig. 1. Effects of UV-C irradiation on dragon fruit body rot disease development during storage at 28 ± 2 ºC.

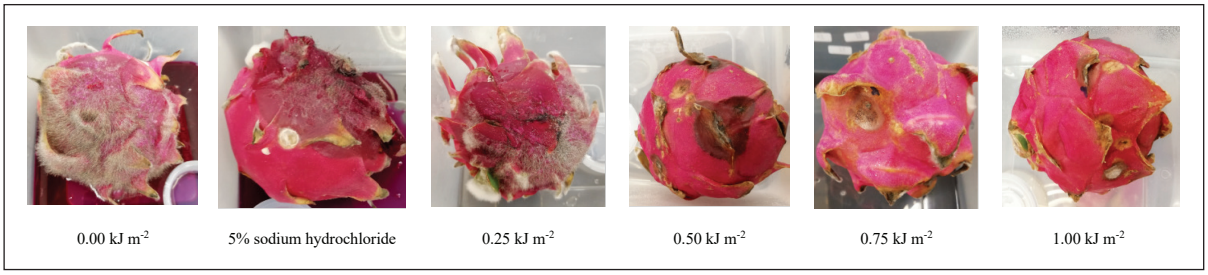

Fig. 2. The decay severity of dragon fruit for all treatments on day 10th of storage at 28 ± 2 ºC.

Effect of UV-C irradiation on bract appearance

The score of bract browning appearance increased with storage time for all the treatments at ambient condition 28 ± 2 ºC (Figure 3). The dragon fruit irradiated with UV-C at 0.75 and 1.0 kJ m^{-2} demonstrated the least browning of bract after the 8th day of treatment was observed. Interestingly, the bract browning appearances of dragon fruit irradiation with UV-C at 1.0 kJ m^{-2} were constant after 8 days in storage at 28 ± 2 ºC.

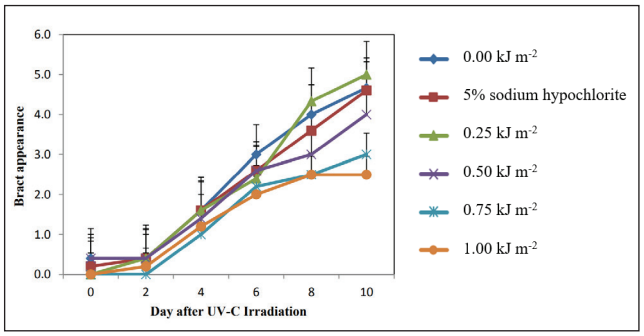

Fig. 3. Effects of UV-C irradiation on dragon fruit bract appearance development during storage at 28 ± 2 ºC.

Effect of UV-C irradiation on physicochemical properties

Generally, the percentage of weight loss increased relative to the storage period for all the treatments. UV-C irradiations at all the dosages did not significantly affect weight loss of dragon fruit stored at 28 ± 2 ºC (Figure 4). The total weight loss of dragon fruit irradiated with UV-C at 1.0 kJ m^{-2} increased linearly from 0.39% to 1.92% during the 10 days of storage at 28 ± 2 ºC.

The external firmness of dragon fruit was reduced over storage timings. However, the external firmness of dragon fruit irradiated with UV-C at higher dosages: 0.50, 0.75, and 1.00 kJ m^{-2} were significantly maintained and almost constant from the 6th day onward in storage compared to other treatments (Figure 5). On day 10th in storage, dragon fruit treated with 1.0 kJ m^{-2} UV-C was recorded with the highest external firmness (1.523 N) compared to other treatments.

The initial soluble solids concentrations (SSC) of all dragon fruits were at the maximum levels, ranging between 12.00-13.13% (Figure 6). There were no significant changes of SSC in dragon fruit irradiated with UV-C at 1.0 kJ m^{-2} throughout the 10 days of storage at 28 ± 2 ºC. The SSC of dragon fruits treated with 5% sodium hydrochloride (positive control) and those without UV-C irradiation (negative control) exhibited drastically decreasing trends during storage. On day 10th of storage, dragon fruit irradiated with UV-C at 1.0 kJ m^{-2} was recorded with the highest SSC (12.2%) compared to other treatments (Figure 6).

The pH value of dragon fruits irradiated with UV-C increased relatively to storage timings before day 6th and achieved almost static thereafter except dragon fruit treated with 5% sodium hypochlorite (positive control) and those without UV-C irradiation (negative control). Dragon fruit irradiated with UV-C at 1.00 kJ m-² exhibited the lowest pH (5.31) in storage compared to others (Figure 7). While the titratable acidity (TA) for all the treatments was decreased throughout the storage duration at 28 ± 2 ºC (Figure 8) except for dragon fruit irradiated with UV-C at 1.00 kJ m^{-2}. A constant TA was achieved for dragon fruit treated with UV-C 1.00 kJ m-² from day 6th in storage. The treatments applied had no significant effect (P>0.05) on the TA of dragon fruits at day 8th in storage (Figure 8).

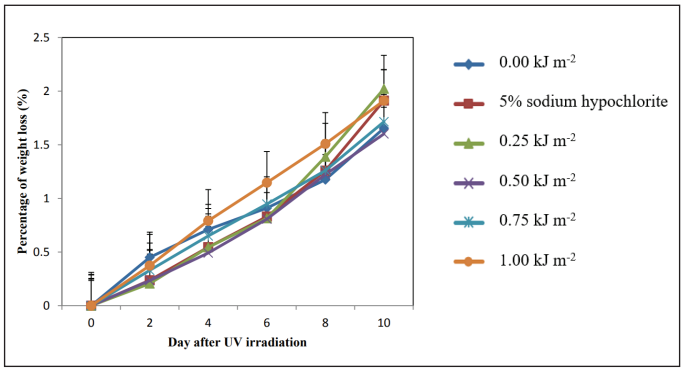

Fig. 4. Effect of UV-C irradiation on total weight loss of dragon fruit during storage at 28 ± 2 ºC.

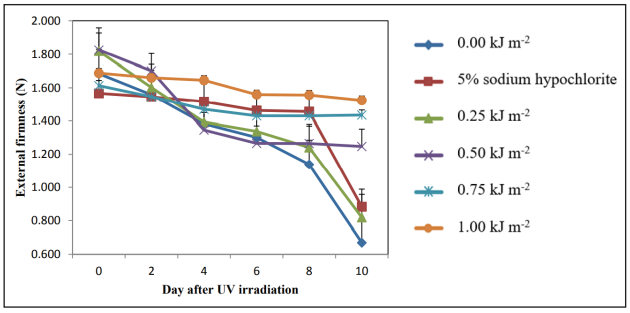

Fig. 5. Effect of UV-C irradiation on external firmness of dragon fruit during storage at 28 ± 2 ºC.

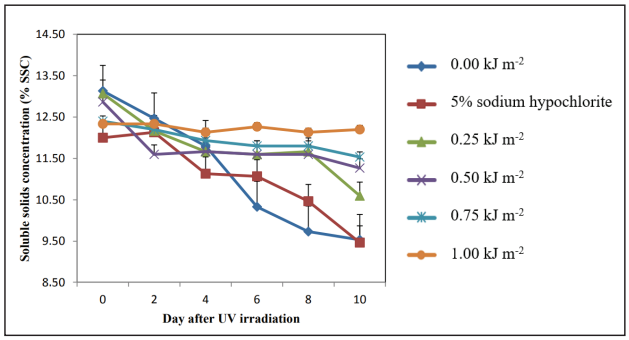

Fig. 6. Effect of UV-C irradiation on soluble solids concentration (SSC) of dragon fruit during storage at 28 ± 2 ºC.

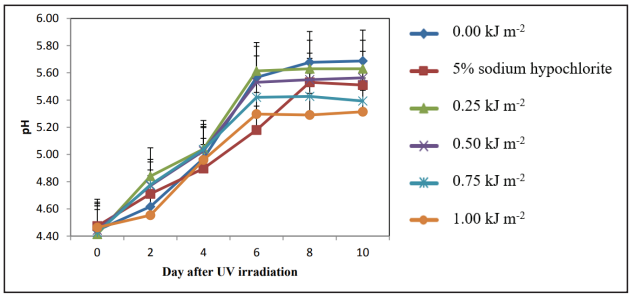

Fig. 7. Effect of UV-C irradiation on pH value of dragon fruit during storage at 28 ± 2 ºC.

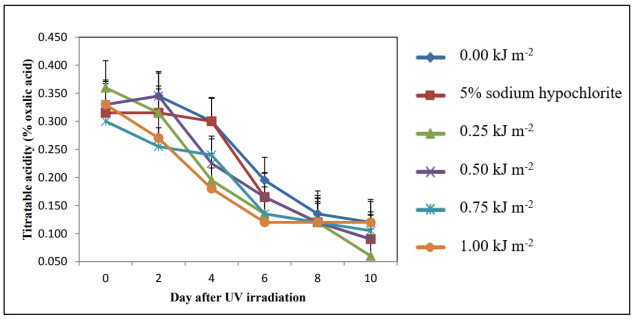

Fig. 8. Effect of UV-C irradiation on titratable acidity of dragon fruit during storage at 28 ± 2 ºC

DISCUSSION

A disease or pathogen-free fruit is the main consideration of consumers as the diseased fruit may risk the health and reduce the post-harvest quality. UV-C irradiated dragon fruit at 2 and 4 kJ m^{-2} was reported to delay bract browning when stored at 10 ºC (Kowitcharoen *et al*., 2010). In this study, lower UV-C irradiated (0.75 & 1.00 kJ m^{-2}) dragon fruit significantly reduced in body rot disease infection from 2.7% (0 kJ m^{-2}) to 1.80% (0.75 and 1.00 kJ m^{-2}, respectively). This was in agreement with Terry and Joyce (2004) and Palou *et al*. (2008) who reported that UV-C dosage ranged from 0.25-8 kJ m^{-2} was effective in controlling postharvest fruit rot. The effectiveness of UV-C irradiation on controlling postharvest disease was also reported on zucchini squash (Erkan *et al*., 2001), strawberry (Nigro *et al*., 2000; Erkan *et al*., 2008), grapefruits (D'hallewin, 2020), banana (Mohamed *et al*., 2017) and rice grain (Cristiano *et*

al., 2021). Stevens *et al*. (1996) reported that UV-C irradiation reducing postharvest decay of fruits was due to its germicidal effect on the fruit surface and its ability to induce fruit resistance. In rice, UV-C irradiation at 2.06 kJ cm^{-1} was effective in controlling fungal decontamination and photodegradation of mycotoxins (Cristiano *et al*., 2021). This was explained that the DNA of the pathogen was destroyed through the formation of pyrimidine dimers which alter the DNA helix to prevent microbial growth and cell replication after exposure to UV-C irradiation (Lucht *et al*., 1998; Lado & Yousef, 2002), The stimulation of anti-fungal biochemical such as phytoalexins and flavonoids was also associated with the induction of defense system caused by UV-C radiation (Charles *et al*., 2009). The two phytoalexins: scoparone and scopoletin were elicited by UV light (Rodov *et al*., 1992; Rodov *et al*., 1994; D'hallewin, 2020). The detoxification of mycotoxins in UV-C irradiated rice was reported during the storage of 6 months (Cristiano *et al*., 2021).

Bract appearance is important in reflecting the post-harvest quality of dragon fruit. Throughout the senescence of the fruit, the bract color will turn from green to brown and finally blackened during storage. Similarly, the UV-C irradiated dragon fruit with 0.75 and 1.0 kJ m^{-2} exhibited a reduction in the browning of bract due to the alleviation of the fruit decay. In this study, the browning and blackening of the bract appearance were closely related to the deterioration caused by fruit rot. The fruit decay caused by the fungal pathogen damaged the cells and accelerated the degradation of chlorophyll around the bracts and hence induced the browning of the bracts. Nevertheless, irradiation dosage can either improve or reduce postharvest disorders in treated fruits (Morris & Jessup, 1994). Disorders on dragon fruit included bract wilting, browning, softening, or decay (Wall & Khan, 2008). However, in this study the optimum UV-C dosage used showed no disorder irradiation effect on bract appearance but delayed the senescence. This was in agreement with Kowitcharoen *et al*. (2010) where UV-C irradiation at high dosage (6 kJ m^{-2}) induced senescence, while at 2 and 4 kJ m^{-2} helped to delay the bract browning and chlorophyll degradation of dragon fruit.

Water loss is the major cause of post-harvest deterioration of fruits and vegetables (Lufu *et al*., 2020). Dragon fruit in all treatments undergoes weight loss and reduction in firmness during storage was explained probably due to the ongoing respiration and transpiration process after harvest (Kowitcharoen *et al*., 2010). Generally, overall fruit weight loss in this study was low ranged 1.60-1.98% after 10 days stored at 28 ± 2 ºC. Similarly, the low weight loss (0.8-1.5%) of X-ray irradiated dragon fruit (12 days stored at 10 ºC) was also reported by Wall and Khan (2008). In comparison, weight loss of 3.33% for untreated dragon fruit stored 10 days at 7 ºC was also reported by Razali *et al*. (2016). Storage temperature is the most important factor affecting the water loss of fresh produce. This study revealed that the weight losses of dragon fruit treated with UV-C were linearly increased over storage duration up to 10 days at ambient conditions (28 ± 2 ºC). High storage temperature was having an impact on the water potential of fruit and relative humidity of the surrounding, increasing the water potential deficit between fruit and its environment (Gahan, 1999). Thus, it is likely that the high storage temperature facilitates an increased depletion rate of respiration substrates and moisture diffusion across the fruit peel (Bowi *et al*., 2018). The membrane permeability, transpiration, and metabolic activity of dragon fruit might be impacted by UV-C irradiation. However, a study by Artes-Hernandez (2010) concluded that by using an optimal dose of irradiation, the shelf life of fruits and vegetables could be extended. This may be associated with the germicidal role of UV-C irradiation to mitigate fruit rot disease during storage. Nevertheless, UV-C irradiation on dragon fruit helps to maintain the postharvest quality with irradiation dose-dependent (Kowitcharoen *et al*., 2010).

Generally, the firmness of dragon fruit decreased throughout the ripening while stored at 28 ± 2 ºC was due to the deterioration of cell wall structure and water losses. Also, quick softening of fruits was also reported about the decreasing of sugar and acidity at storage above 20 ºC (Punitha *et al*., 2010). UV-C irradiation with 0.75 and 1.0 kJ m^{-2} dosage was significantly effective to retard softening in comparison to other treatments. This could be associated with the effect of the UV-C irradiation on delaying the enzymatic activity involved in cell wall degradation (Pan *et al*., 2004) such as polygalacturonase (PG) and pectin methylesterase (PME) (Sethu *et al*., 1996). The activation of these enzymes causes pectin substances to dissolve and hydrolyze the cell wall structure and lastly soften the fruit (Adams, 1991). Therefore, to delay cell wall degradation, both degrading enzymes (methylesterase and polygalacturonase) are the targets of UV-C (Barka *et al*., 2000). Also, Maharaj *et al*. (1999) reported that the retarded softening of UV-treated fruit could be associated with elevated levels of polyamines, which effectively suppressed cell wall softening and activity of polygalacturonase (Kramer *et al*., 1989).

The total soluble solid content in dragon fruit is a sweetness indicator of fruit as sugars are the major soluble solids in fruit juice besides organic and amino acids and soluble pectin. According to Pushpakumara (2005), dragon fruit has a relatively high level of total soluble solids (TSS), which ranged from 11-19%. As reported by Wall and Khan (2008), TSS of dragon fruit was not affected by an X-ray irradiation dose. UV-C did not adversely affect TSS in tomato (Charles *et al*., 2005), fresh-cut dragon fruit (Nimitkeatkai & Kulthip, 2016), and orange juice (Pala & Toklucu, 2013). Interestingly, UV-C irradiated dragon fruit (1.0 kJ m^{-2}) showed no significant changes of TSS throughout the 10 days of storage, while the TSS of dragon fruit in other treatments decreased significantly during storage at 28 ± 2 ºC. This study revealed that dragon fruit irradiated with 1.0 kJ m^{-2} UV-C significantly prevents the depletion of TSS. UV-C might not prevent the depletion of TSS directly, but the germicidal effect of the UV-C in reducing the microbial growth might be contributed to the

depletion of TSS. The decrease of TSS might be due to the action of pathogenic fungi and yeasts that initiate the fermentation process and convert the soluble solids into ethanol. Higher UV-C dosage effectively kills the pathogenic fungi and therefore prevents the fermentation process that causes depletion in TSS of dragon fruit.

The acidity of fruit juice is due to the content of several organic acids such as citric, malic, fumaric, acetic, ascorbic, galacturonic, and oxalic acid. The main organic acid that is contained in dragon fruit is oxalic acid. During the storage, the titratable acidity and pH of dragon fruit were not UV-C irradiation dependent. Titratable acidity indicated a declining trend during storage, while pH was increased through storage. The same scenario was also observed in raspberry (Guimarães *et al*., 2013) and strawberry (Françoso *et al*., 2008). The decrease of titratable acidity might be due to the increase of the respiration rate that uses up organic acid as the substrate in this process (Lurie and Klein, 1990). The deterioration and senescence of fruit are associated with the increase of respiration rate. When the respiration rate increases, more respiratory substrates such as carbohydrates, fats, organic acids, and protein are degraded to produce energy that is required for various activities of the cell. In this process, organic acids are oxidized under aerobic conditions to carbon dioxide and water. As the acidity decreases, the pH of the fruit will increase as pH measures the free hydrogen ions in the solution.

CONCLUSION

The postharvest quality of UV-C irradiated dragon fruit was dose-dependent. This study is the first to indicate that UV-C irradiation at 0.75 and 1.0 kJ m^{-2} were effective to reduce post-harvest decay and indirectly maintain the quality of dragon fruit stored at ambient conditions (28 ± 2 ºC) up today 10th. Results revealed, dragon fruit irradiated with UV-C dosage at 1.0 kJ m^{-2} has significantly reduced the presence of rot, preserved the bract appearance, slowed down total soluble solid depletion, and retarded fruit softening without affecting the titratable acidity of dragon fruit. Also, UV-C irradiation at this dosage did not significantly reduce the weight loss percentage of dragon fruit and also prevented the depletion of SSC during storage at ambient conditions (28 ± 2 ºC). TSS is crucial in maintaining the quality of dragon fruit during storage, especially in ambient conditions. However, further studies are needed to evaluate the impact of low dosage UV-C irradiation on the antioxidant activity, sensory and consumer acceptance of dragon fruit stored at ambient conditions.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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