# ผลของการจุ่มน้ำร้อนและรังสีแกมมาต่อคุณภาพหลังการเก็บเกี่ยวของผลแก้วมังกร

Effect of hot water dip and gamma ray on postharvest quality of dragon fruit

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## บทคัดย่อ

การศึกษาผลของการจุ่มน้ำร้อนและรังสีแกมมาต่อคุณภาพของแก้วมังกร (*Hylocereus* sp.) ทำโดยเก็บเกี่ยวผลแก้วมังกรจากสวนที่ปลูกเป็นการค้าและนำมาจุ่มในน้ำร้อนอุณหภูมิ 50 องศาเซลเซียส นาน 5 นาที, รังสีแกมมาที่ปริมาณ 400±10 เกรย์ และจุ่มในน้ำร้อนร่วมกับฉายรังสีแกมมา สำหรับชุดควบคุมคือผลแก้วมังกรที่ไม่ได้จุ่มน้ำร้อนและไม่ได้ฉายรังสีแกมมา จากนั้นทำการเก็บรักษาผลแก้วมังกรไว้ที่อุณหภูมิ 10 องศาเซลเซียส ความชื้นสัมพัทธ์ 85% นาน 15 วัน ผลการทดลองพบว่าการจุ่มน้ำร้อนร่วมกับการฉายรังสีแกมมามีประสิทธิภาพดีที่สุดในการยับยั้งการเน่าเสียของผลแก้วมังกรในระหว่างการเก็บรักษาได้และมีผลกระตุ้นกิจกรรมของเอนไซม์ peroxidase ซึ่งเป็นเอนไซม์ที่เกี่ยวข้องกับความต้านทานโรคของพืชเมื่อเปรียบเทียบกับชุดควบคุม อย่างไรก็ตาม ไม่พบความแตกต่างของความแน่นเนื้อ ปริมาณของแข็งที่ละลายน้ำได้ ปริมาณกรดที่ไตเตรดได้ ปริมาณเส้นใย อัตราการหายใจ และกิจกรรมของเอนไซม์ phenylalanine ammonia-lyase ของแก้วมังกรในทุกทรีตเมนท์ ผลการทดลองนี้แสดงให้เห็นว่าการจุ่มน้ำร้อนสามารถช่วยลดการเน่าเสียของผลแก้วมังกรที่ต้องผ่านการฉายรังสีแกมมาได้

## ABSTRACT

The effect of hot water dips and gamma rays on the quality of dragon fruit (*Hylocereus* sp.) was investigated. Dragon fruit were harvested from the commercial orchard and treated with hot water (HW) at 50°C for 5 min, gamma rays at 400±10 Gy, or HW combined with gamma irradiation. Non-HW and non-gamma treated fruit were used as the control. After treatment, all fruit were stored at 10°C and 85% relative humidity (RH) for 15 days. It was found that the combination of HW dip and gamma irradiation showed the greatest effect to suppress postharvest decay and also to enhance the activity of peroxidase, the enzyme associated with plant defense, when compared with that of the control. However, there were no significant differences in flesh firmness, total soluble solids content, titratable acid, fiber content, respiration rate, and phenylalanine ammonia-lyase activity among all treatments. This result implies that hot water dips have the ability to reduce postharvest decay of gamma-irradiated dragon fruit.

Key Words: hot water, *Hylocereus* sp., gamma ray, postharvest disease

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# INTRODUCTION

The dragon fruit (*Hylocereus* sp.) have an oblong-oval shape with bright red skin and is covered with green bracts or “scales” (Morton, 1987). The origin of dragon fruit  is the tropical and sub tropical area of Mexico and Central and South American countries including Guatemala, Costa Rica, El Salvador,  Venezuela, Colombia, Brazil and Uruguay (Britton and Rose, 1963). The red dragon fruit with white flesh is the most popular variety grown in Thailand. Dragon fruit quality normally decreases as storage time increases up to 8-10 days at room temperature. The green color of the bract turns yellow from the increase of chlorophyllase activity (Matile et al., 1997). Plant defenses decline as produce ripens and senesces, resulting in a diseased appearance during long storage (Lin et al., 1988). Postharvest diseases of dragon fruit in Thailand have been investigated by Athipunyakom et al. (2009) and Sornvilai et al. (2012) who found that there are many fungi associated with fruit rot diseases, such as *Dothiorella dominicana, Colletotrichum gloeosporioides, C. capsici,* and *Bipolaris cactivora*. Hot water (HW) treatment is a promising method for fungal control as it is an effective, inexpensive, and safe method that produces no chemical residue. It also has been used to disinfest insects (Lurie, 1998). Several evidences showed that HW treatment has been successful to control postharvest diseases in many fruits. Preliminary tests of Wasantha et al. (2011) showed that HW dips at 50°C for 5 min could retard fruit rot disease of dragon fruit by 49%. While Sornvilai et al. (2012) reported that *D. dominicana* inoculated dragon fruit dipped in HW at 53°C for 1 min reduced the incidence of fruit rot disease by more than 40%,  there were not significant differences in natural infected fruit after being dipped in HW at 54°C for 1 min.

The insect infestation is also a significant trade barrier problem of exporting. Gamma irradiation has been well used to disinfest many pests in fresh produce for plant quarantine, and also to retard postharvest diseases, senescence and plant germination (Hajare et al., 2010). FAO (2009) reported that a minimum irradiation dose of 150 Gy was approved by IPPC for disinfesting tephritid fruit flies, and a minimum dose of 400 Gy was approved by the US (APHIS, 2006) for disinfesting all insects except pupae and adults of Lepidoptera. However, tephritid fruit flies and mealy bugs are the main pests of dragon fruit (Hallman, 2001; APHIS, 2008). Several reports showed that gamma irradiation combined with postharvest management was successful in reducing postharvest disease. Jitareerat et al. (2012) showed that PET tray covered with an Active bag was suitable package for gamma-irradiated lychee fruits as it significantly delayed postharvest disease, reduced the browning index and polyphenol oxidase activity. At present, there is a little information about postharvest pests and disease management of gamma-irradiated dragon fruit. Thus, the objective of this study was to determine the effect of HW dips and gamma irradiation on the postharvest quality of dragon fruit.

## MATERIALS AND METHODS

**1. Fruit preparation**: Freshly mature dragon fruits were harvested at 28 days after flowering from the commercial orchard and then brought to the Division of Postharvest Technology at King Mongkut's University of Technology Thonburi (Bangkuntien campus). Defect-free and uniform fruits were chosen. Fruits were washed with tap water and followed by 100 ppm sodium hypochlorite solution to disinfect prior to treatment. The prepared fruits were separated into 4 treatments as follows: 1) hot water (HW) dip, 2) gamma irradiation (Ir), 3) HW dip followed by Ir, and 4) non-HW dip and non-Ir (control).

**2. Hot water treatment and gamma irradiation:** Hot water treatment was conducted by dipping fruit in hot water at 50°C for 5 min (Wasantha et al., 2011), and then transferred into cooled water at 10°C until the final temperature inside the fruit was 20°C. The heated fruits (approx. 12 fruits) were packed in a carton box (net weight 6 kg/box) with the size of 29.7x59x13.7 cm, and then stored at 10°C and 85% RH for 15 days.

Gamma irradiation was done at Synergy Health (Thailand) Ltd. in the Chonburi province. The HW-treated fruits and non-HW treated fruits (approx. 12 fruits) were packed in a carton box as described above. Thereafter, dragon fruit were transported to the irradiation plant and irradiated with gamma rays at the dose of 400±10% Gy (the doses ranged from 360-440 Gy). All irradiated fruit were transported back to the laboratory at KMUTT and stored at 10°C and 85% RH for 15 days. Disease assessment, fruit quality and physicochemical changes of dragon fruit were evaluated every 3 days.

**3. Disease and quality assessment**: Disease incidence was determined according to the following equation: % of disease incidence = no. of rotten fruit/total no. of fruitX100. Fruit firmness was measured with a texture analyzer (TA-XT 2, Stable Micro-system, England). Total soluble solid (TSS) content was determined using a hand refractometer (ATAGO, Model NI). Titratable Acidity (TA) was measured by the method of Guleria (2000).

**4. Physicochemical properties:** Respiration rate was measured with a gas chromatograph (GC, 8A, Shimadzu, Japan). Flesh fiber content, peroxidase (POD) and phenylalanine ammonia-lyase (PAL) activities were detected as described by Gould (1997), Zhang et al. (2005), and Jiang and Jovce (2003), respectively.

**5. Statistical analysis:** The experiment was laid out on a Completely Randomized Design (CRD). Each treatment was comprised of 3 replicates. All data were subjected to analysis of variance (ANOVA) conducted using SAS software (SAS Institute Inc. Cary, NC). Duncan's multiple range test was used to compare the mean values at each storage day.

## RESULTS AND DISCUSSION

### 1. Effect of HWT, gamma irradiation and their combination on postharvest decay

The disease incidence of all treated dragon fruit had no significant difference during storage for 9 days. High disease incidence significantly appeared in gamma-irradiated fruit (66.67-72.22%) and that of the control (44.45-66.67%) from day 12 to day 15 of storage, whereas there was no disease incidence (0%) in fruit treated by HW combined with gamma irradiation throughout storage. HW treatment alone could suppress the fruit rot disease. At the end of storage, the percentage of disease incidence of HW treated fruit was 11.11% (Figure 1a). This result indicated that the combined treatment showed a great result to suppress postharvest disease of dragon fruit. Disease severity and disease index of all treatments had similar trends in disease incidence (data not shown). However, suppressing disease development in dragon fruit by HW treatment and HW plus irradiation might be related to their direct effects on fungal growth and indirect effects to induce plant defense mechanisms. The direct effects of HW treatment and gamma irradiation were documented by Lurie (1998) and Chung et al. (2002), respectively. Wet heat from hot water may penetrate fungal cells to result in protein precipitation and cell death (Couey, 1989). The indirect effects may be due to the induction of the activities of enzymes associated with plant defense, i.e. peroxidase (POD), Phenylalanine ammonia-lyase (PAL), chitinase and $\beta$-1,3-glucanas (Terry and Joyce, 2004).

POD is a one of the phenolic enzymes whose activity may increase in response to biotic and abiotic stresses (Cohen et al., 1988). Our results showed that disease suppression was also related to the increase of POD activity, but not PAL activity (Figure 1b-1c). POD activity of dragon fruit was induced by HW plus irradiation and irradiation alone (Figure 1b). However, the high percentage of disease incidence of gamma-irradiated fruit on the last day of storage was not involved in the activity of POD, as its activities were not significantly different to those of the control. The high percentage of disease incidence of gamma-irradiated fruit might be due to the dose of gamma rays at 400±10 Gy, as it was not sufficient to suppress fruit rot diseases. Calado et al. (2011) reported that gamma irradiation at a dose lower than 3 KGy was not enough to reduce yeast and *A. parasiticus* loads on chestnut, but both microbes could not survive at a high dose of 10 kG. The activity of PAL is involved in the production of the free phenolic compounds that are the basis of the browning reactions (Zhu et al., 2010). The PAL of all treated dragon fruit was lower than that of the control (Figure 1c). Thus, PAL activity may not be associated with disease resistance in dragon fruit.

### 2. Effect of HWT, gamma irradiation and their combination on fruit quality

The TSS contents of all treated fruit decreased during storage time. The TSS of the control fruit and HW combined irradiated fruit slightly declined, whereas the TSS of irradiated fruit and HW treated fruit rapidly decreased from the initial date to day 6 of storage. However, there were no significant differences in all treatments at the last day of storage (Figure 2a). The TA was measured with respect to citric acid and all treatments behaved in a similar manner as they decreased along with the storage time (Figure 2b). The respiration rates of dragon fruit were induced by HW, gamma irradiation and their combined treatments at the initial date when compared to the control, and it slightly increased during storage in all treatments (Figure 1d). The decrease of TSS contents and TA correlated with the increase of the respiration rate in all treatments. Sugars contained in TSS are converted to organic acid which is a substrate for the respiration (Vicente et al., 2002).

However, the peel color (L*, *a**, *b** value and hue angle) of dragon fruit did not have significant differences ($p \geq 0.05$) in all treatments during the storage period (data not shown), but the peel of those fruits became dark red along the storage period. Total chlorophyll content of bracts for all treatments declined during storage and there were no significant differences (data not shown). The peel firmness of fruit tended to increase during storage in all treatments (Figure 2c). Dietary fiber consists of a variety of non-starch polysaccharides which includes cellulose (CEL), hemicellulose (HC), pectin, $\beta$-glucans, gums and lignin (Lamghari et al., 2000). The flesh fiber of dragon fruit of all treatments was not significantly different and tended to increase. In particular, the flesh fiber of non-treated fruit (control) was slightly higher than other treatments throughout storage (Figure 2d).

## CONCLUSIONS

The combined effect of HW dips at 50°C for 5 min and gamma irradiation at 400±10 Gy could suppress the postharvest decay of dragon fruit during storage at 10°C by enhancing the activity of plant defense enzymes (peroxidase), except phenylalanine ammonia-lyase. The combined treatments also showed a higher effect in suppressing fruit decay than HW dips alone. Moreover, both HW dips and gamma irradiation did not affect the physicochemical qualities of dragon fruit.

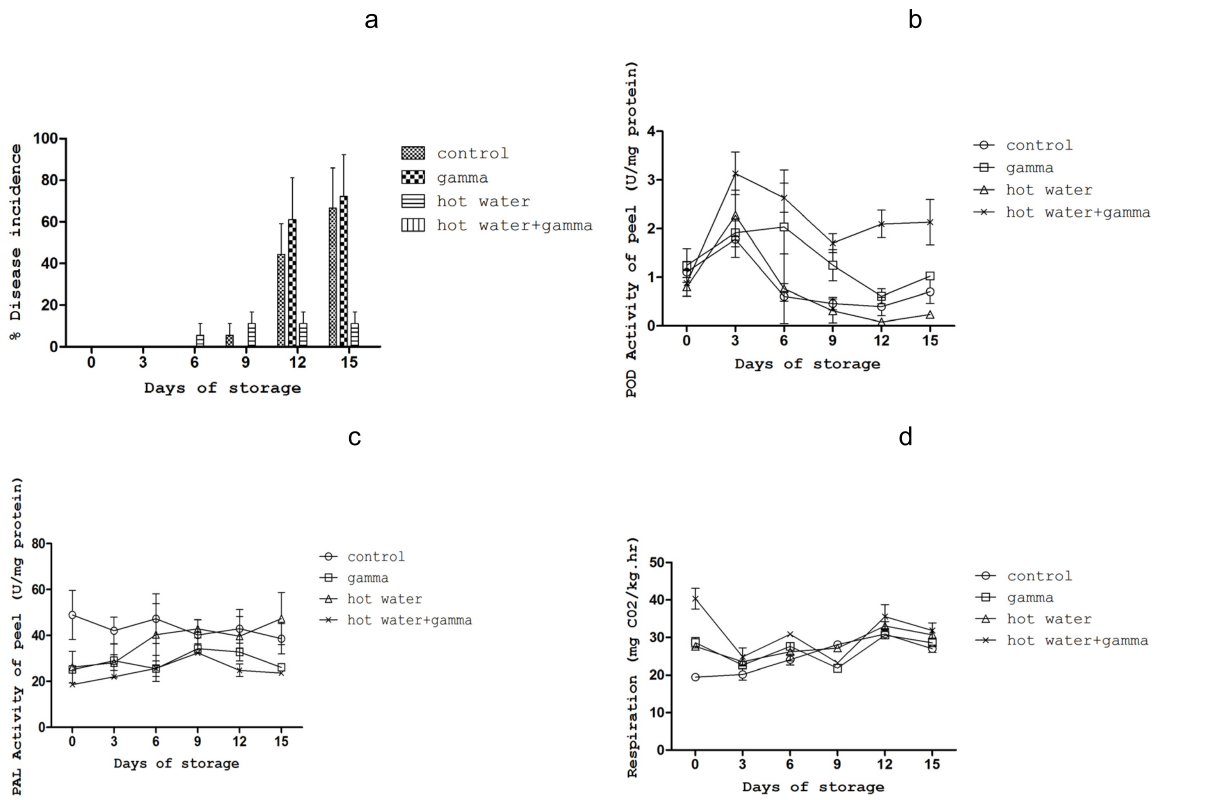


**Figure 1** Disease incidence (a), POD activity (b), PAL activity (c) and respiration rate (d) of dragon fruit treated with hot water at 50°C for 5 min, gamma rays at 400±10% Gy, and hot water plus gamma rays before storage at 10°C for 15 days. Untreated fruits served as the control.

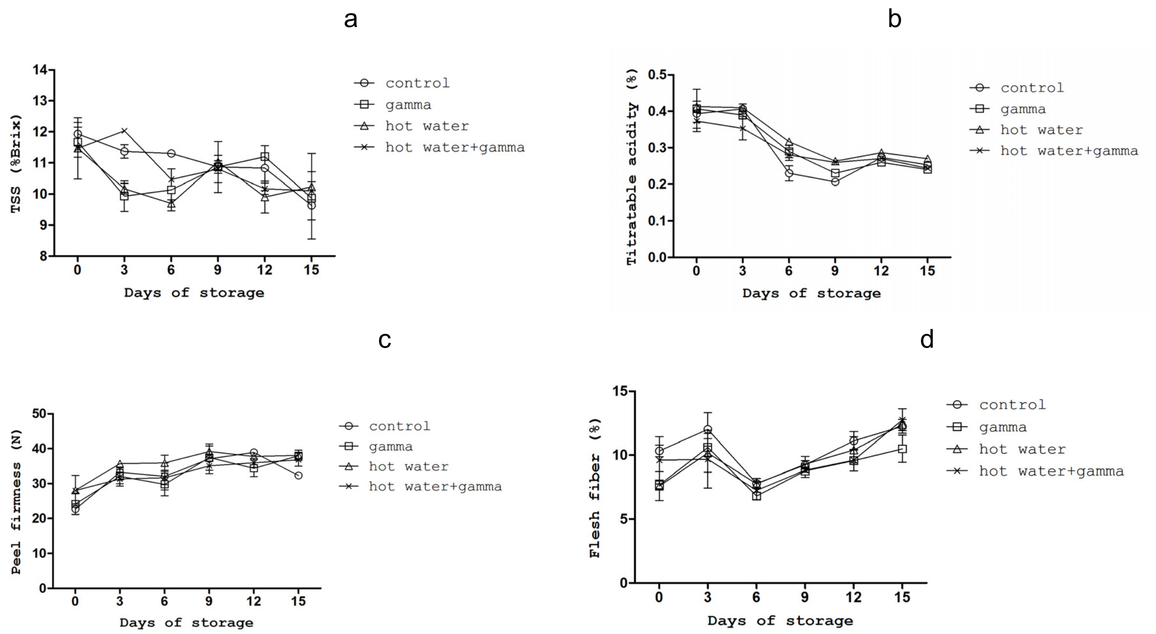


**Figure 2** Total soluble solid (TSS) contents (a), titratable acid content (b), peel firmness (c), and flesh fiber (d) of dragon fruit treated with hot water at 50°C for 5 min, gamma rays at 400±10% Gy, and hot water plus gamma rays before storage at 10°C for 15 days. Untreated fruits served as the control.

## ACKNOWLEDGEMENTS

This research was financially supported by the National Research University and Thailand International Co-operation Agency. The first author was gratefully acknowledged.

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