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การฉายรังสียูวีสามารถชะลอการเหลืองของมะนาวตาฮิติ
UV-B Irradiation Delays Yellowing of Tahiti Lime

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Abstract

Tahiti lime (*Citrus latifolia* Tan.) is classified into the same group as a lime grown in Thailand. Mature green is a prefered stage for the consumer due to the fruit's aromatic compounds and exotic flavors. Peel yellowing is the main problem of the lime fruit during postharvest period that limits the maketable life. In the past, there were many trials to control the yellowing of lime fruit including coating, modified atmosphere packaging, heat treatment and so on. However, no report of UV-B application to maintain the quality of lime fruit has been recorded. This experiment was attemped to use the UV-B at 0 (control), 8.8 and 13.2 kJ/m^2 for delaying the yellowing of Tahiti lime during storage at 25°C. The results found that UV-B at 13.2 kJ/m^2 induced the water loss from lime fruit whereas at 8.8 kJ/m^2 a trend of water loss similar to the control was observed. Moreover, UV-B at 13.2 kJ/m^2 enhanced the chlorophyll degradation in the flavedo tissue of the lime fruit, while UV-B at 8.8 kJ/m^2 delayed the chlorophyll breakdown. This indicates that UV-B at suitable dose might be an alternative method for maintaining the postharvest quality of Tahiti lime.

Keywords : *Citrus latifolia Tan.*, yellowing, chlorophyll, UV-B

บทคัดย่อ

มะนาวตาฮิติจัดอยู่ในกลุ่มเดียวกันกับมะนาวที่ปลูกในประเทศไทย ซึ่งวัยของมะนาวในระยะที่เปลือกยังคงเป็นสีเขียวคือลักษณะที่ต้องการของผู้บริโภคเนื่องจากอุดมไปด้วยสารประกอบหอมระเหยและมีกลิ่นเฉพาะตัว แต่อย่างไรก็ตามหลังจากการเก็บเกี่ยวมะนาวพบว่าการเหลืองของเปลือกเป็นปัญหาที่สำคัญซึ่งทำให้อายุการวางจำหน่ายสั้นลง จากการศึกษาที่ผ่านมาได้มีความพยายามในการลดการเหลืองของเปลือกมะนาวโดยการเคลือบผิว การเก็บรักษาในถุงดัดแปลงบรรยากาศ การใช้ความร้อนและวิธีการอื่นๆ อีกมากมาย แต่ยังไม่มีการศึกษาผลของการฉายรังสียูวีบีต่อการควบคุมการเหลืองของมะนาว ดังนั้นในงานวิจัยนี้จึงได้ศึกษาการฉายรังสียูวีบีที่ความเข้ม 0 (ชุดควบคุม) 8.8 และ 13.2 กิโลจูลต่อตารางเมตร เพื่อชะลอการเหลืองของมะนาวในระหว่างการเก็บรักษาที่อุณหภูมิ 25 องศาเซลเซียส ผลการศึกษาพบว่าการใช้รังสียูวีบีที่ระดับ 13.2 กิโลจูลต่อตารางเมตร มีการกระตุ้นให้เกิดการสูญเสียน้ำออกจากผลมะนาวในขณะที่การสูญเสียน้ำของผลมะนาวในชุดควบคุมและผลที่ฉายรังสียูวีบี 8.8 กิโลจูลต่อตารางเมตร แตกต่างกันเพียงเล็กน้อย นอกจากนี้รังสียูวีบีที่ระดับ 13.2 กิโลจูลต่อตารางเมตร ยังกระตุ้นให้เกิดการสลายของคลอโรฟิลล์เร็วกว่าชุดการทดลองอื่นๆ สำหรับการฉายรังสียูวีบีที่ระดับ 8.8 กิโลจูลต่อตารางเมตรสามารถชะลอการสลายของคลอโรฟิลล์ได้ดีกว่าชุดการทดลองอื่นๆ ดังนั้นการใช้รังสียูวีบีในระดับที่เหมาะสมจึงเป็นอีกทางเลือกหนึ่งในการยืดอายุหลังการเก็บเกี่ยวมะนาว

คำสำคัญ : มะนาวตาฮิติ, การเหลือง, คลอโรฟิลล์, ยูวีบี

Introduction

Tahiti lime fruit is usually marketed while the peel is still green. Under ambient conditions, the lime fruit become yellow within a few days. Normally, the peel of lime fruit is green due to the presence of chlorophyll pigment. Peel yellowing of lime fruit is attributed to the degradation of chlorophyll. In oranges, a similar loss of green colour is correlated with a decrease of the chlorophyll content and an increase of the chlorophyll-degrading enzyme activities (Goldschmidt, 1997). Maintenance of the green colour in postharvest lime peel is required to obtain premium prices. In this research, we focused on the effects of UV-B on physical changes in the Tahiti lime.

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UV-A, UV-B and UV-C treatments have been reported to maintain the postharvest quality of fruit and vegetables. UV-C, especially, has been excellent for inhibiting chlorophyll degradation in broccoli florets (Costa et al., 2006). However, the application of UV-C may be harmful to the user if the dose is too high. Thus, UV-B is an alternative method that may maintain the postharvest quality of fresh produce. However, no study has been undertaken to examine the effect of the postharvest application of UV-B on chlorophyll degradation in the Tahiti lime. Here, therefore, we examined the effect of UV-B on chlorophyll degradation in the Tahiti lime.

Materials and Methods

Plant materials

Mature green Tahiti lime fruit were purchased from Tokio-Fukuoka Co., Ltd., Fukuoka Prefecture, Japan. After transportation to the laboratory, fruit were selected for uniformity in maturity, size, shape, peel colour and lack of defects.

UV-B treatment

Lime fruit were irradiated with UV-B (spectral peak value: 312 nm, T-15M, VL). Each fruit was placed under UV-B lamps at a distance of 15 cm, resulting in UV-B energy doses of 0 (0 min; control), 8.8 (20 min), and 13.2 (30 min) kJ/m^2. After irradiation, lime fruit were kept in polyethylene bags and stored at 25°C in the dark condition. The samples were removed at 5-day intervals for analysis of weight loss, peel colour and chlorophyll content.

Chlorophyll assay and peel colour evaluation

The chlorophyll content was determined using *N,N*-dimethylformamide (Moran, 1982). The surface colour of the equatorial plane of the fruit, as represented by the hue angle, was measured with a colour difference meter (Nippon-denshoku NF 777).

Results

Physical changes in the Tahiti lime

The weight loss of the Tahiti lime fruits in the control and UV-B-treated fruit increased with the progress of storage period. During storage, the weight loss in the control and 8.8 kJ/m^2 UV-B treated fruit was significantly lower than that in 13.2 kJ/m^2 UV-B-treated fruit (Figure 1A). Shriveling of the peel, indicating water loss, in 13.2 kJ/m^2 UV-B-treated fruit was observed after 10 days of storage.

The peel colour of the Tahiti lime was measured and reported as a hue angle value (Figure 1B). The hue angle value of UV-B-treated fruit was slightly decreased during storage, especially in 8.8 kJ/m^2 UV-B-treated fruit. A decrease in the hue angle value was found after day 10 in the control, and the decrease was lower than that in fruit treated with UV-B. The decrease of the hue angle value was delayed by 8.8 kJ/m^2 UV-B compared with 13.2 kJ/m^2 UV-B-treated fruit.

Chlorophyll content in the Tahiti lime peel

UV-B treatment at 8.8 kJ/m^2 delayed the reduction of chlorophyll *a* and chlorophyll *b* content in the Tahiti lime, as shown in Figures 2 A and B. Chlorophyll *a* was slightly decreased in the control and 8.8 kJ/m^2 UV-B-treated fruit throughout the storage period, while a sharp decrease of the chlorophyll *a* content was observed in 13.2 kJ/m^2 UV-B-treated fruit after day 10 to a level lower than that of other treatments (Figure 2A). In the case of chlorophyll b, the alteration trend of its content was similar to that of the chlorophyll *a* during storage (Figure 2B).

The lime fruit treated with 8.8 kJ/m^2 UV-B and the control had a higher content of chlorophyll *a* and *b* than 13.2 kJ/m^2 UV-B-treated fruit.

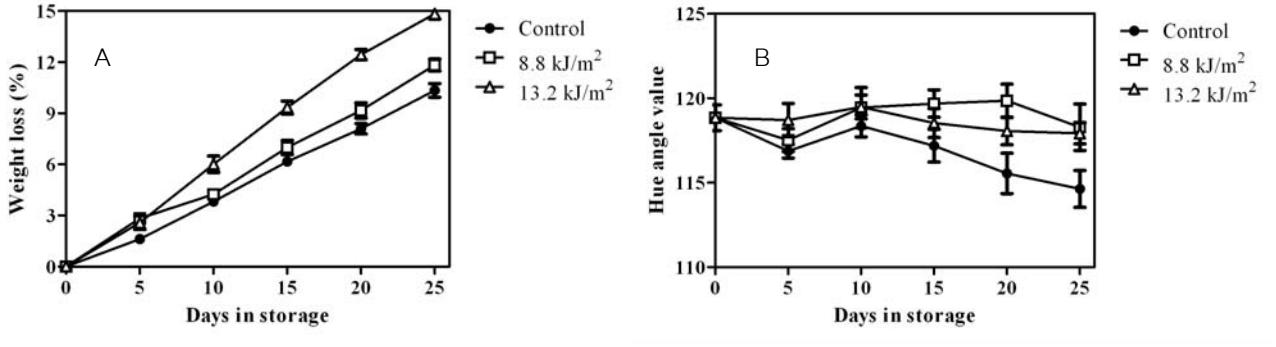

Figure 1 Weight loss (A) and hue angle value (B) of Tahiti lime irradiated with UV-B at 0 (control), 8.8 and 13.2 kJ/m2.

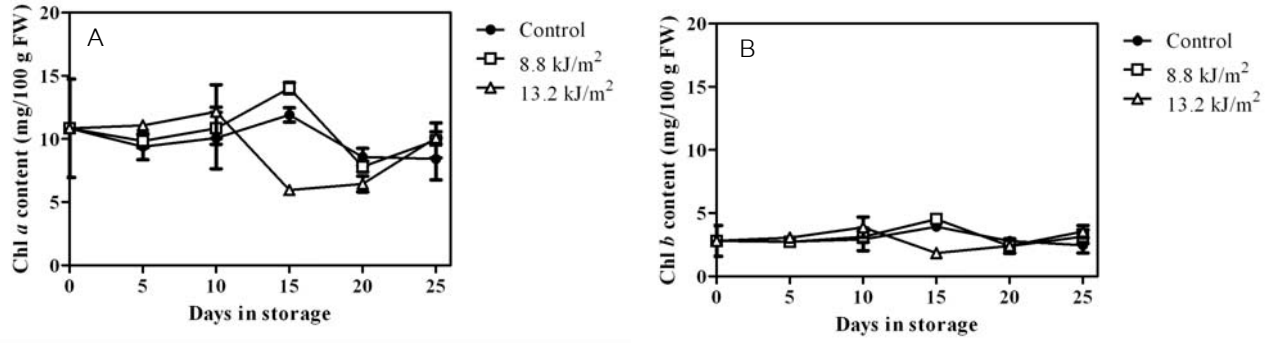

Figure 2 Chlorophyll *a* (A) and chlorophyll *b* (B) content of Tahiti lime fruits irradiated with UV-B at 0 (control), 8.8 and 13.2 kJ/m2.

Discussion

Lime is widely used in Asian dishes. The green colour of immature lime is due to the presence of chlorophylls. Several techniques have been applied to maintain the green colour of lime. In the present study, Tahiti limes were irradiated with UV-B at 8.8 and 13.2 kJ/m^2. From the results found that 8.8 kJ/m^2 UV-B treatment delayed the chlorophyll breakdown in the lime peel while UV-B at 13.2 kJ/m2 induced the chlorophyll degradation and also enhanced water loss. It appears that UV-B at 13.2 kJ/m^2 may induce the tissue damage on the fruit peel while UV-B at lower dose may affect the stomata closure. Salvador et al. (1999) found that UV-B irradiation can cause stomata closure in plants thus the transpiration process was reduced. In this experiment also found that UV-B at 8.8 kJ/m^2 could retard the reduction of the hue angle value of lime peel. This means that the yellowing of lime peel was delayed by the UV-B treatment, especially at a dose of 8.8 kJ/m^2. This result was correlated with the chlorophyll *a* and chlorophyll *b* contents in lime peel from 8.8 kJ/m^2 UV-B-treated fruit, which had higher level of chlorophyll than that of the control and 13.2 kJ/m^2 UV-B treatments, respectively. Our result agrees with the study of Aiamla-or et al. (2010), who found that UV-B at 8.8 kJ/m^2 effectively delayed the chlorophyll degradation in broccoli florets. They explained that the delay of chlorophyll degradation by UV-B treatment was due to the suppression of chlorophyll-degrading enzyme activities. From the results, hue angle value of 13.2 kJ/m^2 UV-B treated fruit was not concomittant with the chlorophyll content. The hue angle value of 13.2 kJ/m^2 UV-B treated fruit showed a similar trend as in 8.8 kJ/m^2 UV-B treated fruit but the chlorophyll content of 13.2 kJ/m^2 UV-B treated fruit

was lower than that of other treatments. This might be because the chlorophyll *a* was degraded to chlorophilide *a* which has green colour thus the hue angle value was still high in 13.2 kJ/m^2 UV-B treated fruit. According to the results, UV-B at 13.2 kJ/m^2 enhanced chlorophyll breakdown, this may be due to the fact that UV-B at higher dose induced tissue damage which leads to senescence and cell death.

Conclusion

In conclusion, the irradiation with UV-B at 8.8 kJ/m^2 effectively retarded the degradation of chlorophyll in flavedo tissue of the Tahiti lime during storage at 25^{o}C, while UV-B at 13.2 kJ/m^2 induced the chlorophyll breakdown. The application of UV-B at a lower dose may be used as an alternative method for delaying chlorophyll degradation in lime fruit.

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