Effect of Ultraviolet Light on Anthocyanin Synthesis in Light-Colored Sweet Cherry, cv. Sato Nishiki

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Summary

Ultraviolet (UV) radiation, provided by a fluorescent lamp with 1.3 W \cdot m^{-2} and emission peak at 312 nm (UV312), was much more effective on anthocyanin synthesis in light-colored sweet cherry, cv. Sato Nishiki, than was white fluorescent lamp with 4.0 W \cdot m^{-2}. Anthocyanin accumulation was linearly correlated to the duration of irradiation with UV312 light and the storage in the dark after irradiation. The use of cut-off filters revealed that the most effective wavelength of UV312 was in the region of UV-B (UV from 280 to 320 nm). The effect of UV-B on anthocyanin production in ‘Sato Nishiki’ seemed to have an important role in the development of the desirable red skin color under field light conditions.

Introduction

Red color of sweet cherries is important for marketability of the fruit. Intensity of the anthocyanin developed in a given cultivar is affected by light conditions (Drake et al., 1980). In apples, Arakawa et al. (1985) reported that UV light from 280 to 320 nm (UV-B) synergistically stimulated anthocyanin synthesis when it was combined with red light. UV-B alone was much more effective in anthocyanin synthesis than red light.

The effect of light on anthocyanin accumulation in sweet cherry has not been studied in detail. The purpose of this research was to study the effect of UV light on anthocyanin synthesis in light colored sweet cherry.

Materials and Methods

Pale yellow, mature fruits of ‘Sato Nishiki’ were harvested in the Experimental Orchard of the Faculty of Agriculture, Hirosaki University, Hirosaki. Fruits were stored at 0°C for a month until experiments were initiated. UV312 light was obtained from fluorescent lamps of FL20S.E (Toshiba, Tokyo), eliminating wavelength below 290 nm by a polyvinyl chloride film and polymethyl methacrylate plates (Arakawa et al., 1985). The spectral irradiance of UV312 measured by a spectroradiometer (Japan Spectroscopic Co., Ltd, Tokyo) is shown in Fig. 1. White light was obtained from white fluorescent lamps (FL20S.W, Toshiba, Tokyo), which eliminate wavelengths below 390 nm by polyvinyl chloride film (Arakawa et al., 1985). Intensities of UV312 and white light, measured by a compensated thermopile (E-1; Kipp and Zonen, Delft, The Netherlands) with microvoltmeter (PM-16A, Toa Electronics, Tokyo), was 1.3 and 4.0 W \cdot m^{-2}, respectively. The four UV312 levels which were measured by UV digital radiometer (UV103-B, Macam Photometrics Ltd., Livingston, Scotland) were maintained by using a combination of neutral density shading materials positioned above a petri dish. To characterize wavelength dependence, cut-off filters (Hoya Corporation Ltd., Tokyo) were used for UV312, described previously (Arakawa et al., 1985). Fruits without peduncles were placed on quartz sand in a petri dish and covered with thin polyethylene film (Arakawa et al., 1985), then irradiated with light in the cabinet at 20°C. For determination of the amount of anthocyanin, a piece of exocarp (5mm \times 5mm) was cut from the irradiated area and anthocyanin was extracted with 6 ml of a 1 : 99 (v/v) HCl: methanol mixture.

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Absorbance of each extract was measured at 530 nm. Eight to 10 fruits were used for each experiment.

Results and Discussion

Anthocyanin accumulation in the fruit under white light increased linearly with time from 24 to a maximum at 96 hr, whereas it increased in UV312 from 24 to a maximum at 72 hr (Fig. 2). UV312 light with 1.3 W·m⁻² was much more effective than white light with 4.0 W·m⁻². Arakawa et al. (1985) reported that a combined irradiation of UV-B and white light synergistically stimulated anthocyanin synthesis in apples. In cherries, however, such interaction between UV-B and white light was not found (data not shown). Therefore, UV312 light alone was used for further experimentation.

The relationship between the duration of irradiation and the amount of anthocyanin formed is shown in Fig. 3. The initial sample (0 hr) for anthocyanin revealed no increase in absorbance at 530 nm after storage of 48 hr. The level of anthocyanin increased linearly with time from 12 to 48 hr. Irradiation for 12 hr was sufficient to induce pigment formation; after 18 hr measurable anthocyanin was formed. Subsequently, anthocyanin content increased linearly in the dark up to 72 hr when the level reached maximum (Fig. 4).

Effect of UV312 light intensity on anthocyanin synthesis is shown in Fig. 5. Anthocyanin accumulation increased curve-linearly with fluence rate of UV312. To investigate the effective UV region of UV312, the effects of different cut-off filters on anthocyanin accumulation were examined. These filters eliminate wavelengths within the UV range; the internal transmission of UV-28, UV-30,
UV-32 and UV-34 is 50 % at 280, 300, 320, and 340 nm, respectively (Arakawa et al., 1985). The level of anthocyanin decreased with the increasing wavelengths, while the use of UV-28 and UV-30 had a little effect on anthocyanin production (Table 1).

Results show that anthocyanin synthesis in light-colored sweet cherry is dependent on irradiation with UV312 light. It also depends on the duration, intensity and the dark storage period after irradiation. The relationship between light and anthocyanin synthesis has been determined in many plant systems (Mancinelli, 1985). Among these, the characteristic of requiring prolonged exposure to high intensity light is similar to that of apple fruit. Siegelman and Hendricks (1957) determined the wavelength-dependence curve for anthocyanin synthesis in apple fruit and showed that the red region near 650 nm was most effective. Arakawa et al. (1985) found that UV-B light was much more effective than red and blue light, and simultaneous irradiation with red and UV-B had a synergistic effect on anthocyanin synthesis. The involvement of the regulation by the photoreceptor, phytochrome in anthocyanin synthesis under red light was determined by Arakawa (1988) who suggested that a UV-B absorbing photoreceptor was involved. In sweet cherry, the effective wavelength region in white light and the photoreceptor for anthocyanin synthesis were not determined because the effect of white light was very low. The most effective wavelength in UV312 is in the UV-B region from 290 to 320 nm. The photoreceptor involved in the effect of UV-B appears to be the same as that of apple fruit, considering that the effective wavelength in UV312 on anthocyanin accumulation in sweet cherry fruit was almost equal to that of apple fruit (Arakawa et al., 1985).

Effect of UV-B on anthocyanin synthesis appears to have an important role for color de-

Fig. 4. Time course of anthocyanin accumulation in sweet cherry, cv. Sato Nishiki fruits previously irradiated at 1.3 W · m⁻² with UV312 for 18 hours and stored in the dark. Vertical bars indicate standard errors.

Fig. 5. The effect of fluence rate on anthocyanin accumulation in sweet cherry, cv. Sato Nishiki fruits irradiated with UV312 for 96 hr. Vertical bars indicate standard errors.

Table 1. Effect of different cut-off filters inserted in the irradiation of UV312 light on anthocyanin accumulation in sweet cherry.

<table>
<thead>
<tr>
<th>UV cut-off filters</th>
<th>Anthocyanin (A₅30)¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>without filters</td>
<td>0.067 a¹</td>
</tr>
<tr>
<td>UV-28</td>
<td>0.052 b</td>
</tr>
<tr>
<td>UV-30</td>
<td>0.052 b</td>
</tr>
<tr>
<td>UV-32</td>
<td>0.011 c</td>
</tr>
<tr>
<td>UV-34</td>
<td>0.007 c</td>
</tr>
</tbody>
</table>

¹ Anthocyanin was assayed after 96 h light irradiation.
² The internal transmission of UV-28, UV-30, UV-32 and UV-34 is 50% at 280, 300, 320 and 340 nm, respectively.
³ Mean separations within columns by Duncan's new multiple range test, 5% level.
velopment of the light-colored sweet cherries on the tree. It is well known that the cherries of light-colored cultivars develop less red color in the interior of the tree. The intensity of UV-B is very weak at those locations, because most of the UV light is absorbed by leaves.

Acknowledgement

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Literature Cited


紫外光が甘果ウオトウ '佐藤錦' 果実のアントシアニン生成に及ぼす影響

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要約

甘果ウオトウ '佐藤錦' 果実のアントシアニン生成に対し、蛍光灯による 312 nm に最大強度を持つ紫外光（UV312）は、その光強度は低いにもかかわらず、同じ蛍光灯による白色光より著しく効果が大きかった。アントシアニン生成量は UV312 の照射時間、照射後の暗黒の時間およびその光強度に比例して増加した。UV 312 に紫外域を除去する様々なフィルターを組み合わせて照射した結果から、280-320 nm の UV-B の波長域がアントシアニン生成に対する効果が最も大きいことが判った。この UV-B は '佐藤錦' 果実の樹上における良好な着色に大きな役割を果たしていることが推察された。