# Effects of OLED as light source to the growth and antioxidants-concentration of broccoli sprout

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## 1. Abstract

Organic light-emitting diode (OLED) is considered the next generation artificial light source after LED. However, no research was conducted using OLED as light source for plant growth. This study demonstrates the potential of OLED as the light source for sprout production. An experiment was conducted to grow broccoli sprout using OLED and LED as light source for comparison. The sprouts, grown for 5 days, provided with PPF at 105 μmol.m$^{-2}$.s$^{-1}$. The results show that there are no significant difference on fresh mass, vitamin C, total phenols and anthocyanin. However, there is significantly improvement on DPPH scavenging capability for those grown under OLED. OLED can be used to grow sprouts with preferred features for healthy diet.

**Key words:** Organic light-emitting diode, OLED, sprout, anthocyanin, DPPH

## 2. INTRODUCTION

At present, organic light-emitting diode (OLED) was used only on TV backlight and limited amount of 3C appliance. Due to the advancement of efficiency and manufacturing technology of OLED, it will have the opportunity to compete in the traditional lighting market. (Reineke*et al.*, 2009). White OLED has been applied in lighting (Duggal *et al.*, 2002; D'Andrade, and Brown, 2006). In addition to lighting purposes, agricultural application is also one of the options. Photosynthesis is the most important physiological effect of plant. At present, LED has started successfully applied to plant lighting. No previous research was conducted for plant growth using OLED as light source mainly due to low luminous efficiency and high cost. OLED is a surface light source, its wide continuous spectrum and wavelength characteristics are significantly different from that of LED.

Sprouts, have vitamins, minerals, enzymes and amino acids, are beneficial to health (Márton*et al.*, 2010).Studies showed that light quality can regulate the active ingredients incrops (Cevallos-Casals and Cisneros-Zevallos, 2010; Maeda *et al*., 2006). For example, brassica crops such as cauliflower, broccoli, red cabbage are generally considered excellent antioxidant vegetables (Wu *et al*., 2007; Maeda *et al*., 2008).Broccoli sprouts have beneficial phytochemicals, can relief skin and urinary bladder from oxidative stress(Dinkova-Kostova et al, 2006;Rex et al., 2008).

This study aimed at comparing the effectsof OLED and LED on the growth and antioxidant contents of broccoli sprout.

## 3. MATERIALS AND METHODS

In this study, there are two different light quality treatments. White OLED at 2557K color temperature was used in this study. Ratio of Red and blue spectrum and ratio of Red and far-red spectrum are 6.5 and 5.1, respectively. More details on spectral distribution on OLED and LED used can be found in Table 1.

A RGB LED light source capable of adjusting each one of the components was used and the ratio among RGB was adjusted to mimic the ratio of OLED as shown in Table 1. The biggest difference between two spectra is that OLED has far-red as shown in the last 2 columns of Table 1.

Table 1 Percentage of photons of blue, green, red and far-red light over PPF range (400 ~ 700 nm) of OLED and LED used

| Treatments | Color temperature | Blue (B) 400~499 | Green (G) 500~599 | Red (R) 600~699 | Far-red (FR) 700~799 | R/FR |
|---|---|---|---|---|---|---|
| OLED | 2557 | 11 | 18 | 71 | 14 | 5.1 |
| LEDRGB | 2608 | 12 | 18 | 70 | 0 | - |

Fig. 1 shows the experimental setup. At bottom is the plastic box filled with hydroponically grown sprouts and at upper side is the light source consists of 5 pieces of OLED panels. Luminaire area is 52 mm × 260mm.At current density of 22.16 mA.cm$^{-2}$, the PPF provided by OLEDs is 105 μmol m$^{-2}$ s$^{-1}$.measured at 3 cm below.

Broccoli seeds were treated with 70% alcohol for 30 seconds, then soaking with distilled water for 1.5 hours at 18℃, then put in the dark for four days for germination. After the germination, the sprouts were transferred to growth chamber with 12/12 light cycle at 105 μmol m$^{-2}$ s$^{-1}$ light intensity. The air temperatures at D/N is 25/18 °C. In each treatment the sprouts were grown for 7days.Each sample has 5 replicates. Fresh mass, plant height, root length and chlorophyll content were measured and totally concentrations of 5 phytochemicals were analyzed, including carotenoids, lutein, total phenols, anthocyanins and DPPH (1,1-diphenyl-2-picryhydrozyl, $C_{18}H_{12}N_5O_6$) radical scavenging (RS) capacity.

Fig. 1 Photo of experimental setup of sprout production using OLEDs

**Statistical analysis**

The significance of differences was compared using the T-test at 95% confidence level.

## 4. RESULTS & DISCUSSION

No significant difference on fresh mass was found, but OLED treatment increase plant height and root length significantly (Table 2).This is mainly due to high R/FR ratio (value of 5 as shown in Table 2). The R/FR ratio of the Sun and the metal halide (MH) lamps used in greenhouse are both at about 1.1. Many studies have been conducted to evaluate the effects of R/FR ratio on plant height by removing the far-red potion by using filters.

Table 2 Effect of different light treatments on the plant growth, flavonoid, triterpenes and antioxidant ability of broccoli sprouts.

| Treatments | Growth | | | |
|---|---|---|---|---|
| | Fresh mass (g) | Plant height (cm) | Root length (cm) | chlorophyll content (mg/g) |
| OLED | 0.68 ± 0.03 | 6.9 ± 0.22 | 8.1± 0.74 | 0.38± 0.02 |
| LEDRGB | 0.62 ± 0.06 | 5.4 ± 0.42 | 6.4± 0.82 | 0.50± 0.02 |
| Significant[1] | n.s. | * | * | * |

[1]n.s.: no significant, *: $P<0.05$

Using traditional fluorescent lamp as light source, the R/FR ratio is quite low, the plant not only elongated but also looks pale (reduction of chlorophyll content). However, no difference was found on fresh mass(Shibuya *et al*., 2010).In this study using OLED as light source has similar results as described above. High percentage of far-red light will lead to elongation of plants and pale on leaves.

No significant differences were found on the concentration of total phenols, anthocyaninand lutein among OLED and LED treatments. However, OLED reduce carotenoids content (Table 3). Anthocyanin is a secondary metabolite, mostly present in the cell vacuole. It is a water-soluble antioxidant. With the accumulation of anthocyanin, petals, leaves, seeds of plants, will rendered as blue orpurple (Takeoka *et al*., 1997). Red leaf lettuce irradiated with UV makes a lot of anthocyanin accumulation and the leaf color turns red. OLED treatments can increase anthocyanin content on red cabbage sprout (unpublished).

Table 3 Effect of different light treatments on the flavonoid, triterpenes and antioxidant ability of broccoli sprouts.

| Treatments | Flavonoid | | Triterpenes | | antioxidant ability |
|---|---|---|---|---|---|
| | total phenols (mg/g) | anthocyanin (mg/g) | carotenoids (mg/g) | lutein (mg/g) | DPPH (%) |
| OLED | 50.15 ± 9.5 | 0.58 ± 0.22 | 2.69 ± 0.20 | 2.51 ± 0.21 | 86 ± 2.0 |
| LEDRGB | 53.41 ± 5.71 | 0.76 ± 0.16 | 3.34 ± 0.19 | 3.06 ± 0.21 | 80 ± 3.0 |
| Significant[1] | n.s. | n.s | * | * | * |

[1]n.s.: no significant, *: $P<0.05$

DPPH, a stable radical, with absorption peak at 510 nm, can be used to quantitatively determine the radical scavenging (RS) capacity of antioxidants. This study showed that the broccoli sprouts produced using OLED as light source can have significantly high DPPH RS capability. Similar result was found on other crop in previous study (unpublished). The mechanism behinds this is still unclear

## 5. CONCLUSIONS

This study demonstrates that OLED can be used to grow broccoli sprout. Compare with LED, OLED treatment increase DPPH radical scavenging capacity are prefer features for healthy diet.

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