Effect of LED Lighting on the Quality of Radish Sprout

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Abstract

Radish sprouts are rich in health-promoting phytochemical constituents. In this study we evaluated the growth and quality of radish sprouts under different light conditions, including red LED, blue LED, white fluorescent and darkness. The experiment was performed at ambient temperature (31±1°C and RH 70±5 %), under controlled light condition (white fluorescent 185 lux, red and blue LEDs 167 lux during 12 h photoperiod) for 8 days. The results showed that the maximum hypocotyl length was observed in harvested radish sprouts grown in the dark. Dark grown sprouts had the lowest amount of chlorophyll content compared with other light conditions. The greatest chlorophyll a, b and total chlorophyll contents were observed with red LED, but with no enhancement of sprout growth. Blue LED lighting promoted the accumulation of ascorbic acid and increased the fresh/dry weight. No significant differences were found in phenolic content among treatments. Applying blue LED lighting for 12 h photoperiod during sprout growth enhanced the growth and nutritional values of radish sprout.

Keywords: ascorbic acid, chlorophyll, growth, LED light

Introduction

Radish (Raphanus sativus) is an important plant that is cultivated throughout Asia. It is grown for its edible root or sprout. Eating the fresh sprouts is the best way of gaining all of the health benefits. Radish sprouts are very rich in health-promoting phytochemical constituents such as glucosinolates, antioxidants, phenolic compounds and ascorbic acid. Light is involved in seed germination, morphogenesis, internode and hypocotyl elongation and plays an important role in sprout development and secondary metabolite production (Samuoliene, 2013). Variations in the type and quality of artificial lighting and irradiance levels can affect the growth and nutrition of plants. Bourget (2008) suggested that the LEDs have become the latest energy efficient light source with several advantages, including low heat production, easily installation and manipulation, small mass and volume, long life and narrow bandwidth. In addition, LEDs can easily assembled to generate the light quality that matches the maximum absorption of chlorophyll and for plant growth (Bouget, 2008). Many researchers have shown that LEDs enhances the growth of buckwheat sprouts (Lee, 2013), tomato transplants (Brazaityte, 2009) and fresh produce such as lettuce (Muneer, 2014). Studies have also shown that modulated light quality from LEDs results in positive effects on eating quality of sprouts from a number of species including lettuce (Muneer, 2014), safflower (Chang, 2013) and buckwheat (Lee, 2013). The objective of this work was to evaluate the growth and quality of radish sprouts grown under different light conditions.

Materials and Methods

Organic radish seed (Raphanus sativus) was obtained from Adams Enterprises Ltd, Thailand. Seeds were washed three times in water prior to being sown in plastic basket (28 cm × 32 cm × 8.5 cm) containing moist coconut coir (fiber), 300 seeds were germinated in four replicates for each treatment. The seeds were planted about 0.5 cm deep and spaced 0.5 cm apart, grown for 8 days at ambient temperature (31±1°C and

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70±5%RH) and watered four times with tap water. Throughout the growing period the seeds were exposed to white fluorescent (daylight - 85 lux), or red or blue LEDs (Lumingrow® - 167 lux) to a 12 h light/12 h dark cycle with 24 h no light as the control. Sprouts were harvested 8 days after planting. The length and shoot and root fresh weight and dry weight of sprouts were measured. Chlorophyll a, b and total chlorophyll contents, vitamin C and phenolic compounds were determined. Completely randomized design (CRD) was used in this study with 4 replications. Statistical analysis was performed by using SAS software to carry out ANOVA, Duncan’s multiple range test (DMRT) was used for mean separation.

Results and Discussion

Growth measurement: The fresh and dry weights of the sprouts was significant different between different light sources. Fresh weight (shoot, root and shoot + root) was increased with LEDs light compared sprouts grown in the dark and under white fluorescent light. The highest fresh weight of radish sprouts was observed when grown under blue LED light compared to other light conditions (Figure 1A). This finding is in agreement with the results obtained for broccoli (Pardo, 2014) with blue being necessary for normal sprout development. The smallest accumulation in fresh weigh occurred in sprout grown in the dark. Seedling morphogenesis and the synthesis of chlorophyll are both dependent on absorption of light (Bougret, 2008). The fresh/dry weight ratio (shoot + root) was greater for radish sprouts grown under white fluorescent light compared to other light conditions (Figure 1B); however the lowest fresh/dry weight ratio was observed in sprouts grown under blue LED light. Blue LED light resulted in higher dry weight production as well as highest fresh weight accumulation than other light conditions. This finding is also in agreement with previous studies with several seedlings including radish. According to Wang et al. (2009), blue and purple LED light lead to higher stomatal conductance in cucumber leaves and photosynthesis intensity when compared to other LEDs light sources. Radish sprout length under all light conditions showed the highest growth rate between day 4 and 6 (Figure 2A). The maximum length was observed when grown in the absence of any light treatment compared to other light conditions. Hypocotyl and internode elongation is one of the features of etiolated growth. Sprout grown under blue LED light showed significantly less etiolation than other light treatments.

Chlorophyll a, b and total chlorophyll content: Lighting environment should provide sufficient photosynthetic photon flux for optimal efficiency for plant photosynthetic processes. Chlorophyll a and b are two major photosynthetic pigments in higher plants. In previous studies, Shin et al. (2008) found that the red LED application led to reduce the chlorophyll content. In our studies the highest chlorophyll a, b and total chlorophyll contents occurred in sprouts grown under red LED light (Figure 2B, 2C and 2D). The chlorophyll content of seedlings grown in the dark was the least of all light conditions. Seedlings require light not only for photosynthesis, but also to initiate photomorphogenesis and chlorophyll synthesis (Shin et al., 2008).

Vitamin C: Red and blue lights produce different morphogenetic and photosynthetic responses in plants associated with different photoreceptors. Red light is absorbed by the phytochromes family of light sensing receptors, whereas blue light is absorbed by cryptochrome and phototropin photoreceptors (Lin, 2012). A specific light quality can be used to increase yield and improve phenolic and vitamin C content of vegetables in commercial production (Lin, 2012). Our results showed that sprouts grown under blue LED light had higher accumulation of vitamin C compared with the other light environments (Figure 2E). This is in agreement with Urbonaviciute (2009) who concluded that blue LED light acting on different photoreceptors normalized metabolism and lead to higher contents of vitamin C.

Phenolic Compounds: The phenolic compounds in the leaves and stalk of radish sprouts did not significantly differ among various light conditions (Figure 2F). This finding is in generally agreement with the findings of Hossen (2007) with buckwheat sprouts. Sprouts grown under blue LED light had about 11% higher content of
phenolic compounds than sprouts grown under red LED light. Blue LEDs can also increase the accumulation of some nutritional substances (Lin, 2012), and this effects may be dependent upon plant species and cultivars.

Figure 1 Effect of different light conditions on fresh weight (A) and FW/DW ratio (B) of radish sprouts. Different letters indicate significant differences ($P < 0.05$).

Figure 2 Effect of different light conditions on shoot length (A), total chlorophyll (B), chlorophyll a (C), chlorophyll b (D), ascorbic acid (E), phenolic compounds (F) in radish sprouts. Different letters indicate significant differences ($P < 0.05$).
Summary
Radish sprouts growth and nutritional value can be varied by selecting different light growth environments. Red LED lights improved the chlorophyll content in radish sprouts with no impact on growth. Blue LEDs as a light source enhanced both growth and nutritional quality when applied at 167 lux with a 12 h light/dark cycle during germination and seedling growth.

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Literature cited