Revista Argentina de Clínica Psicológica
2020, Vol. XXIX, N°5, 1630-1634
DOI: 10.24205/03276716.2020.1158

Effects of Blue and Red Light on Carotene Content of Red and White Cabbage without using Substrate

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Abstract

Carotenoids in the cabbage sprouts is the high-valued nutritional components that have many benefits on human health. The content of Carotene depends on many factors such as seed quality, temperature, humidity, and environmental light during germination and development. Carotene content in red and white cabbage sprouts are also different. In this paper, we present the results of cultivating red and white cabbage sprouts without using substrate, with the use of appropriate light, temperature and humidity. The main purpose of Research is to find the optimal conditions of blue and red light to the content of Carotene. The experiment has shown the optimal conditions of light to the content of Carotene. From this result, sprout growers can use to increase the yield and quality of red and white cabbage sprouts using artificial light.

Keywords: Carotene, Blue and Red light, red cabbage sprouts, white cabbage sprouts

1. Introduction

Sprouts are great sources of protein, fiber, and an array of vitamins and minerals, providing the body with the nutrients it needs for most of its functions. There are many benefits of eating sprouts, such as Increase blood supply, help grow hair, adjust the need with hormones, benefit the skin, provide more protein, minerals, vitamins, prevent cancer,

Carotenoids also called tetraterpenoids, are yellow, orange, and red organic pigments that are produced by plants and algae, as well as several bacteria, and fungi [2]. Carotene is a precious nutrient in red cabbage sprouts, Carotene makes fight aging, maintains heart health, gets healthy skin, prevents cancer, boosts the immune system for body, is good for the brain.

We know that, unlike plants, humans cannot synthesize carotenoids but use carotenoids from eating plants to protect themselves. Carotenoids help fight oxidizing agents from outside.

There are over 1,100 known carotenoids [11] which can be further categorized into two classes, xanthophylls (which contain oxygen) and carotenes (which are purely hydrocarbons and contain no oxygen). All are derivatives of tetraterpenes, meaning that they are produced from 8 isoprene molecules and contain 40 carbon atoms. In general, carotenoids absorb at wavelengths ranging from 400 to 550 nanometers (violet to green light). This causes the compounds to be deeply colored yellow, orange, or red.

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There are many precious nutrients such as Vitamin C, K, E, Calcium, Magnesium, and especially Carotene in the cabage sprouts. The carotenoids (beta-carotene/ vitamin A, lutein, zeaxanthin, violaxanthin) are fat soluble antioxidants that are important for organ function and can protect cellular structures from damage. The beta-carotene content of red cabbage shoots is an incredible 260 times that of mature red cabbage leaves! Lutein/zeaxanthin are carotenoids that act to help prevent age-related eye degeneration and cataract, dark leafy green vegetables are recommended sources. Red cabbage shoots contain high amounts of lutein/zeaxanthin. Violaxanthin is a carotenoid found in the photosynthetic organs of plants, and red cabbage shoots are a good source [12,13].

According to S.L. Ellison, in Encyclopedia of Food and Health, 2016 [8]. Carotenoids are synthesized by photosynthetic organisms for light-harvesting and for photo-protection of the pigment-protein light-harvesting complexes and photosynthetic reaction centres in the thylakoid membrane. There are many methods to measure Carotene content, including LC, UV-vis, HPLC, APCI methods. UV-vis is a popular method for Carotene content determination.

Light is the important environmental que to improve the bioactive compounds in plant materials [4]. Light stimulate the enzyme activation and regulate the enzyme synthesize pathways, such as

PAL (phenylalanine ammonia-lyase) activity in phenyl-propanoid pathways, which promote the bioactive compound accumulation in plant [6].

Blue light is more efficiently absorbed by photosynthetic pigments than other spectral regions. Swatz et al. [10] suggested that the effects of green light on plant growth and development are similar to those of blue light. Similar positive effects of blue and green light on plant growth, such as photosynthetic capacity and phytochemical production, have been reported on various plants [1,3].

According to Md Obyedul Kalam Azad et al, Artificial light emitting diode (LED) light are being extensively used in controlled production system in order to improve the plant food quality. Light quality directly influences plant growth and chemical composition; therefore, it can be used as an external stimulus to obtain vegetal material with tailored composition [5]. The effects of LED illumination in sprout cultivation has been investigated in several species, such as Brassica spp. [7], pea, broccoli, mustard, borage, amaranth, kale, beet, parsley [11], and buckwheat [9].

Artificial blue LED light enhance secondary metabolites, such as ascorbate, total phenolic, anthocyanin, flavonoid contents, and antioxidant activity in basil [11].

2. Experimental

Prepare materials and experimenting methods:

Red and white cabbage seeds are prepared for use with properties suitable for germination. All seeds are pre-treated by soaking in warm water at about 40 degrees Celsius for 4-8 hours. The purpose of seed treatment is to eliminate mold, and increase germination of the seed. Depending on the type of seed, the seed is soaked until the seed cracks, or about 2 times increase in volume is most suitable. After the seeds are processed, they are spread evenly onto the inside of the tray (3) in Figure 2 without using substrate.

Red and Blue LEDs are used with a ratio of 30% blue and 70% red and have an average power of 25 W, a photon flux of 32 μmol/s. In the experiment, we use two separate types of blue and red lights to adjust the different blue/red ratio. The the figure 1 below is the light spectrum of the LED lamp with a ratio of Blue and Red is 30/70 (B/R). The Blue and Red Lamp has emission peaks about 460 nm and 660 nm, respectively

The Sprouting rack system is a system that can change the height size to adjust the light flux by varying the lighting distance between the lamp and the sprout. Figure 2 is a cross-section of the sprouting rack system in the experiment. In figure (1) are the Blue and Red LEDs arranged so that the light shines back on the diffuse reflector (3). Diffuse reflective screen (3) has a 5-sided box shape, making to disperse the light source into the sprouting tray (2) more evenly. The experimental lighting arrangement will give sprouts in different locations to be equally illuminated during growth.

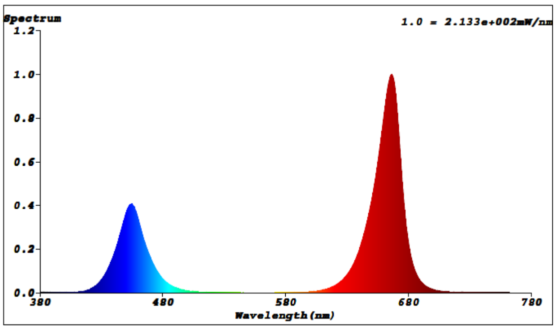

Figure 1. **Electroluminescence spectra of Blue and Red LED Lamp**

The sprouting tray (2) has an open bottom, with a gap size of about 1mm. The gap is both effective to keep the seed, where the roots grow down and create ventilation. In which the bottom of the tray is the part with a small opening to ensure not to let the seeds pass through and have ventilation. The slots of the tray help keep the seedlings stable, the roots can grow naturally. In the Sprouting rack system, the nebulizer head are arranged in such a way that water is provided to the sprouts positions equaly

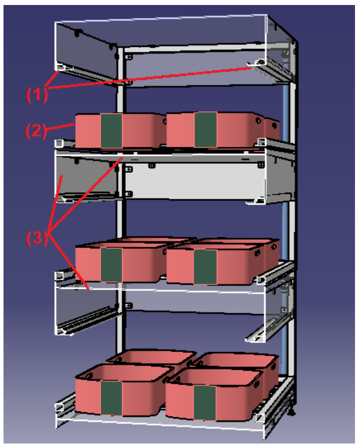

Figure 2. **Cross – Section of Sprouting rack system**

With the experimented sprouting rack structure, the red and white cabbage sprouts had a harvest time or about 7 days. The red and white cabbage sprouts were examined about Carotene content by UV-vis method. Survey results are measured by the

National Institute for food control department of health has been assessed and found to conform with the requirements of ISO / IEC 17025: 2017 for Field or Accreditation Chamical, Biological, Measurement - Calibaration with Accreditation No VILAS 203. Due to the confidentiality and principles of the National Institute for food control department of health, we have only had results in the aggregated results without data results but for each measurement. the National Institute for food control department of health is the most prestigious and quality organization in Vietnam.

3. Result and Discussion

Growth of sprouts depends on many factors such as temperature, humidity, air, light intensity, and ratio of blue and red light (B/R). In the experiment, we have conducted to survey all of the above modes. However, in this article, we present the results of sprouts growing in the conditions of fixed, optimal temperature and humidity and changes in light intensity. Through experiments, we found that the best conditions for red and white cabbage sprouts growing were in the range of 80 % humidity and about 32 degrees Celsius. We have changed in the ratio of light components (B/R) and varying light intensity, or flux at the temperature and humidity of environment are 80 % and 32 degrees Celsius at the experiment. Figure 3 shows the results of absorption spectra test for Carotene content of red cabbage.

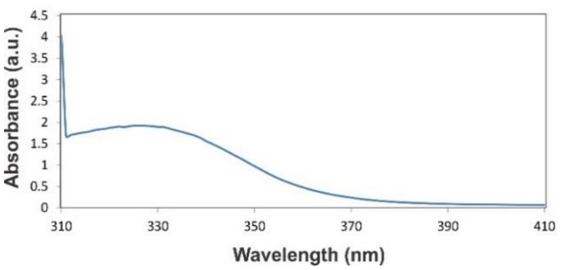

Figure 3. **Absorption spectra of Radish Sprouting**

From the measured samples, we received results on the content of Carotene of red and white cabbage sprouts. Figure 4 shows the results of the Carotene content of red and White cabbage sprouts illuminated with a B/R ratio of 30/70 under different light intensity conditions. The results showed that, under the same experimental conditions, the highest Carotene content was 6.95 mg/100g and 6,15 mg/100g of sprouts at a flux of 30 µmol/s respectively. The results also showed that carotene of red cabbage are about 13 percent higher than white cabbage sprouts at the maximum value. This result is completely reasonable. As discussed above,

Carotenoids also called tetraterpenoids, are yellow, orange, and red organic pigments that are produced by plants. Carotene content was investigated at a flux of 30 µmol/s, because before that, we had investigated and found that at this flux, the Carotene content was the highest. In order to generate the nutritional component of carotene, in addition to the blue light component, many factors such as water, nutrients in the seeds are needed, etc. According to the results, carotene content can be shown Saturation threshold at flux of 30 µmol/s.

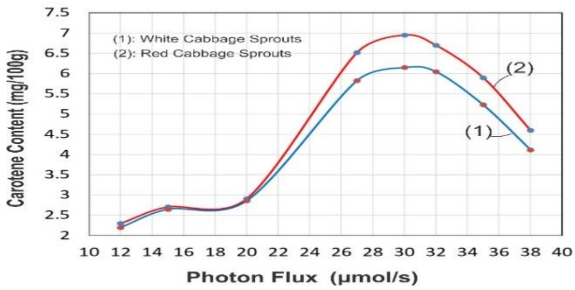

Figure 4. **Carotene Content of Red and White cabbage sprouts according to Photon Flux**

Figure 5 shows the results of the Carotene content of red and white cabbage sprouts with different light ratios at the same photon flux of 27 µmol/s. From the figure, the concentration of Carotene increases rapidly as the ratio of blue light increases, and decreases slowly as the ratio of red light decreases and the highest Carotene content with the ratio of B/R light is 30/70. The above results are completely reasonable because blue light plays a major role in the synthesis of Carotene. When the blue light component increases, the Carotene content will increase rapidly. The ratio 30/70 of B/R is the ratio that helps the carotene content is the highest. When the amount of blue light increases, it means that the photon flux increases by more than 30 µmol/s, at the same time the carotene content is saturated, no further increase.

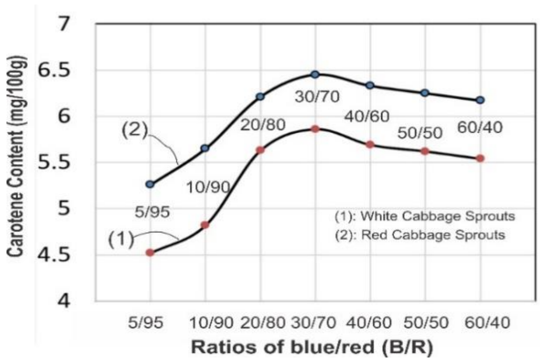

Figure 5. **Carotene Content of red and white cabbage sprouts by Ratios of Blue/Red light**

Figure 6 shows the results of investigating the Carotene content of red and white cabbage sprouts illuminated with a B/R ratio of 30/70 under different lighting cycle conditions. We investigation of three light cycle are 6 hour, 8 hour and 12 hour. The results showed that, under the same experimental conditions, the highest Carotene content was 6,45 mg/100g and 5,86 mg/100g of red and white sprouts at a flux of 32 µmol/s respectively.

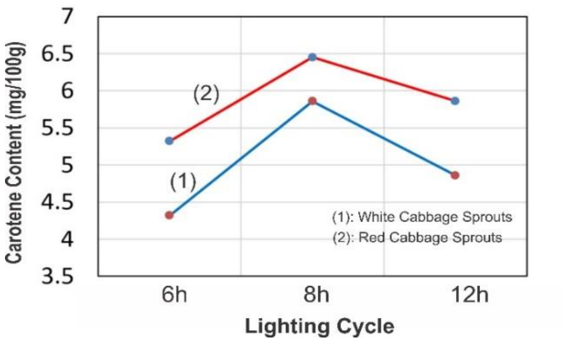

Figure 6. **Carotene content of red and white cabbage sprouts with different lighting cycle**

4. Conslusion

We have experimentally investigated the effects of many factors on the content of red and white cabbage such as temperature, humidity, and light. Although in this article we do not specify the survey process related to temperature, humidity. However, with the temperature and humidity conditions we used are the optimal conditions. We have investigated the Carotene contents of the red and white cabbage sprouts under different lighting conditions at the optimal temperature and humidity conditions, Specifically at the temperature and humidity of environment are 80 % and 32 degrees Celsius. The above results are all average results, of many trials, the results are highly repeatable and reliable. Experiments show that the Carotene content of red cabbage sprouts is higher than white cabbage sprouts and the best Carotene content bolt of two red and white cabbage sprouts, it should use blue and red light at the ratio of 30 blue/70 red and the photon flux of 32 µmol/s.

5. Acknowledgement

This research is funded by Graduate University of Science and Technology under grant number GUST.STS.ĐT2017-ST01.

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