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LIGHT-EMITTING DIODES (LED'S) IN THE CULTIVATION OF CABBAGE MICROGREEN

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Abstract: Microgreens are edible plants formed from vegetable seeds, herbs or grains, with a tender and immature appearance, presenting the first pair of definitive leaves. Microgreens are harvested and consumed with a developed stem, non-senescent cotyledonous leaves and a pair of true leaves. The growth and morphology of the plant is strongly influenced by the quality of light. The objective of this work was to evaluate the effect of different types of LEDs on the production of cabbage microgreens. To conduct the work, seeds of red cabbage variety Mammouth Red Rock® were used. They were sown in plastic trays containing Carolina Soil® substrate. The microgreens were grown under the red LEDs, the blue LEDs and the green LEDs. The control treatment consisted of the absence of use of artificial light. The experimental design used was completely randomized with five replications. After 18 days of growing the microgreens, the height of the plants, the number of soluble solids (ºbrix), fresh mass and dry mass were evaluated. The data obtained were subjected to analysis of variance, with the means being statistically compared using the Tukey test at a 5% probability of error. A significant effect of the type of light was obtained for the variables ºbrix, fresh mass and dry mass of microgreens. On the other hand, for the variable height of the plants there was no significant effect of the type of light. For the conditions used in the experiment, the type of light influences the production of red cabbage microgreens variety Mammouth Red Rock®.
Keywords: Quality of light. Nutraceutical. Brasica oleraceae.

INTRODUCTION

Historically, microgreens began to be produced in the late 1980s by American farmer Lee Jones at the request of chef Charlie Trotter. On that occasion, Trotter asked Jones to produce young, soft, resistant and tasty plants for him to decorate his restaurant's dishes. So that he could impress his customers through different colors and a different taste (LATIMES, 2023).

In recent years, the interest of chefs and consumers in microgreens has grown significantly. This increase in demand may be related to several factors, among which we can highlight the possibility of being able to decorate dishes with foods of different colors, texture and flavor. Furthermore, consumers are concerned about eating foods that are functional. In other words, foods that present, in addition to basic nutritional functions, a high content of phytochemicals, vitamins and mineral salts, so that they contribute to reducing the risk of chronic diseases when consumed regularly (KYRIACOU et al., 2021; KOWITCHAROEN, et al., 2021).

According to specialized literature, microgreens have many health benefits. This is because it is considered a functional food and can help reduce the risk of chronic diseases. In general, people who include nutraceutical foods, such as microgreens, regularly in their diet will have a lower chance of being affected by coronary heart disease, type II diabetes and some types of cancer. The lower occurrence of these health problems is related to antioxidants, which are present in the tissues of microgreens and other types of foods (NIVYA et al., 2012).

Among the diseases that affect humans, cancer is the second leading cause of death worldwide. The number of cases is estimated to increase in the coming decades, especially in low- and middle-income countries, such as Brazil. Therefore, there is an urgent need for cost-effective cancer prevention measures. One of the alternatives to be adopted is by increasing the intake of phytochemicals (vitamin C, carotenoids, anthocyanins, among others), present in various types of foods. Among which, we can mention microgreens from species in the Brassicaceae family (KOH et al., 2020; XIAO, et al, 2019).

For the production of microgreens, one of the prerequisites is obtaining high-quality seeds. High-quality seeds are those that have guaranteed genetic and health quality. High quality seeds can be understood as those that present a high level of purity, germination, vigor, and absence of microorganisms, such as fungi and bacteria.

The growing conditions of microgreens influence their production. Light is considered one of the most important environmental factors, as it has a strong influence on plant growth and development, as well as on the synthesis of photosynthetic pigments (KIM et al., 2011). When growing in a controlled environment, artificial light can be used, with LEDs (Light Emitting Diode) being a unique alternative as a light source to be used due to the high efficiency in transforming electrical energy into light energy. According to Nhut et al. (2003), this type of light source could contribute to increasing the productivity of cultivated plants by enabling the supply of a specific wavelength.

Although the first LEDs were developed more than a hundred years ago by Russian researcher Oleg Losev, their use as a source of light for growing plants only occurred in the late 1990s. In part, the use of LEDs as a source of lighting in environments was possible due to technological advances in manufacturing materials, which allowed the creation of a new generation of LEDs capable of emitting high brightness. First generation LEDs emitted little light, so their use was limited to serving as an on and off indicator for electrical/electronic equipment (ZHELUDEV, 2007).

Given this context, the objective of this work was to evaluate the effect of different types of light on the production and quality of red cabbage microgreens.

MATERIAL AND METHODS

This work was conducted at the Department of Agricultural Sciences of ``*Universidade Regional Integrada do Alto Uruguai e das Missões*`` – URI Erechim-RS.

To conduct the experiment, transparent trays made of polystyrene with dimensions of 11 x 11 x 3 cm were used, containing 37 g of commercial Carolina Soil® substrate. In each tray containing substrate previously moistened with water, 500 mg of red cabbage seed, variety Mammouth Red Rock®, were sown. The trays were placed in a dark environment and after emergence, they were transferred to a growth chamber with a photoperiod of 16 hours and light intensity of 25 $\mu mol\ m^{-2}\ s^{-1}$. Throughout the cultivation period, watering was carried out daily with the aid of a pick, in order to meet the water needs of the microgreens.

The treatments used in the production of microgreens consisted of different light sources arranged on the benches, supplied by red LEDs EDER 3LA3 630nm, blue LEDs EDEB-3LA1 470nm, green LEDs 3LA1 530nm, with the control treatment being the absence of artificial light. The trays containing the microgreens were placed at a distance of approximately 60 cm from the light sources arranged on the benches in the growth chamber.

The experimental design used was completely randomized with five replications per treatment, with the experimental unit consisting of a tray. After 18 days of growing the microgreens under different types of light, the height of the plants was evaluated with the aid of a graduated ruler, the soluble solids content (ºbrix), the fresh mass and the dry mass.

To determine the fresh mass, a cut was made in the stem of the plant, with the aid of scissors, approximately 1 cm from the surface of the substrate. The cut plant material was weighed on a digital scale and then placed in a paper bag. Then, the identified plant material was placed in a forced aeration oven at a temperature of 60 °C for 72 hours, until constant weight was obtained.

To determine the °brix, a sample of plant tissue was collected, consisting of completely expanded leaves from the five replications of each light treatment. The collected plant material was wrapped in aluminum foil and taken to the laboratory to be macerated in a crucible with the help of a porcelain rod. After complete maceration of the plant tissue, a few drops were collected with the aid of a pipette to read the °brix on a previously calibrated digital spectrometer.

The data obtained were subjected to analysis of variance, with the means compared using the Tukey test at a level of 5% probability of error using the Saneste statistical program (ZONTA & MACHADO, 1992).

RESULTS AND DISCUSSION

According to the analysis of variance, the type of light used in the production of microgreens had a significant effect on all variables analyzed, except for the variable average plant height. It can be seen that there was no difference in the height of the microgreens grown in the different types of light (Table 1 and Figure 1). The plant height variable presented an average between 9.87 cm (EDER 3LA3 630nm Red LEDs) and 8.09 cm (Control treatment). These values can be considered adequate for the duration of the cultivation period (18 days). However, microgreens plants can reach greater heights. Because, according to the literature, the microgreens harvesting period can be carried out up to 21 days of cultivation.

However, it is not recommended to grow microgreens for periods longer than three weeks due to the possibility of the plants beginning to show yellowish leaves, due to the beginning of plant senescence. This yellowing in microgreens occurs due to the lack of nutrients in the seeds, as the plant grows, and also in the substrate used in cultivation.

Type of light	Plant height (cm)
EDER 3LA3 630nm red LEDs	9,87 a
EDEB-3LA1 470nm blue LEDs	8,71 a
3LA1 530nm green LEDs	8,62 a
Control treatment	8,09 a
CV (%)	13,13

Table 1: Plant height of Mammouth Red Rock® red cabbage microgreens, grown under different types of light, after 18 days of germination.

* Averages followed by the same letter in the column do not differ significantly from each other, at a 5% error probability level.

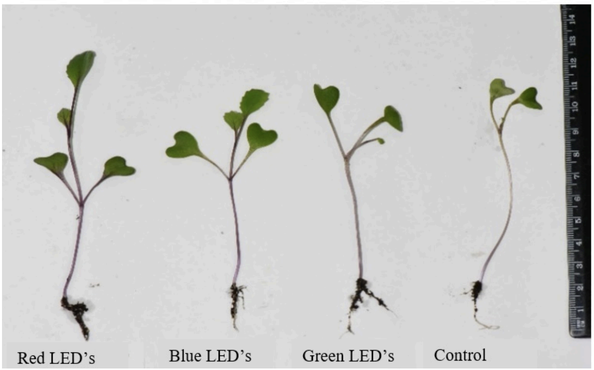

Figure 1: Visual appearance of Mammouth Red Rock® red cabbage microgreens plants, grown under different types of light, after 18 days of germination.

Regarding the variable number of soluble solids, there was a significant effect of the type of light. The highest average (4.13 °brix) was obtained from microgreens grown under EDER 3LA3 630nm red LEDs. The microgreens from cultivation under blue EDEB-3LA1 470nm LEDs were those that reached the second highest average (2.25 °brix) and the

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lowest amount with the microgreens from the control treatment, that is, cultivation without artificial light (Table 2). According to Taiz & Zeiger (2013), photosynthetically active light ranges from 400 to 700 nm. The wavelengths corresponding to red and blue are those where the highest photosynthetic rates occur. According to Allogia et al. (2023), in addition to light having a strong influence on plant morphology, it also has an effect on the synthesis of various compounds, such as phenolic compounds and total soluble solids. According to Bian et al. (2015); Ouzounis et al. (2015), the quality of light has a pronounced effect on the accumulation of phytochemicals in the tissues of cultivated plants, with blue light (420-450 nm) and red light (600-700 nm) considered the most effective wavelengths. of light to determine plant yield.

Type of light	**Soluble solids (ºbrix)**
EDER 3LA3 630nm red LEDs	4,13 a
EDEB-3LA1 470nm blue LEDs	2,25 b
3LA1 530nm green LEDs	1,80 c
Control treatment	1,51 d
CV (%)	3,81

Table 2: Number of soluble solids (ºbrix) in microgreens of red cabbage variety Mammouth Red Rock®, grown under different types of light, after 18 days of germination.

* Means followed by the same letter in the column do not differ significantly at the 5% error probability level using the Tukey test.

The amount of fresh mass produced by microgreens was influenced by the type of light. In table 3, it can be seen that the microgrens grown under the red LEDs EDER 3LA3 630nm (12.85 g) and blue LEDs EDEB-3LA1 470nm (12.53 g) presented a greater amount of fresh mass than those grown in the absence of artificial light/control treatment (9.88 g). On the other hand, there was no statistical difference between the values obtained with microgreens grown with 3LA1 530nm green LEDs (12.07 g) and the control treatment (9.88 g). The results obtained in the present work demonstrate that the production of fresh mass of microgreens can be influenced by the wavelength of light. Considering that microgreens are grown for a short period of time, the use of LEDs in the in-door cooking environment can contribute to increased biomass production (Figure 2).

Type of light	Fresh mass (g)
EDER 3LA3 630nm red LEDs	12,85 a
EDEB-3LA1 470nm blue LEDs	12,53 a
3LA1 530nm green LEDs	12,07 ab
Control treatment	9,88 b
CV (%)	10,57

Table 3: Quantity of fresh mass obtained from microgreens of red cabbage variety Mammouth Red Rock®, grown under different types of light, after 18 days of germination.

* Means followed by the same letter in the column do not differ significantly at the 5% error probability level using the Tukey test.

The results indicate that LEDs can be considered as an alternative light source for indoor cultivation and this is also due to their advantageous characteristics over other light sources. According to Yeh & Chung (2009) and Nhut & Nam (2010), LEDs have high efficiency in generating light with low heat emission, absence of toxic substances such as mercury, small volume and mass with a long useful life, which can reach up to 100,000 hours.

Figure 2: Visual appearance of the amount of fresh mass (a) of red cabbage microgreens variety Mammouth Red Rock®, grown under the red LEDs (b), after 18 days of germination.

In relation to the amount of dry mass, the microgreens grown under the EDER 3LA3 630nm red LEDs (3.11 g) presented a greater quantity than the microgreens grown under the control treatment (2.78 g), however, when comparing the results obtained with the different types of LEDs, there was no statistical difference between them.

Type of light	Dry mass (g)
EDER 3LA3 630nm red LEDs	3,11 a
EDEB-3LA1 470nm blue LEDs	2,98 ab
3LA1 530nm green LEDs	2,99 ab
Control treatment	2,78 b
CV (%)	4,16

Table 3: Quantity of dry mass obtained from microgreens of red cabbage variety Mammouth Red Rock®, grown under different types of light, after 18 days of germination.

* Means followed by the same letter in the column do not differ significantly at the 5% error probability level using the Tukey test.

CONCLUSIONS

For the conditions under which the experiment was conducted, it can be concluded:

- The production of Mammouth Red Rock® red cabbage microgreens are influenced by the type of light;

- The number of soluble solids (ºbrix) is strongly influenced by the type of light, with the red EDER 3LA3 630nm LEDs being considered the most suitable;

- The use of LEDs in the cultivation of microgreens can be considered a viable alternative to optimize their production and quality.

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