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Functional Lentil Sprouts Produced under Different Led Light Wavelengths Conditions

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ABSTRACT

Advances in innovative agricultural technology could allow to satisfice the production of fresh foods. The use of light emitting diodes (LEDs) indoor farming production could, modify biological responses increasing the functional value of vegetable food like lentil sprouts, offering higher antioxidants content and to promote the bioavailability of their nutrients. Lentil growth under blue, violet, green, orange and red light in a dark growing chamber. As internal and external controls, seeds were germinated under white and natural (outdoor) light. Morphological, physiological and biochemical variables were evaluated. Green light enlarged the sprouts stem, reduced the biomass and the concentration of chlorophyll. Violet and white lights increased the protein concentration. Blue wavelength increased the seeds germination, concentration of β-carotenes, phenolic compounds and the antioxidant activity. The experimental evidence suggest blue LED light could be useful to produce functional lentil sprouts with a high nutritional value.

Key words: Antioxidants, Functional sprouts, LED light, *Lens culinaris.*

The demand for high-quality fresh vegetables and the growing interest of society in the ecological impacts, merge in the need of sustainable production, high nutritional food and obtaining therapeutic active molecules (Djahida and Houcine, 2021; Nguyen and Saleh, 2019). In this context, regular consumption of lentils could be enriching the human diet and in order to improve the nutritive value of lentils, growing techniques (including sprouting) have been developed to significantly raise the bioavailability of their nutrients (Gharachorloo *et al.,* 2012).

The use of light emitting diodes (LEDs) shows sustainable advantages (Hernandez-Velasco and Mattsson, 2019). LEDs can be customized, enhancing productivity (He *et al.,* 2019) and raise functional and nutritious characteristics. In several plants blue and red light affect morphogenesis processes like opening of stomata, chlorophyll synthesis, elongation of stem, seed germination and induction to floration among the others (Lin *et al.,* 2021).

During germination of sprouts, macromolecules are transformed into smaller molecules, increase the digestibility and phytochemistry regular consumption of lentils could be prevent or reduce the development of chronic diseases In order to improve the nutritive value of lentils. The aim of this study was to evaluate the production of functional lentil sprouts produced in indoor farming under different LED light wavelengths.

Plant material and experimental conditions

The present investigation was carried out during 2020 at *Campus* Irapuato, Guanajuato University. Lentil seeds of Guanajuato cultivar were soaked in 500 mL with 0.07% sodium hypochlorite for 10 min and then washed with distilled water twice to neutral pH. The hydrated seeds were germinated in paper trays and covered with transparent plastic, germinated at 25°C under blue, violet, green, orange, red at 150 (±10) lx in a dark chamber specially designed for this experiment. As light source panels of 1,645 cm^2 with 882 LED SMD5050 RGB with control of light intensity were used. As internal and external controls, groups of seeds were geminated under white and natural (outdoor) light, respectively. Seeds were germinated for 7 days under a photoperiod of 12:12 h. The germination (GE, %) was determined as the percentage of normal seeds. The lengths of the stem (SL, cm) and root (RL, cm) were measured. The biomass (BM, mg) was recorded after drying the plants at 90°C overnight. The relative water content (RWC, %) was determined according to Ruiz-Nieto *et al.* (2015). The protein (PT, mg mL^{-1}) content was evaluated using the protocol described by Bradford (1976).

Proline (PL, μg mL^{-1}) was determined using the method described by Bates (1973) measured at 517 nm. β carotene

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(BCT, μg mL^{-1}) was determined according to (Karnjanawipagul *et al.,* 2010) at 461 nm. Phenolic compounds (PHC) (μg mL^{-1} gallic acid). was performed according to (Zin *et al.,* 2006) The Antioxidant activity were determined according to Martínez-Cruz and Paredes-Lopez (2014). and ABTS according to (Kuskoski *et al.,* 2005), Chlorophyll a, b and total (mg mL^{-1}) were determined according to Dudek *et al.,* (2014) and the equations reported by Lichtenthaler (1987) and Lichtenthaler and Buschmann (2001). The data were analyzed using a completely randomized design with five replications, ($p<0.05$) using the statistical software Minitab® 16.2.3 (trial version).

Recent studies have proven that the phytochromes modulate endogenous levels of gibberellin (GA) and abscisic acid (ABA), light has an essential role in this physiological process (Seo *et al.,* 2009). In our results, highly significant differences ($p<0.01$) were identified in GE. In accordance with Tufail *et al.* (2020) GA3 promote the number of leaves and leaf area in plants. In other species like lettuce and buckwheat the green and red wavelengths stimulate the germination (Zhang *et al.,* 2020; Hayashi *et al.,* 2008).

The SL was strongly affected by white light decreasing 55.81%, green light shows an increase of 31% related the natural light, this could be due skotomorphogenesis which is the evolutionary mechanisms of adaptation to the darkness of plants. In accordance with Setyaningrum *et al.* (2020) light intensity affected the fresh weight of plants proportionally. Green light generated stems 2.7 cm longer than natural light and limited the growth as biomass formation (BM, $p<0.05$). Our results in blue light, are according to Kaydan and Yagmur (2008) which mention that the seedlings with longer root length have more water uptake abilities resulting in a higher RWC.

Table 1: Determined variable in response to light treatments in lentil sprout.

Variable	Blue	Violet	Green	Orange	Red	White	Natural
GE**	78.3a	63.3ab	67.7ab	66.3ab	53.3bc	39.0c	73.7ab
SL**	8.9b	6.4c	11.3a	10.4a	8.0b	3.8d	8.6b
RL**	8.6a	5.0cd	4.3d	5.9c	2.9e	2.5e	7.5b
BM*	211ab	213ab	199b	225a	215ab	230a	216ab
RWC*	77.7a	68.7b	73.3ab	68.4ab	73.3ab	68.5ab	76.2ab
PT**	21.5d	23.3a	22.3b	22.2bc	21.9bc	23,2a	22.3cd
PL**	62.8b	65.1a	62.3b	62.8b	62.3b	66.0a	61.7b
BCT**	252a	217c	222c	229b	223bc	204d	218c
PHC**	670ab	620c	610c	691a	626bc	681a	492d
DPPH**	53.2f	73.3d	80.6a	75.9bc	77.7b	65.8e	74.5cd
ABTS**	7.4g	32.6f	59.2a	51.3c	47.1d	45.5e	54.7b

Germination rate (GE, %), Stem length (SL, cm), Root length (RL, cm), Biomass (BM, mg), Relative, water content (RWC, %), Protein (PT, mg gdw^{-1}), Proline (PL, μg mL^{-1}), β-carotene (BCT, μg mL^{-1}), Phenolic compounds (PHC, μg mL^{-1} gallic acid), Antioxidant activity by DPPH (DPPH, %) and ABTS (ABTS, %). Values with the same lowercase letter within averages rows are statically equal according to Tukey $p<0.05$. Significant differences $p<0.05$ (*), highly significant differences $p<0.01$ (**).

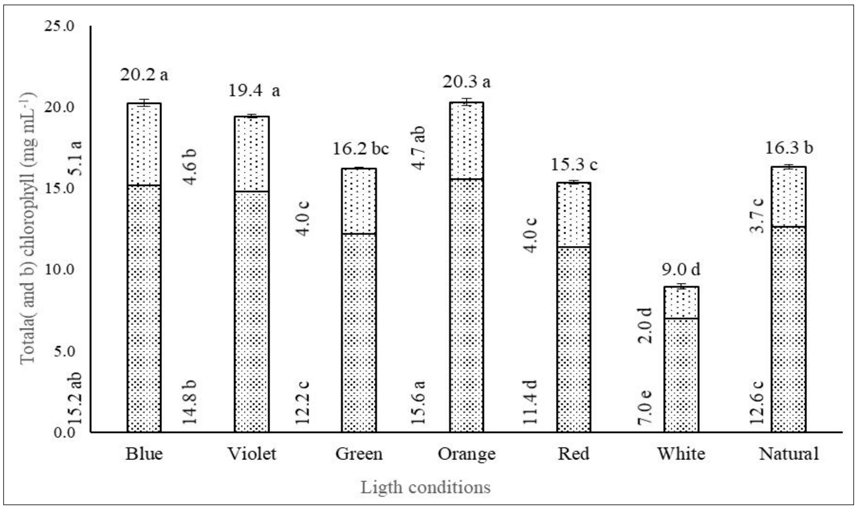

Fig 1: Concentration of total**, a** and b** chlorophyll (mg mL^{-1}) under light treatments in lentil seedlings. The chlorophyll a and b correspond to ▒ and ░ of the bar. Values with the same lowercase letter within for each variable are statically equal according to Tukey $p<0.05$. Significant differences $p<0.05$ (*), highly significant differences $p<0.01$ (**).

The higher concentrations of protein were determined with white and violet light with 23.3 and 23.2 mg gdw^{-1} ($p<0.01$) respectively, being the violet light a mix of red and blue wavelength, red and blue light are the two major types of light driving photosynthate biosynthesis (Bian *et al.,* 2015). Evidence suggests a close relationship between the metabolism of ROS and proline as part of the antioxidant response of plants (Rejeb *et al.,* 2014), although the excessive production of ROS in plants cause damage to protein, lipids, carbohydrates and DNA (Govindaraj *et al*., 2017). Under blue light, lentil sprouts show higher concentrations of β carotene (252 μg mL^{-1} gallic acid, $p<0.01$) and phenolic compounds (670 μg mL^{-1} gallic acid, $p<0.01$), as well as the highest antioxidant activity DPPH (53.2%, $p<0.01$) and ABTS (7.4%, $p<0.01$) (Table 1). Regard chlorophyll, the higher concentration was determined under the treatments of blue, violet and orange light ($p<0.01$). These effects of blue light may be caused by inefficient energy transfer from the carotenoids to the chlorophylls (Loreto *et al.,* 2009). Chlorophyll a and b are the major light harvesting pigments and sensitive to the wavelengths (Dutta *et al*., 2017). In our results, despite of the changes in the concentration of total chlorophyll, no significant differences were identified ($p>0.05$) in the proportions of chlorophyll a and b with an average of 76.0 and 24.0 % respectively (Fig 1).

CONCLUSION

The generation of sprouts with both high antioxidant and nutrition value in indoor faming conditions, through the precise management of blue light without a significant affecting of their growth and physiological state. The indoor farming sprouts might be produced in order to obtains nutritious food and or increase healthy eating habits. Despite of the obtained results, further studies are required to evaluate different intensities of blue light, photoperiods, legumes species and cultivars.

Conflict of interest: None.

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