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LED-enhanced dietary and organoleptic qualities in postharvest tomato fruit

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ABSTRACT

Tomato fruit possess high lycopene concentrations, which increases after reaching the breaker stage of ripeness. Light emitting diode (LED) systems have emerged as a clean and efficient artificial lighting technique for use in horticulture. The objective of this research was to examine the effect of LEDs on postharvest and lycopene quality parameters. The effects on quality parameters were significantly different depending on the tomato fruit cultivar. The commercial and organoleptic quality parameters most affected were firmness and titratable acidity. The lycopene concentration in all tomato cultivars increased between 30% and 60% when they were exposed to LED light compared with dark-exposed fruit. One hour of LED light exposure per day during the postharvest phase of fruit increased commercial and organoleptic parameters, and increased the lycopene concentration. Fruit exposed to LED light with a high red:far red (R:FR) light ratio had increased firmness compared with those exposed to other types of white LED light. The highest R:FR ratio used in this study resulted in fruit with higher titratable acidity than those exposed to lower R:FR ratios. Overall, the results of this study demonstrated that the postharvest exposure of tomato fruit to LED light with a high R:FR ratio induces lycopene synthesis, with lycopene concentrations being 41% higher in comparison with exposure to darkness and 24% higher in comparison with exposure to other LED lighting conditions.

1. Introduction

Interest in food and human health has increased, especially in terms of the consumption of added-value vegetables containing anti-carcinogens such as antioxidants, carotenoids and vitamins (Dhandevi and Rajesh, 2015). Carotenoids are an important part of the human diet (Krinsky and Johnson, 2005), as they provide resources for the formation of vitamin A. As such, carotenoids are an essential component and precursor of volatiles in plants (Vogel et al., 2010). In addition to their antioxidant function, carotenoids provide the tomato fruit with its distinctive colour and contribute to its nutritional quality (Shao et al., 2015). Furthermore, epidemiological studies have shown that the consumption of foods rich in lycopene help prevent cardiovascular diseases (Müller et al., 2016) and several types of cancer (Giovannucci, 1999; Sandmann et al., 2006; Ford and Erdman, 2012).

The tomato (*Solanum lycopersicum* L.) is a climacteric fruit and continues to ripen after harvest. During ripening, chlorophylls are degraded, while carotenoids are synthesized (Liu et al., 2009). Lycopene concentrations, the primary antioxidant in tomatoes, increase after reaching the breaker stage of ripeness (Liu et al., 2009) or when changing maturation states (defined by the USDA (2005) ripeness scale) during its ripening process (Davies and Hobson, 1981). This phenomenon indicates light will have a significant effect on the synthesis of lycopene. The development of tomato antioxidants depends on genetic and environmental factors and their stage of ripeness (Javanmardi and Kubota, 2006).

Light plays a role in the evolution of the colour of tomatoes after harvest as it affects the metabolism of pathways involved in biosynthesis of pigments. Particularities of the light spectrum affect the pigments synthesized, which play a decisive role on the shelf lives of tomatoes. For example, the relationship between red light and blue light has a significant effect on the pigmentation of tomatoes (Azari et al., 2010; Toledo-Ortiz et al., 2010; Li et al., 2013). Current postharvest work (Moya et al., 2017) consists of three basic objectives related to market acceptance, which include maintaining the following factors: 1) high commercial quality of the fruit (firmness, size and colour); 2) high nutritional quality (lycopene, ascorbic acid, antioxidant activity and total phenol content); and 3) desirable organoleptic properties

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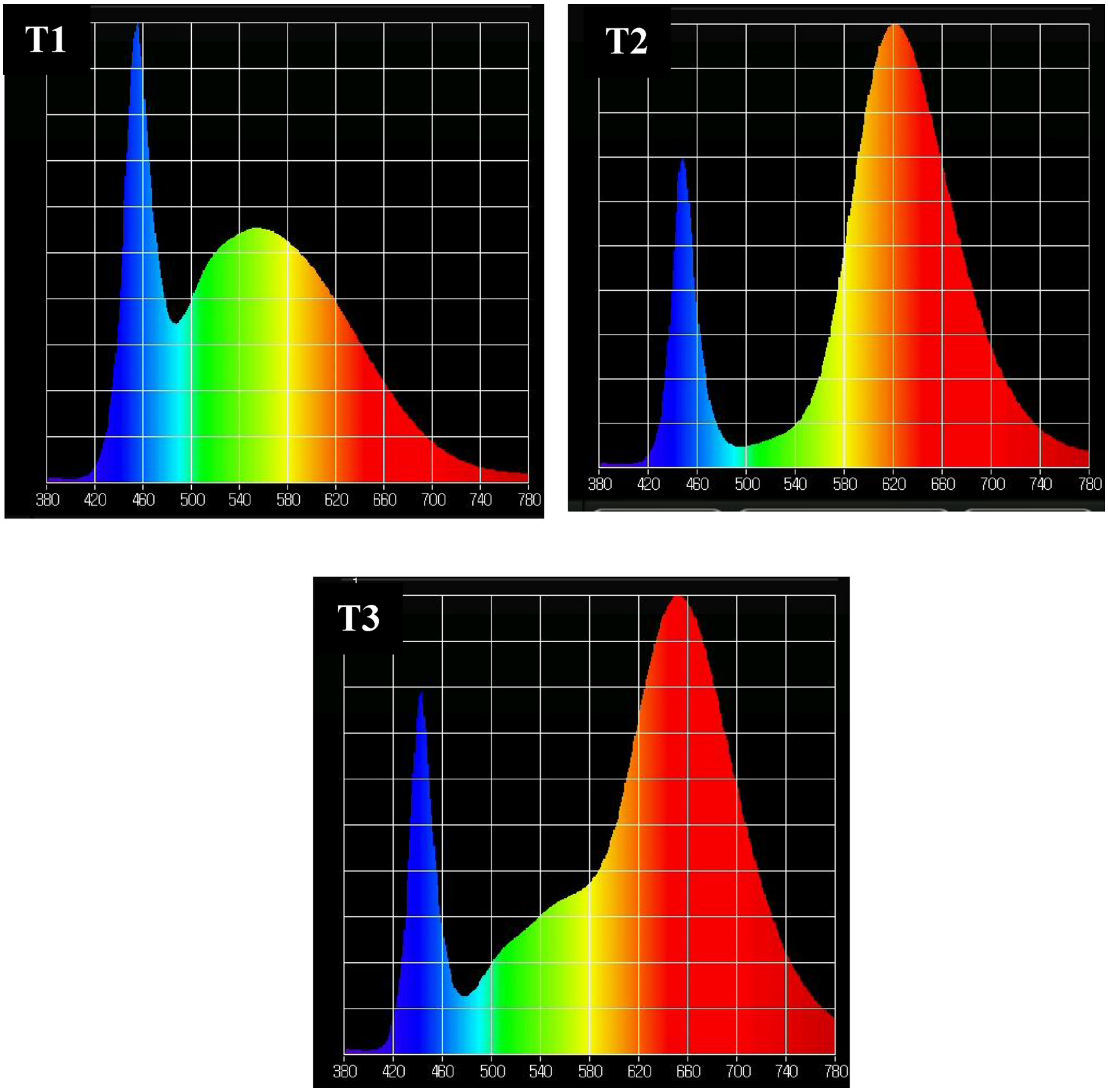

Fig. 1. LED light spectra. T1 = L18 T8 Roblan®, T2 = L18 AP67 Valoya® and T3 = L18 AP673 L Valoya®.

(titratable acidity, pH, electrical conductivity and total soluble solids). Achieving these objectives includes optimizing temperature, relative humidity, oxygen and carbon dioxide concentrations and, in some cases, ethylene concentrations (Kader and Rolle, 2004; D'Souza et al., 2015).

Postharvest studies are usually performed in the dark, where lycopene continues to increase because of the presence of phytochromes in the pericarp of tomatoes (Alba et al., 2000; Demotes-Mainard et al., 2016) and cryptochromes (Giliberto et al., 2005). The storage temperature of the fruit is another important factor (Toledo-Ortiz et al., 2010). Toor and Savage (2006) obtained a threefold higher lycopene content in fruit stored at a temperature range of 15 °C–25 °C than those stored at 7 °C, a temperature commonly used for tomato.

Toledo-Ortiz et al. (2010), and Toor and Savage (2006), have found that light (Naoya et al., 2008) and temperature affect lycopene synthesis in addition to other postharvest quality parameters, including colour, soluble solids, titratable acidity and texture. Therefore, designing an efficient system of artificial growth to feed a constantly growing population while simultaneously meeting the food demands of having high nutritional quality that provides health benefits is possible (Darko et al., 2014).

The integration of light emitting diodes (LEDs) in horticultural lighting systems has increased over the last decade (Morrow, 2008; Urrestarazu et al., 2016). Unlike other conventional lighting systems, LEDs are being developed with technology that allows for the design of specific spectra, direction and light intensity (Massa et al., 2008). LEDs are also being developed as components of lighting systems that exhibit an energy efficiency ratio that is associated with increased plant growth (Toledo-Ortiz et al., 2010; Urrestarazu et al., 2016; Massa et al., 2008; Ouzounis et al., 2015).

Information concerning the effects of the use of LED lamps on certain aspects of horticulture, especially on the influence of the LED spectrum on the development of anticancer nutritional quality (Urrestarazu et al., 2016) is limited. The objective of this work was to evaluate the light spectra of three different types of LED lamps on the organoleptic, commercial and dietary qualities of tomato fruit during the postharvest stage of six cultivars.

2. Materials and methods

2.1. Plant materials and growth conditions

The experiment was conducted at the University of Almería. Tomato fruit (*Solanum lycopersicum* L.) from six different tomato cultivars were used and are denoted as follows: A = Redondo cv. Pasadena, B = Pera cv. Fangora, C = Rama cv. Fahara, D = Cherry cv. Bronco, E = Cherry