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Effect of Light-Emitting Diodes (LEDs) on Accelerating/Delaying Ripening in Postharvest Life Fruits and Vegetables

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SUMMARY

Ripening is the most obvious phenomenon that determines the shelf life of fresh produce during the postharvest period. Light is also a predominant parameter affecting the ripening of fruits and vegetables? Light accelerate or postpone the maturation/ripening of fruits and vegetables by controlling the amount of ethylene production. LEDs influence the rapid ripening of plant species by respiration and ethylene output amplification. LEDs have the potential to regulate senescence which lead to ripening, and thereby improving fruit quality and nutritional attributes of fruits and vegetables. The potential of LEDs to extend the storage life of horticultural crops is advancing. More of LEDs effects on accelerating/delaying ripening in postharvest fruits and vegetables are described in this article.

INTRODUCTION

LEDs are in solid-state (i.e., semiconductor-based) system that converts electrical energy to electromagnetic radiation usually in the infrared or visible regimes (Rodyoung *et al.*, 2016), and seldomly in ultraviolet regimes. The LEDs consists a semiconductor with a p-n (positive-negative) junction, inclusive of p-type (positive-doped) semiconductor on the right and n-type (negative doped) semiconductor on the left. A depletion region, described because of the barrier between p-type and n-type regions that avoid the movement of electrons from n-type and holes from p-type semiconductors, is created because of diffusion currents. The depletion region generally left with positive and negative charged ions. Electrons and holes (being the absence of particles) recombine spontaneously whilst an ahead bias (*i.e.*, applied electric field) forces them to engage within the depletion region. This recombination process produces light (as photons) in a spontaneous emission process, defining the method of the LEDs. A phenomenon concerned withinside the operation of LEDs is electroluminescence, which is a non-thermal method of emitting light when the electric current passes via the semiconductor.

LEDs role on accelerating/delaying ripening during postharvest period

Advantageous properties of LEDs include their monochromatic nature, long life, prohibition of thermal degradation, and high photon productivity. All these beneficial characteristics make LED application useful to extend the storage life of fruits and vegetables. The monochromatic nature of LEDs allows for the choice of the wavelength specific emission light spectra favoured for the production, preservation, and storage of fresh horticultural produce. The application of LEDs in postharvest has expanded because of its numerous advantages over conventional/traditional light sources. LEDs have more effective and efficient energy utilization and a prolonged lifespan. LEDs plays a key role in postharvest storage of fresh produce, including its effect on physiological characteristics, secondary metabolism, nutritional characteristics, ripening process, senescence, shelf-life enhancement, and microbial spoilage of fruits and vegetables. LED treatment has promoted the accumulation of various phytochemicals, such as phenolic compounds, vitamins, glucosinolates, chlorophyll, total soluble solids, and carotenoids. Changes in the dietary content, anthocyanin content, antioxidant capacity, and ripening had been found additionally after the treatment. Depletion of microbial spoilage and slowdown in senescence were marked after the LED exposure. As a residue-free physical sterilization and preservation process, light-emitting diode (LED) treatment, has recently been implemented for postharvest storage of fruits and vegetables by numerous researchers.

Ethylene production is triggered by various parameters, including LED light, which can affect the yang cycle of ethylene synthesis (Sanusi *et al.*, 2021). In this metabolic pathway, receptors cause an upgrade or degrade in the expression of auxin-related or photosynthetic genes that interfere in the ripening process (Tadiello *et al.*, 2016). Besides ethylene production, pigment accumulation is another relevant regulatory event related with fruit ripening. An increase in gene expression and corresponding mutations in fruit effected in an intensification of carotenoid and flavonoid concentrations. LED light interface with these gene modifications through light signal transduction and photo-oxidation processes, targeting the entire ripening phase of horticultural crops.

The influence of LED light usually depends on the type of fruits and vegetables, light intensity, wavelength, and treatment parameters. When LED (450 nm) is treated on sweet oranges (*Citrus* × *Sinensis*) for about 3 to 18 days at a fluence rate between 60-630 W m^{-2} at 20 °C resulted in acceleration of ripening process in citrus fruits by increasing the synthesis of ethylene (Ballester and Lafuente 2017). Blue LED (470 nm) is treated on Peaches (*Prunus persica* cv.) for about 15 days of at a fluence rate of 40 W m^{-2} at 10 °C resulted in acceleration ripening process of peaches and increased ethylene synthesis, and it significantly increase gene expression, including lipoxygenase, 1-aminocyclopropane-1-carboxylic acid, ethylene response factors, ethylene sensors, and ethylene receptors, for 15 days at 10 °C (Gong *et al.*, 2015). Satsuma Fruit (*C. unshiu Marc. Aoshimaunshu'*) treated with red LEDs (660 nm) for about 4 days at a fluence rate of 12 W m^{-2} resulted in acceleration of colour in the rind of irradiated fruit compared with those stored in darkness (Ma *et al.*, 2014). Green Tomato (*Solanum Lycopersicum L.*) treated with Red LEDs (665 nm) for about 20 days at a fluence rate of 113 W m^{-2} at 20/ 19 °C, after 20 days of red LED treatment, the content of lycopene, β-carotene, total phenolic content, total flavonoid concentration and antioxidant activity in green tomato showed a significantly increased trend overall compared with non-treated sample (control). However, continuous red light irradiation accelerated the ripening of green tomatoes during the storage period (Panjai *et al.*, 2019). When Blue (470 nm) LEDs is treated on Strawberry (*Fragaria ananassa*) for about 12 days at 5 °C at a fluence rate of 40 W m^{-2} resulted in increase of development of red colour, total antioxidant activity, and antioxidant enzyme activity compared with control for 12 days at 5 °C (Xu *et al.*, 2014a, 2014b). Many studies suggested the use of LED sources increased the ripening process of fruits and vegetable during storage, which aid in enhancing the storage life and quality of fresh produce for consumers.

CONCLUSION

The application of LEDs at specific wavelengths and fluence rates is an effective approach for regulating the processes of ripening and is also used to speed up or slow down the ripening process during the postharvest stage. Finally the influence of other LEDs of different wavelengths and fluence rates should be investigated on other climacteric fruits and equated with the impact of secondary ripening in fruits and vegetables.

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