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Influence of Postharvest Red LED Light on Bioactive Compound Accumulation in Tomato Fruits

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INTRODUCTION & AIM

Light-emitting diode (LED) systems have emerged as a promising and sustainable technology with significant biotechnological applications in horticulture. Numerous studies have highlighted their use in greenhouse farming and food safety. This study aimed to investigate the influence of red LED lights on the postharvest accumulation of bioactive compounds in tomato (Solanum lycopersicum) fruits and the impact of maturity stage on this process. Tomato fruits harvested at the Breaker and Pink stages were exposed to daily cycles (12 hours) of red light for 14 days, followed by 7 days of dark storage. The results revealed changes in color parameters (a* and a*/b*) in Breaker fruits, with lycopene levels increasing by 52% and 53% in both Breaker and Pink stage fruits, respectively by the end of the storage period. No significant differences were observed in firmness, soluble solids, and titratable acidity parameters. Additionally, the expression levels of genes involved in the biosynthetic pathways of lycopene, vitamins C and E, and folate were analyzed using qPCR assays. The SlGGP1 and SlHPPD1 genes, which regulate vitamin C and E biosynthesis, respectively, showed changes in relative expression in Breaker stage tomatoes stored in the dark. The SlPSY1 gene, involved in lycopene biosynthesis, exhibited altered expression only in Breaker stage tomatoes after 14 days of treatment. The SlGCHI gene, a regulator of folate biosynthesis, increased its relative expression in both Breaker and Pink stages during the treatment. These findings suggest that the Breaker stage is particularly suitable for red light treatments, as it results in significant increases in lycopene levels while maintaining the organoleptic quality traits of tomato fruits

METHOD

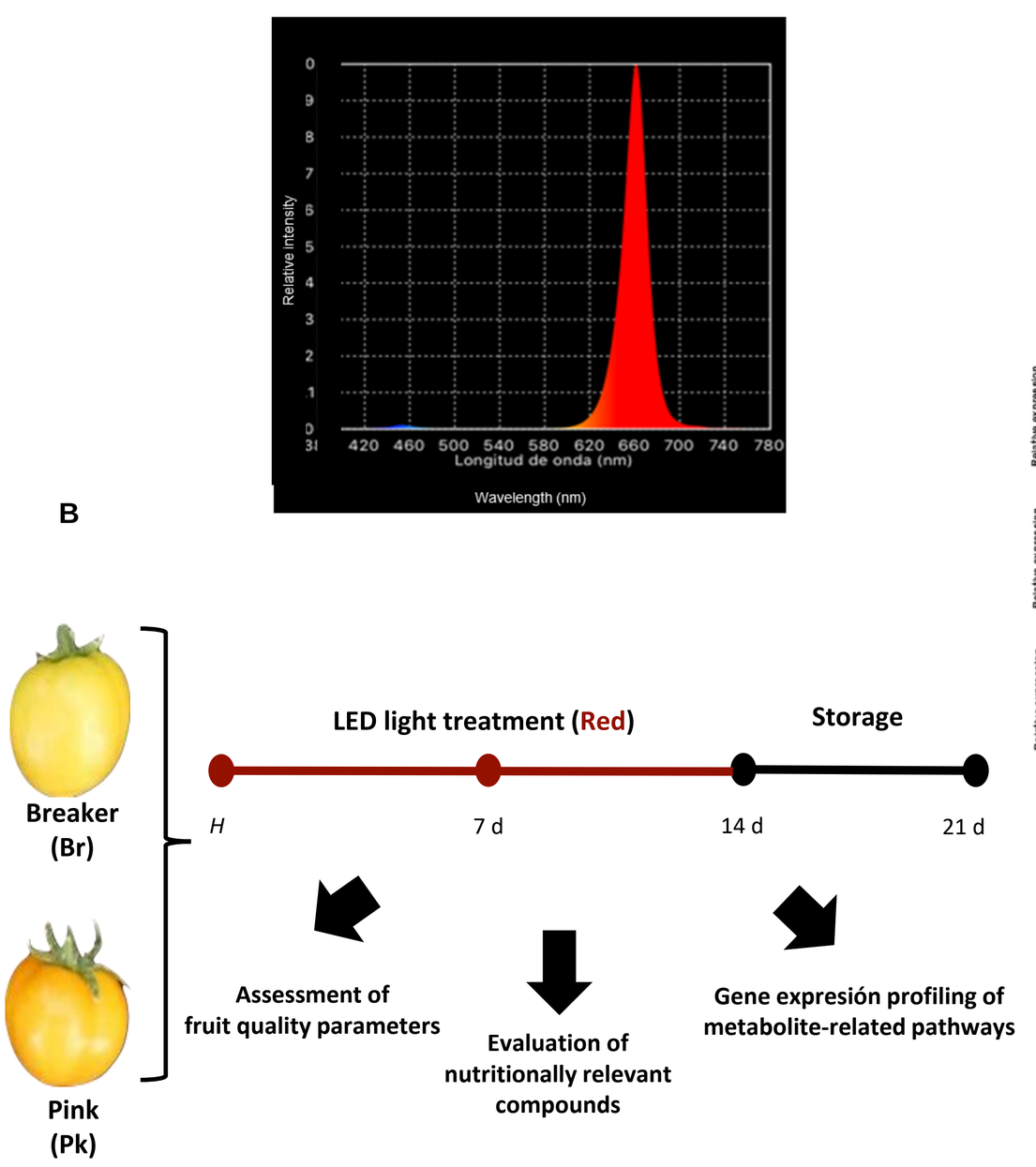

Figure 1. Experimental design for LED lighting spectral quality treatments on *S. lycopersicum* cv. cerasiforme. *A*. Wavelength profile of LED lights used for treatments to cherry tomatoes at different developmental stages. ***B*.** Cherry tomatoes were exposed to darkness (Control) vs to cyclic irradiation (12 h light:12 h darkness) of Red-LED light for 14 days and then stored in darkness for 7 days. Treated and control fruits were sampled at each time.

RESULTS & DISCUSSION

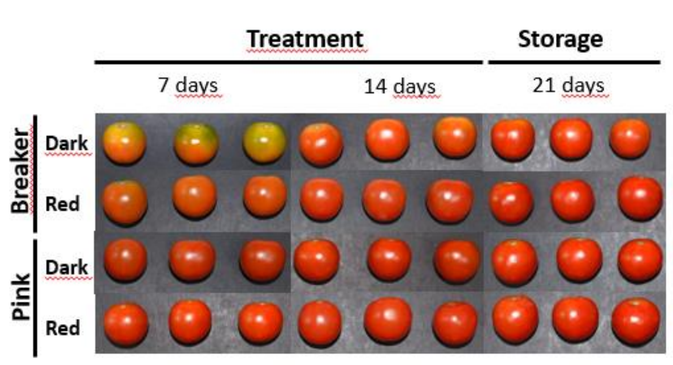

Figure 2. Representative phenotype of cherry tomato fruits exposed to different LED light wavelength regimes. This figure shows representative tomatoes before and after red or control 14-day treatment and after 7 days of storage at 20 °C in darkness. Intensity was adjusted to 100 µmol·m^{2}·s^{-1} and daily monitored by a spectroradiometer.

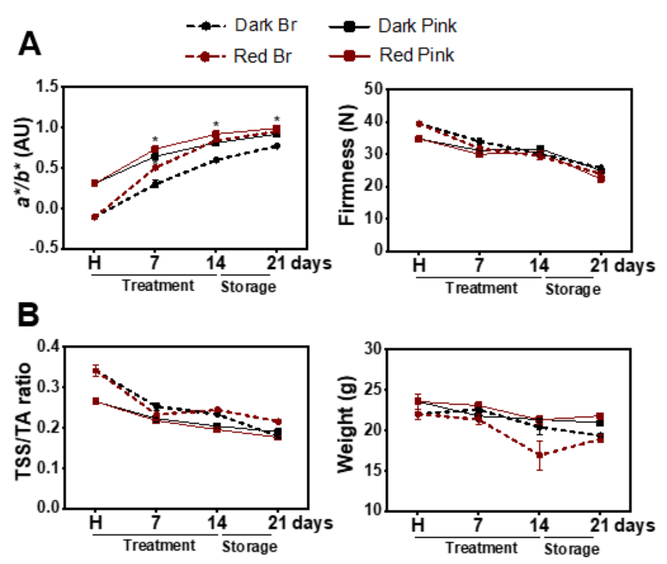

Figure 3. Evaluation of fruit quality traits in cherry tomato fruits exposed to lighting treatment. Skin color expressed as *a*/b** (***A***), Firmness (***B***), TSS/TA ratio (***C***) and fruit weight (***D***) were determined in fruits 7 and 14 days after treatment and after 7 days of storage at 20 °C. Results are shown as mean ± SD for three biological replicates. Asterisks represent significant differences (n=45, ANOVA, p<0.05,*; 0.01,**; 0.001,***).

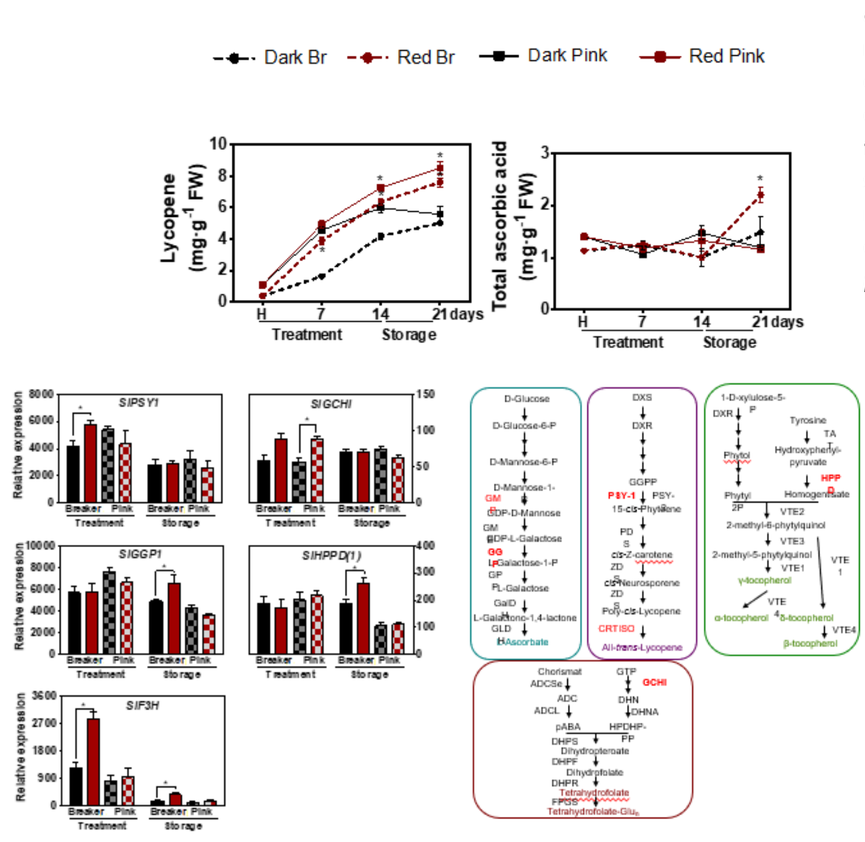

Figure 4. Evaluation of bioactive compounds in cherry tomato fruits exposed to different wavelength regimes. Lycopene and total ascorbic acid determined by spectrophotometric quantitative methods in fruits during treatment and storage period. Results are shown as mean ± SD for three biological replicates. Asterisks represent significant differences (n=3, Mann-Whitney *U-test*, p<0.05,*; 0.01,**; 0.001,***).

Figure 5. RT-qPCR analysis of genes related to bioactive compounds in cherry tomato fruits exposed to different spectral quality treatments. Transcript level of key genes related to biosynthesis of ascorbic acid, lycopene, folate and vitamin E after during treatment and storage. Results are shown as a mean relative expression value of treated fruits compared to control and normalized to *SlPP2acs*. Additionally, diagrams shown in represent simplified versions of plant biosynthetic pathways of each metabolite evaluated by qRT-PCR through key genes (in red). Asterisks indicate significant differences (n = 3, Mann-Whitney *U-test*, p<0.05,*; 0.01,**; 0.001,***).

CONCLUSION

- Red lighting modifies skin color without compromising firmness, fruit weight and TSS/TA ratio.
- Treatment with red LED light enhances lycopene and ascorbic acid, correlating with gene expression profiles.
- Gene induction after red treatment are mostly transient, suggesting that changes induced by red light are not maintained during storage in darkness.
- These findings suggest that the Breaker stage is particularly suitable for red light treatments, as it results in significant increases in lycopene levels while maintaining the organoleptic quality traits of tomato fruits

FUTURE WORK / REFERENCES

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