



## Data Article

# Color biogenesis data of tomatoes treated with hot-water and high temperature ethylene treatments

Francisco E. Loayza<sup>a</sup>, Jeffrey K. Brecht<sup>a,\*</sup>, Amarat H. Simonne<sup>b</sup>, Anne Plotto<sup>c</sup>, Elizabeth A. Baldwin<sup>c</sup>, Jinhe Bai<sup>c</sup>, Elena Lon-Kan<sup>a</sup>

<sup>a</sup> Horticultural Sciences Department, University of Florida, Gainesville, FL 32611-0690, United States

<sup>b</sup> Family, Youth and Community Sciences Department, University of Florida, Gainesville, FL 32611-0310, United States

<sup>c</sup> U.S. Horticultural Research Laboratory, USDA ARS, Fort Pierce, FL 34945, United States

## ARTICLE INFO

*Article history:*

Received 25 January 2021

Revised 20 April 2021

Accepted 28 April 2021

Available online 8 May 2021

*Keywords:*

Tomato

Ripening

Color

Visual appearance

## ABSTRACT

Controlled postharvest stresses were used to induce the synthesis of carotenoids in tomato fruit. The accumulation of carotenoids was observed by the change of color of the tomato fruit from green to red. This change of color was monitored by the  $a^*$  value and hue of the CIELAB\* color coordinates in which the  $a^*$  value increased following a sigmoidal curve and hue decreased in a similar trend. This sigmoidal curve marked the transition from chloroplasts to chromoplasts; in other words, the change of color tracked the disorganization or degreening, which was simultaneously accompanied by chromoplast biogenesis or red color development when tomatoes were at the Turning stage of development. The color data and photographic images provides information on how heat stress affected the synchronicity of chloroplast disorganization and chromoplast biogenesis in the early developmental stages of tomato ripening.

© 2021 The Author(s). Published by Elsevier Inc.

This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

DOI of original article: [10.1016/j.postharvbio.2020.111314](https://doi.org/10.1016/j.postharvbio.2020.111314)

\* Corresponding author.

E-mail address: [jkbrecht@ufl.edu](mailto:jkbrecht@ufl.edu) (J.K. Brecht).

<https://doi.org/10.1016/j.dib.2021.107123>

2352-3409/© 2021 The Author(s). Published by Elsevier Inc. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>)

## Specification Table

Subject	Horticulture
Specific subject area	Postharvest physiology of fresh fruit
Type of data	Table Graph Figure
How data were acquired	Colorimeter and DLSR camera
Data format	Raw and Analyzed
Parameters for data collection	The color data was collected using the CIELAB* coordinates (L*, a* and hue). The a* value and hue tracked the transition of color from green to red during tomato ripening. The changed of color was also monitored using unprocessed JPG pictures.
Description of data collection	Data showed the change of color
Data source location	Institution: University of Florida City/Town/Region: Quincy/ Florida, Gainesville/Florida Country: United States
Data accessibility	Available with the article
Related research article	E.E. Loayza, J.K. Brecht, A.H. Simonne, A. Plotto, E.A. Baldwin, J. Bai, and E. Lon-Kan, Synergy between hot water treatment and high temperature ethylene treatment in promoting antioxidants in mature-green tomatoes, <i>Postharvest Biol Technol</i> , 170, 111,314. doi: <a href="https://doi.org/10.1016/j.postharvbio.2020.111314">https://doi.org/10.1016/j.postharvbio.2020.111314</a>

## Value of the Data

- The data provides a description of the color and visual appearance changes of tomatoes that were treated with hot water immersion and high temperature ethylene treatment allowing the study of color biogenesis at early stages of ripening.
- The data facilitate the construction of sorting color charts and visual appearance guides to packers, distributors and retailers in order to correctly assess early developmental ripeness stages of heat stressed tomatoes.
- Our data will serve scientists studying chromoplast biogenesis to enhance or to delay different aspects of color formation in tomatoes by applying a controlled heat stress.

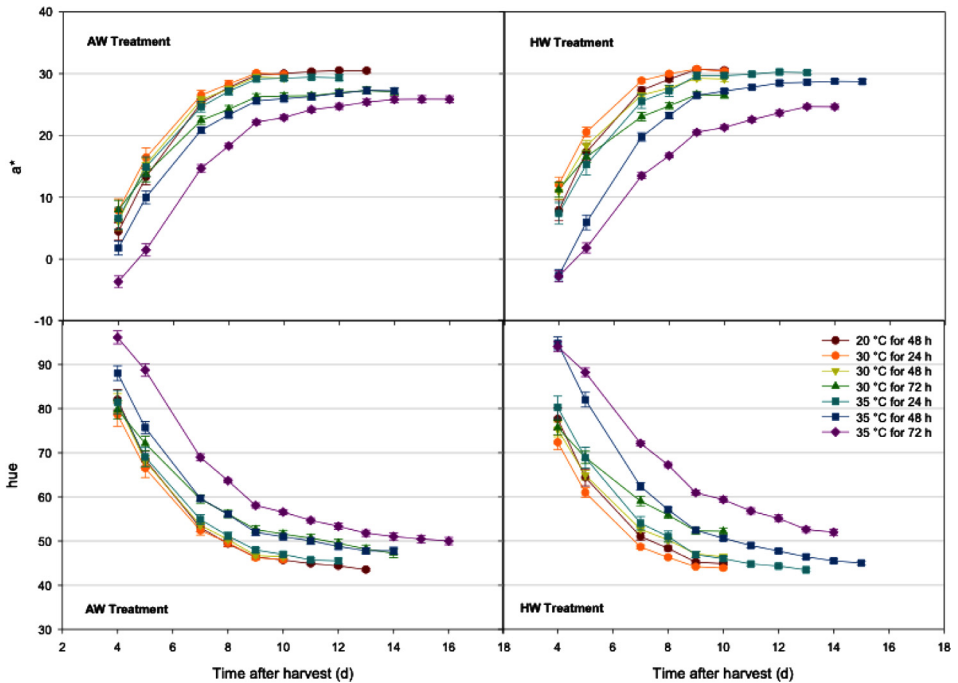
## 1. Data Description

The hot-water (HW) treatment stimulated ripening of tomatoes (10 d to full red color) compared to ambient-water (AW) treated fruit (13 d) when exposed to standard ethylene ripening conditions (20 °C for 48 h) (Table 1). The HW-treated and AW-treated tomatoes expressed typical color development from Turning (mostly green with 10–30% red) to Red (100% red color)

**Table 1**

Time after harvest to reach full ripeness for AW-treated and HW-treated tomatoes exposed to high temperature ethylene treatment in spring 2010.

High temperature ethylene treatment	Water immersion treatment	
	25 °C for 5 min	52 °C for 5 min
20 °C for 48 h	13	10
30 °C for 24 h	10	10
30 °C for 48 h	10	10
30 °C for 72 h	14	10
35 °C for 24 h	12	13
35 °C for 48 h	14	15
35 °C for 72 h	16	14



**Fig. 1.** Color development in terms of  $a^*$  and hue values of AW-treated and HW-treated tomatoes exposed to high temperature ethylene treatment in spring 2010.

ripeness stages (Fig. 1). However, exposure to ethylene at high temperature produced changes in the time to reach full red color and in the pattern of color development. Images of the ripening tomato fruit can be viewed in Loayza et al. [4]. For example, during the first 4 d of ripening we observed a pronounced degreening without red color development for AW-treated and HW-treated tomatoes exposed to ethylene at 30 °C for 48 h such that fruit at the Turning stage were mostly yellow; this was followed by rapid formation of red color when those fruit were transferred to 20 °C for further ripening. The degreening was even more evident in AW-treated tomatoes exposed to ethylene at 30 °C for 72 h or 35 °C for 72 h as well as AW-treated and HW-treated fruit exposed to 35 °C for 48 h, which were mostly pale yellow on Day 4. Although tomatoes from those treatments subsequently slowly developed red color (Fig. 1), it took a longer time for them to reach full ripeness compared to the control treatment (Table 1). The change of color during ripening of tomatoes was evaluated using the L,  $a^*$ ,  $b^*$ , hue (h), and chroma ( $C^*$ ) which was collected and presented in the supplementary files: “BHN-602 Spring 2010 – Color Biogenesis.csv” for season 2010 and “BHN-601 Spring 2012 – Color Biogenesis.csv” for season 2012 (<https://data.mendeley.com/datasets/vkkw8gsvdg/2>). The change of color was evaluated daily after the application of the heat treatment until fruit reached full ripeness according to Brecht et al. [1].

It is widely accepted that the biogenesis of chromoplasts occurs simultaneously with chloroplast disorganization in tomatoes [2]. However, our observations indicate that degreening (chloroplast disorganization) and red color development (carotenoid accumulation in chromoplasts) were independent processes. Generally, the process of degreening was promoted by long exposure to ethylene at high temperature while the accumulation of carotenoids was delayed. These processes were evidenced after tomatoes were transferred to a ripening conducive temperature (i.e., 20 °C).

## 2. Experimental Design, Materials and Methods

### 2.1. Plant material

Tomatoes, commercial variety 'BHN-602', were obtained from a packinghouse in Quincy, FL in the spring season of 2010 (June). The tomatoes were harvested at the Mature-green (MG) stage of development [8] and kept at 20 °C. The tomato size grade was Large according to the grade standards, between 6.35–7.06 cm diameter [6].

### 2.2. Experimental procedure of postharvest treatments

In preparation for the HW treatment, the tomatoes were grouped into batches of 60 fruit. Each batch of fruit was immersed in either 52 °C water for 5 min (HW) or in 25 °C water for 5 min (AW) as an ambient water temperature control treatment. The HW treatment was shown previously to be effective in inducing increased color development and antioxidant accumulation in tomatoes [3]. The HW treatment system used (Model HWH-2, Gaffney Eng., Gainesville, Fla.) was a modified version of the apparatus for HW insect quarantine method development described by Sharp [7].

Following the AW and HW immersion treatments, the tomatoes were air dried at room temperature (24 – 25 °C). The batches of HW-treated and control MG tomatoes were then placed in closed chambers and exposed to 100  $\mu\text{L L}^{-1}$  ethylene in a flow-through system at 20 °C for 48 h (standard ethylene treatment), or at 30 °C for 24, 48 or 72 h, or 35 °C for 24, 48 or 72 h. Ethylene treatment durations and temperatures were previously evaluated by Loayza et al. [5]. The control treatment was defined as AW-treated tomatoes exposed to ethylene at 20 °C for 48 h. Tomatoes that did not show any sign of color change at the conclusion of the ethylene treatment were discarded as having been immature rather than MG at harvest, and each batch was reduced to 30 fruit. Subsequently, the tomatoes were transferred to a 20 °C storage room, where they were held until ripe.

### 2.3. Color

Color was evaluated during ripening by the CIE ( $L^*$ ,  $a^*$ ,  $b^*$ ) values measured at the blossom end with a Minolta chromameter (CR-400, Minolta, Tokyo, Japan), avoiding the blossom end scar, if present [3]. In addition, the color of the tomatoes after ripening was evaluated by hue and chroma.  $L^*$  represents the lightness from 0 (black) to 100 (white);  $a^*$  represents green (negative values) to red (positive values); and  $b^*$  represents blue (negative values) to yellow (positive values). Hue represents the shade of color as an angle from 0 to 360° and was calculated from the  $a^*$  and  $b^*$  values as  $\tan^{-1}(b^*/a^*)$ . Chroma represents the purity of a given hue and was calculated from the  $a^*$  and  $b^*$  values as  $[a^* + b^*]^{1/2}$  with higher numbers representing increasingly pure color and lower numbers trending toward gray.

### 2.4. Time to reach full ripeness

The ripeness was evaluated by the CIE ( $L^*$ ,  $a^*$ ,  $b^*$ ) color space measured at the blossom end with a Minolta chromameter (CR-400, Minolta, Tokyo, Japan), avoiding the blossom end scar, if present. The chromameter has an 8-mm aperture and was set for 2-degree Standard Observer angle and CIE standard illuminant  $D_{65}$  (daylight); it was calibrated using a CR-A43 white calibration plate. When the average  $a^*$  value of a set of 30 tomato fruit ceased to increase from one day to the next, the tomatoes were determined to be fully ripe [1]. At the fully ripe stage, each set of tomatoes was immediately sampled for analysis.

## 2.5. Image acquisition

Tomatoes on a grading table were illuminated using  $0.61 \times 1.22$  m light fixtures placed 1 m above the surface, each containing two F40D, 40-watt, 2400-lumen, 5000 °K full spectrum sun-light fluorescent tubes, one F40B, 40-watt, 2350-lumen, 20,000 °K blue fluorescent tube, and eight, 60-watt, 800-lumen, 3000 °K daylight incandescent bulbs to simulate full spectrum diffuse northern sunlight. Then images of the fruit were taken using a DLSR camera (Lumix DMC-FZ10K, Panasonic Corp., Newark, NJ, USA) with the standard F2.8 Leica DC VARIO-ELMARIT lens. The camera was set using 1/125 s for shutter speed, f 3.3 for aperture, 400 for ISO, 7.0 mm for focal length, Auto WB and Auto focus. Images were recorded as JPEG.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have, or could be perceived to have, influenced the work reported in this article.

## Acknowledgments

The authors acknowledge the support of the [Cooperative State Research, Education, and Extension Service](#), U.S. Department of Agriculture, under Agreement No. 2008–35503–18666, in conducting this research.

## Supplementary Materials

Supplementary material associated with this article can be found in the online version at doi:[10.1016/j.dib.2021.107123](https://doi.org/10.1016/j.dib.2021.107123).

## References

- [1] J.K. Brecht, A.Z. Tulio, K. Cherukuri, M.C.N. Nunes, A.H. Simonne, Cultivar variability in response to tomato fruit lycopene synthesis and antioxidant potential to brief potharvest heat stress, *Acta Hort.* 877 (2009) 1205–1213, doi:[10.17660/ActaHortic.2010.877.164](https://doi.org/10.17660/ActaHortic.2010.877.164).
- [2] L. Li, H. Yuan, Chromoplast biogenesis and carotenoid accumulation, *Arch. Biochem. Biophys.* 539 (2013) 102–109, doi:[10.1016/j.abb.2013.07.002](https://doi.org/10.1016/j.abb.2013.07.002).
- [3] F.E. Loayza, J.K. Brecht, A.H. Simonne, A. Plotto, E.A. Baldwin, J. Bai, E. Lon-Kan, Enhancement of the antioxidant capacity of ripe tomatoes by the application of a hot water treatment at the mature-green stage, *Postharvest Biol. Technol.* 161 (2020) 111054, doi:[10.1016/j.postharvbio.2019.111054](https://doi.org/10.1016/j.postharvbio.2019.111054).
- [4] F.E. Loayza, J.K. Brecht, A.H. Simonne, A. Plotto, E.A. Baldwin, J. Bai, E. Lon-Kan, Synergy between hot water treatment and high temperature ethylene treatment in promoting antioxidants in mature-green tomatoes, *Postharvest Biol. Technol.* 170 (2020) 111314, doi:[10.1016/j.postharvbio.2020.111314](https://doi.org/10.1016/j.postharvbio.2020.111314).
- [5] F.E. Loayza, M.T. Masarirambi, J.K. Brecht, S.A. Sargent, C.A. Sims, Physiological response of mature green tomatoes to treatment with ethylene at high Temperature, *Hort Technol.* 773 (2020) *Hortte* 30, doi:[10.21273/horttech04668-20](https://doi.org/10.21273/horttech04668-20).
- [6] In S.A. Sargent, C.L. Moretti, Tomato, in: K.C. Gross, C.Y. Wang, M. Saltveit (Eds.), *The Commercial Storage of Fruits, Vegetables, and Florist and Nursery Stocks*, U.S. Department of Agriculture, Agricultural Research Service, Washington, DC, USA, 2016, pp. 581–587.
- [7] J.L. Sharp, Hot-water Immersion appliance for quarantine research, *J. Econ. Entomol.* 82 (1989) 189–192, doi:[10.1093/jee/82.1.189](https://doi.org/10.1093/jee/82.1.189).
- [8] U.S. Department of Agriculture, in: *United States Standards For Grades of Fresh Tomatoes*, USDA, Agricultural Marketing Service, 1991, p. 13. Washington, DC, USA.