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RESEARCH ARTICLE

Difference in volatile profile between pericarp tissue and locular gel in tomato fruit

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Abstract

Aroma, a complex mixture of volatile compounds, plays an important role in the perception and acceptability of tomato products by consumers. Numerous studies have reported volatile profiles in tomatoes based on measurement of the whole fruit or pericarp tissue, however, little is understood regarding the volatile compositions in the inner tissues. The objective of this study was to investigate the differences in volatile profile between pericarp tissue and locular gel in tomato fruit. Based on HS-SPME-GC-MS analysis, totally 42 volatile compounds were detected in FL 47 and Tasti-Lee tomato fruits. Regardless of cultivars, a substantial higher concentration of total volatile compounds was observed in pericarp than that in locular gel, associated with higher levels of aldehydes, hydrocarbons, and nitrogen compounds. Pericarp tissue possessed higher levels of *cis*-3-hexenal, hexanal, heptanal, octanal, nonanal, cymene, terpinolene, undecane, dodecane, 2-phenylethanol, 6-methyl-5-hepten-2-one, 2-methylbutyl acetate, 1-nitro-pentane, and 1-nitro-2-phenylethane, while the abundances of 2-methylpropanal, butanal, 2-methylbutanal, 2-methyl-2-butenal, 2-methylpropanol, 3-methylbutanol, 2-methylbutanol, and 2-butanone were higher in locular gel. Principal component analysis (PCA) and cluster analysis using GC-MS and electronic nose (E-nose) data discriminated the two tissues.

Keywords: *Solanum lycopersicum*, tomato fruit, volatile profile, pericarp, locular gel

1. Introduction

Tomato (*Solanum lycopersicum* L.) fruit is consisted of different tissues, including pericarp, septa, columella, placenta, seeds and locular gel according to van de Poel *et al.* (2014) (Fig. 1). Numerous studies have reported volatile profiles in tomatoes based on measurement of the whole fruit or pericarp tissue (Maul *et al.* 2000; Bai *et al.* 2011; Baldwin *et al.* 2011b; Wang *et al.* 2015a, b). Furthermore, the usage of pericarp for physiological/biochemical analysis has the advantage in uniform sample preparation (Maul and Sargent 1998; Moretti *et al.* 1998).

However, information on the volatile profile in other tissues such as locular gel is not well known. Previously, Maul and Sargent (1998) reported that Solimar tomato pericarp (including columnella) produced an average 219% concentration of the 16 volatile compounds quantified by gas chromatography (GC) when compared to locular gel (442 and 203 μL L^{-1}, respectively); meanwhile, the abundances of

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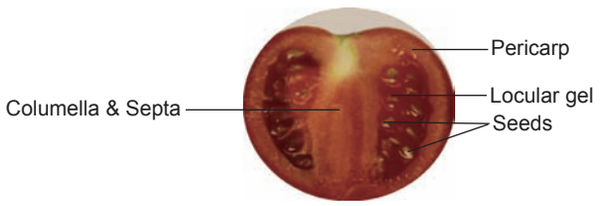

Fig. 1 Schematic cross-section of a tomato fruit showing two locules and the different tissues according to van de Poel *et al.* (2014).

methanol, ethanol, 1-penten-3-one, *cis*-3-hexenal, hexanal, *trans*-2-hexenal, *trans*-2-heptenal, *cis*-3-hexenol, 6-methyl-5-hepten-2-one, and geranyl acetone were higher in pericarp, while locular gel possessed high levels of acetaldehyde, acetone, and β-ionone (Maul and Sargent 1998). Recently, 3-methylbutanal and 2-methylbutanal were proposed by Klee (2010) to be the important contributors to tomato aroma, it is needed to determine the concentrations of these volatiles in the different tissues; also, only one variety used for study could not represent the situation in other cultivars.

The objective of this study was to investigate the difference in volatile profile between pericarp and locular gel in tomato fruits. Two major Florida cultivars, FL 47 and Tasti-Lee, at full-ripe stage were used for the research. The results will provide researchers and general public a tool to evaluate and compare volatile data by different sampling methods.

2. Materials and methods

2.1. Plant materials

Uniform and defect-free FL 47 and Tasti-Lee tomato fruits at full-ripe stage (red color on entire fruit surface) (USDA 1997), 20 fruits per cultivar, with average a^* value of 17.57 and 20.61, respectively, were purchased from a local grocery store on Feb 14, 2015. CIELAB was used for determining the color coordinates by using a colorimeter (model CR-300, Minolta, Tokyo, Japan). The instrument was calibrated using a white tile and color a^* values were recorded where the positive a^* value indicates red color while the negative a^* value represents green color. Fifteen fruits per cultivar were then selected and further divided into five biological replicates with three fruits per replicate.

For sampling, pericarp and locular gel including seeds, were taken with a sharp stainless steel knife, immersed in liquid N_2, fractured, and then stored at –80°C until analyzed. Other inner tissues were discarded.

2.2. Volatile analysis

Volatile analysis was conducted by headspace, solid phase micro-extraction, and gas chromatography-mass spectrometry system (HS-SPME-GC-MS), following the method of Wang *et al.* (2015c). Frozen pericarp tissue was ground to powder under liquid nitrogen and 4.3 g of powder, together with 1.7 mL of saturated $CaCl_2$ solution were transferred to a 20-mL vial and sealed with Teflon-lined septa. For headspace analysis, the homogenized samples were incubated for 30 min at 40°C in a incubator, then they were exposed to the headspace for another 30 min at 40° after 2-cm SPME fiber (50/30 μm DVB/Carboxen/PDMS; Supelco, Bellefonte, PA) was inserted into the vial. After exposure, the SPME fiber was inserted into the injector of a GC-MS (Model 6890, Agilent, Santa Clara, CA) to desorb the extract for 15 min at 250°C. The GC-MS equipment and settings were: DB-5 (60 m length, 0.25 mm i.d., 1.00 μm film thickness; J&W Scientific, Folsom, CA) columns, coupled with a 5973 N MS detector (Agilent). The column oven was programmed to increase at 4°C min^{-1} from the initial 40 to 230°C, then ramped up at 100°C min^{-1} to 260°C and held for 11.70 min for a total run time of 60 min. Helium was used as carrier gas at flow rate of 1.5 mL min^{-1}. Inlet, ionizing source and transfer line were kept at 250, 230, and 280°C, respectively. Mass units were monitored from 30 to 250 m/z and ionized at 70 eV. Data were collected using the ChemStation G1701 AA data system (Hewlett-Packard, Palo Alto, CA). A mixture of C-5 to C-18 *n*-alkanes was run at the beginning of each day to calculate retention indices (RIs). Volatile compounds were identified by comparison of their mass spectra with library entries (NIST/EPA/NIH Mass Spectral Library, ver. 2.0d; National Institute of Standards and Technology, Gaithersburg, MA), as well as by comparing RI with authentic standard aroma compounds purchased from Sigma-Aldrich (St. Louis, MO) or Fluka Chemical Corporation (Buchs, Switzerland).

Quantification was conducted by using a peak size *vs*. concentration curve built by serially diluted five point standard solutions (Baldwin *et al.* 2009). Briefly, a standard compound was dissolved in pure methanol and the mixture was then introduced into a deodorized tomato homogenate. The range of concentrations in the standard curve for each compound covers the concentrations found in the samples.

2.3. Headspace electronic nose analysis

Headspace electronic nose (E-nose) analysis was conducted according to the method of Wang *et al.* (2015b). For sample preparation, 2.15 g frozen pericarp tissue ground to powder under liquid nitrogen, together with 0.85 mL of saturated $CaCl_2$ solution were transferred to a 10-mL vial and sealed with Teflon-lined septa before analysis.

For E-nose analysis, a FOX 4000 system (Alpha MOS, Toulouse, France) was used, fitted with 18 metal oxide gas sensors (LY2/LG, LY2/G, LY2/AA, LY2/GH, LY2/gCTI, LY2/