Lycopene and Total Phenolic Content in Fresh and Processed High-Pigment and Ordinary Tomato Fruits

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Abstract

Recently increasing interest is being given to local tomato genotypes and landraces for their adaptation to the ongoing climatic changes. In this context, we report a comparison between the content of lycopene and total phenolics in red ripe raw tomatoes and the processed paste of two high-pigment (HLT-F81 and HLT-F82) and an ordinary (Rio Grande) tomato landrace. High-pigment tomato berries exhibited 1.82-2.37-fold higher lycopene and their processed paste exhibited also 1.70-2.10-fold higher lycopene respectively compared to the fresh berries and sauce obtained from Rio Grande. Concerning total phenolic content, high-pigment tomato berries exhibited 1.6-2.32-fold higher total phenolic content and their processed paste exhibited also 1.82-2.71-fold higher total phenolic content respective compared to the fresh berries and sauce obtained from Rio Grande. We noticed that the stability of both lycopene and total phenolic content was not affected by processing to produce tomato paste. Such results highlight the hopeful use of new high pigment lines to obtain high nutritional value products with improved beneficial effects on human health

Key Words: *Tomato, high-pigment, kandraces, lycopene, processed tomatoes*

Introduction

Tomatoes are known for their health benefits, primarily due to high carotenoid content. This study evaluates lycopene and total phenolics content in high pigment tomato and a traditional cultivar. Recognizing these variations can guide consumer decisions and improve dietary guidelines. Recent years have seen a significant rise in awareness and interest in tomato landraces and heirloom cultivars, reflected in growing publications and research globally (Corrado et al., 2014, Sacco et al., 2014, Fullana-Pericàs et al., 2019, Scarano et al., 2020, Villena et al., 2023, Negri et al., 2003, Caramante et al., 2023, Landi et al., 2023, Donso et al., 2023, Egea et al., 2023, Arias et al., 2003, Laayouni et al., 2022, 2023). This trend is driven by farmers valuing low-input and water needs of local varieties, and consumers appreciating traditional taste and health benefits (Landi et al., 2023, Egea et al., 2023). Landraces are vital repositories of genetic diversity, with unique characteristics like stress tolerance and superior taste compared to common cultivars. The local germplasm is a crucial source of desirable traits for new cultivars adapted to rapidly changing climate (Corrado et al., 2014).

Considerable differences have been noted among tomato landraces and heirlooms regarding yield, physicochemical properties, disease resistance, and particularly fruit quality. Research on older genotypes and heirlooms indicates some landraces possess higher soluble solid content and superior functional quality compared to commercial hybrids, while achieving comparable yields, especially relevant given current climate shifts (Bonilla-Barrientos et al., 2014, Ilahy et al., 2011a Ilahy et al., 2011b ,Ladewig et al., 2021; Laayouni et al., 2022, 2023). Tomato landraces have also demonstrated adaptability to various new farming systems, including aridoculture (Fullana-Pericàs et al., 2019), low-input methods (Tagiakas et al., 2022) and urban agriculture (Tihanyi et al., 2022). Although the above reported informations, data about processed products quality from such landraces and traditional tomato cultivars is really scarce. Consequently, the objective of this study was to assess the lycopene and phenolic content in fresh tomato berries and processed paste prepared from 2 high-pigment lines and one traditional tomato cultivar widely appreciated in Tunisia.

Materials and Methods

Three determinate open-pollinated cultivars were used, including two high-pigment tomato lines: 'HLT–F81', homozygous with light-responsive hp mutations hp-2dg, and 'HLT–F82', with an UHLY mutation, both selected by the National Agricultural Research Institute of Tunisia for their high-phytochemical profiles. These lines resulted from a breeding program aimed at enhancing tomato nutritional quality. One local cultivars 'Rio Grande', considered genetic resource in Tunisia, was also used. Ancient genotypes are disappearing, grown only in small areas. 'Rio Grande' was among the most cultivated in Tunisia for decades. The trials were conducted under open-field conditions during the 2021 and 2022 seasons at the National Agricultural Research Institute of Tunisia in Ariana, northern Tunisia (36°50′39″ N 10°11′30″ E), with a Mediterranean climate. In 2021 and 2022, temperatures ranged 10–25 °C and 11–27 °C, relative humidity 55–89% and 51–87%, and rainfall 1.2–56.8 mm and 0–33.8 mm, respectively. Sowing used a clay–loamy substrate with a pH of 7.72, EC of 0.19 mS/cm, and suitable mineral and organic composition. Transplanting was in double rows with 3 plants/m², spaced 40 cm and 150 cm within and between rows. Each year, genotypes were grown in three replicated plots. Irrigation used 4 L/h drippers at 40 cm intervals. Agricultural practices involved synthetic fertilization via irrigation with 190 kg N/ha, 135 kg P2O5/ha, 431 kg K2O/ha, and 75 kg MgO/ha, as outlined in Ilahy et al. (2022).

Fruit Sampling

Tomato fruits were harvested from each plant when they reached the commercially desired red-mature-ripening stage. From each block, 20–23 fresh and healthy tomatoes were selected and transported to the laboratory. Three sets of samples were prepared once the tomatoes achieved the ideal red-ripe condition. The chosen tomatoes were rinsed with deionized water, chopped into small pieces, and blended using a laboratory blender (Waring Laboratory Science, Torrington, CT, USA). The resulting homogenates were freshly analyzed for lycopene and total phenolic content to prevent nutrient degradation or oxidation.

Tomato processing:

For processing, the selected tomato fruits were washed with deionized water, cut into small pieces and homogenized in a laboratory blender (Waring Laboratory Science, Torrington, CT, US). After grinding, the tomato puree was cooked at approximately 70°C. Then, the mixture was refined, by discarding seeds and skins to obtain improved texture at the output. The mixture was refined and concentrated at 14% using a vacuum concentration ball under 65-70°C. Finally the obtained paste was stirred and homogenized to obtain the final product.

Lycopene content determination

Lycopene extraction and determination was conducted as described by (Lee 2001) and Fish et al. (2002), respectively. The method uses a mixture of hexane/ethanol/ acetone (2/1/1 by vol.) containing 0.05% butylated hydroxytoluene (BHT). During the extraction process, some precautions were taken, like working in a reduced luminosity room and wrapping glass materials in aluminium foil to avoid lycopene loss by photooxidation. For lycopene quantification, the absorbance of the hexane extract was read at 450 nm respectively using a Cecil Instruments Ltd., Cambridge, UK. Lycopene molar extinction e = 17.2* 104/M/cm in n-hexane was used for lycopene content determination. Lycopene content was expressed as mg/kg fw.

Total phenolic content determination

Total phenols were extracted as described by Martínez-Valverde et al. (2002) on triplicate independent sample of the fresh and processed sample (0.3 g). Briefly, 5 mL of 80 % aqueous methanol and 50 µL of 37 % HCl were added to each sample. The extraction was performed at 4 °C, for 2 h, under constant shaking (300 rpm). Samples were centrifuged at 10000 g for 15 min. The total phenols assay was performed by using the Folin-Ciocalteu reagent as described by Spanos and Wrolstad (1990) on triplicate 50 µL aliquots of the supernatant. The absorbance was read at 750 nm using a Cecil BioQuest CE 2501 spectrophotometer (Cecil Instruments Ltd., Cambridge, UK). The linear reading of the standard curve was from 0 to 300 µg gallic acid equivalent/mL. Results were expressed in mg of gallic acid equivalent (GAE)/kg fw. Since sugars may interfere with the total phenolic content in sample containing high sugar levels, total phenolic contents were corrected for sugar interference, according to Asami et al., (2003) using the same methodology for total phenolics quantification.

Data analysis

The statistical analysis of the data was conducted using the IBM SPSS Statistics software for Windows, Version 21.0. (IBM Corp., Armonk, NY, USA). To compare the mean values, the least significant difference (LSD) procedure was utilized, with statistical significance set at $P<0.05$.

Results and Discussion

Lycopene content

Lycopene content in tomato landraces carrying high pigment mutations such as HLT-F81 and HLT-F82 and their respective pastes showed the highest lycopene content with respect to Rio Grande fresh and processed sauce (Figure 1). High-pigment tomato berries exhibited 1.82-2.37-fold higher lycopene and their respective processed paste exhibited also 1.70-2.10-fold higher lycopene compared to the fresh berries and sauce obtained from Rio Grande. The values obtained are in line with those previously reported for open-field-grown tomato berries, ranging from 52 to 236 mg/kg fw Ilahy et al. (2011). These results are also consistent with the data from Levin et al. (2006) and Ilahy et al. (2018), who reported values attaining 440 mg/kg fw in different tomato genotypes carrying high-pigment mutations.

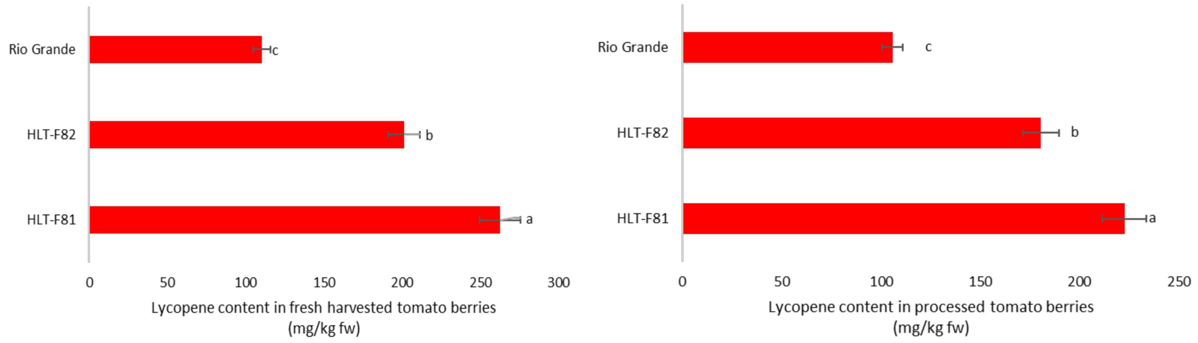

Figure 1. Lycopene content in ripe red raw berries and tomato sauce of different cv of high pigment (HLY-F81 and HLY-F82) and ordinary tomatoes (Rio Grande). The results are expressed as fresh weight (fw) Data are means ± standard deviation of three replicates.

Total phenolic content

Total phenolic content in tomato landraces carrying high pigment mutations such as HLT-F82 and HLT-F81 and their respective pastes showed the highest Total phenolic content with respect to Rio Grande fresh and processed sauce (Figure 2). High-pigment tomato berries exhibited 1.6-2.32-fold higher total phenolic content and their respective processed paste exhibited also 1.82-2.71-fold higher total phenolic content compared to the fresh berries and sauce obtained from Rio Grande. The obtained values align with those reported by various authors

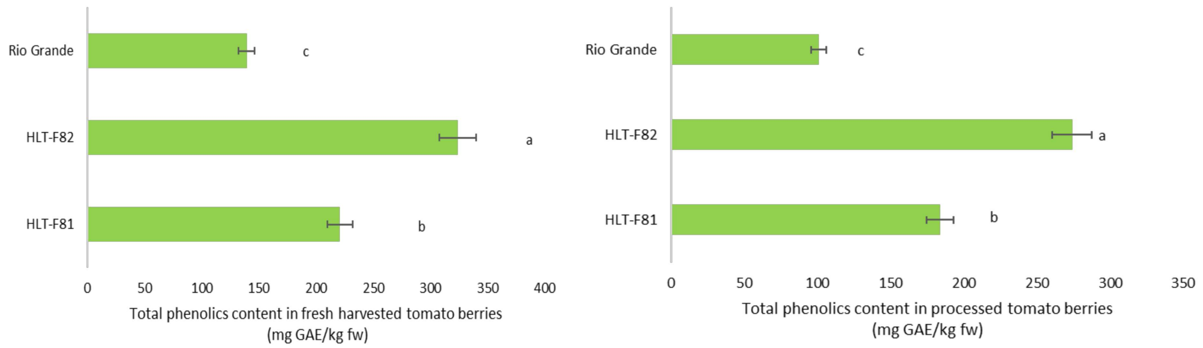

Figure 2. Total phenolic content in ripe red raw berries and tomato sauce of different cv of high pigment (HLY-F81 and HLY-F82) and ordinary tomatoes (Rio Grande). The results are expressed as fresh weight (fw) Data are means ± standard deviation of three replicates.

The higher production of secondary metabolites in high-pigment tomato lines compared to the ancient-tomato genotypes is likely associated with the hp genes carried by such lines, leading to increased plastid biogenesis (Galpaz et al., 2008), and consequently the overproduction of other metabolites generally accumulating in plastids, such as tocochromanols, vitamin C etc (Liu et al., 2004, Kolotolin et al., 2007, Bino et al., 2005). This facts leads to the attractive red-color in fresh and processed tomato products (Figure 3) from such genotytpes which increase their demand by consumers looking for functional foods and higher quality products

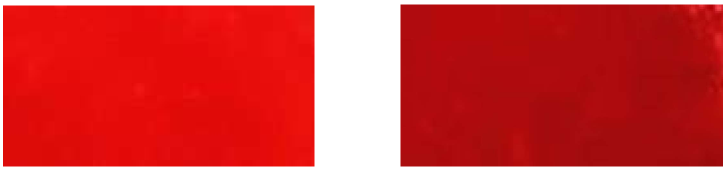

Figure 3. Color of tomato sauces obtained from ordinary (Rio Grande in light red) and high pigment (HLT-F81 in dark red) tomatoes.

Conclusion

The findings highlight the nutritional advantages of high pigment tomato cultivars, which can significantly enhance the carotenoid intake in human diets. These cultivars present opportunities for producing healthier tomato-based products, supporting improved health outcomes.

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