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Mediterranean long storage tomato as a source of novel products for the agrifood industry: Nutritional and technological traits

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ABSTRACT

Long storage tomato is a crop traditionally cultivated under no irrigation in Southern Italy. Recently, great interest has been directing towards this crop, as a source of novel products for industrial purposes. A research has been conducted to assess some nutritional and technological traits which affect the fruit suitability to processing, in two Sicilian landraces ('Pizzottello di Montallegro' and 'Locale di Filicudi') of long storage tomato, compared to the Hy. 'Brigade' of processing tomato (Dry and Irrigated). High total solids (>103 g/kg), total soluble solids (>8°Brix) and reducing sugars (>53 g/kg), mostly greater than those of the control, reveal the tastiness of long-storage tomatoes. These were slightly poorer in lycopene than the control (both dry and irrigated) but richer in polyphenols (≥0.12 mg/g) and vitamin C (≥0.59 mg/g), as also revealed by the antioxidant activity (DPPH>80%). Degradative enzymatic activities (pectin methyl esterase and polygalacturonase) were the lowest in 'Pizzottello di Montallegro', proving a fruit susceptibility to softening even lower than control. In turn, low polyphenol oxidase activity in 'Locale di Filicudi' indicates a great aptitude of fruits to retain the nutritional value.

1. Introduction

Long storage tomato, so-called for the textural properties of fruits that allow an extended shelf-life (they are harvested in summer and consumed up to winter in the Mediterranean regions), is a niche product that combines a good taste with excellent nutritional properties (Siracusa, Avola, Patanè, Riggi, & Ruberto, 2013). In the semi-arid areas of South Italy, this crop is traditionally cultivated under no irrigation after its initial establishment, due to the high drought tolerance of the plant (Patanè, Scordia, Testa, & Cosentino, 2016). Currently, few farmers still cultivate local landraces of this plant, mostly for their own use or for local market. However, the progressive reduction of the genetic diversity in tomato due to an intensive breeding, imposes a recovery, conservation, assessment and exploitation of existing germplasm, including that of long storage tomato, as a source of genetic variation, to prevent its extinction (Elia & Santamaria, 2013; Garcia-Mier et al., 2014). Recently, consumers have great interest on this crop as a source of novel products of high nutritional value, due to the low water content of its berries and the high content in bioactive constituents, including vitamin C, carotenoids and phenols (Vallverdú-Queralt, Regueiro, Rinaldi de Alvarenga, Torrado, & Lamuela-Raventos, 2015). Therefore, fruits of long storage tomato may play an important role in the human nutrition and in the prevention of various diseases (WHO, 2003, pp. 1–149; Vallverdú-Queralt et al., 2011). Additionally, a novel processed product from long-storage tomato may contribute to a diversification in the agrifood industry production.

In this respect, a research has been carried out to assess some nutritional and technological traits which affect the fruit suitability to processing, in two Sicilian landraces of long storage tomato, compared to the Hy. 'Brigade' of processing tomato.

2. Materials and methods

2.1. Plant material

The two Sicilian long storage tomato landraces 'Pizzottello di

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Montallegro' and 'Locale di Filicudi', of the germplasm collection at the CNR-IVALSA of Catania (Italy), were compared to the commercial Hy. 'Brigade' of processing tomato (control). Plants were open-field transplanted on April 30th, 2012, at the experimental farm of the University of Catania (Southern Italy) (10 m a.s.l.). A completely randomized experimental design with three replicates for each cultivar was adopted in the field. Single plot measured 15 m^2 (5 × 3 m), with a 0.75 m row distance and 0.45 m plant distance. Plant density was approx. 3.0 plants/m^2. The two landraces were irrigated at transplant only (41 mm), according to the traditional method of cultivation of this crop. For the control, two water regimes were considered: irrigation at transplant only (Dry, 41 mm) and irrigation for the whole growing season (Irrigated, 233 mm).

The local climate is typically semi-arid Mediterranean. Minimum temperatures ranged between 15.0 and 21 °C, those maximum between 19 and 33 °C. A total of 40 mm of rainfall was recorded during the crop growing season.

Fruits were harvested in mid July and total yield (t/ha fresh weight-FW) was determined. Marketable yield (t/ha fresh weight-FW) was also measured from the sum of red and disease-free fruits. Yield loss was calculated as percentage of unmarketable yield (this last from the difference between total and marketable yield) upon total yield. Total soluble solids-TSS yield (t/ha FW) was calculated by multiplying TSS content by marketable yield.

2.2. Physicochemical analyses

Ripened fruits from each tomato genotype (~1 kg per replicate) were sampled at harvest for laboratory analyses. They were washed with running water to remove dirt and dried with absorbent paper, then they were analysed for fruit weight (g), and firmness (N) by means of a portable texturemeter (Bertuzzi FT 011, Bertuzzi, Brugherio, Italy) using a convex-tipped cylindrical probe (8 mm diameter). Fruit firmness was measured through a compression test based on the resistance of the fruit to deformation at the equatorial zone level. Tomato samples were homogenised in an Ultraturrax T25 (Janke & Kunkel, Staufen, Germany) for 3 min in an ice bath to prevent oxidation, and analysed for (AOAC, 1990): total solids (TS, g/kg FW), determined at 65°C in a ventilated oven until constant weight (72 h); total soluble solids (TSS, °Brix), read in a portable refractometer (Hanna Instruments Digital Brix Refractometer, HI96801) at 20 °C; pH, read with a glass electrode pH-meter (inoLab pH Level 1); titratable acidity (TA, g/kg FW, as citric acid) measured by titration, using 0.1 mol/L NaOH against 20 mL of a filtered 50 mL tomato homogenate sample diluted in 50 mL water (100 mL total volume); vitamin C (AA, mg/g FW as ascorbic acid), measured by titration of homogenate tomato sample (diluted in a 30 g/L *meta*-phosphoric acid solution and a 80 ml/L acetic acid solution) using a 2, 6-dichlorophenolindophenol solution standardized in a solution of ascorbic acid with a known concentration. The following nutritional traits were also determined: reducing sugars (RS, g/kg FW) (Bailey, Biely, & Poutanen, 1992); carotenes (lycopene and β-carotene, mg/g FW), by HPLC-DAD analysis, in samples prepared according to Riggi, Patanè, and Ruberto (2008); total polyphenols (TP, mg/g FW), by HPLC-DAD analysis, in samples prepared according to Siracusa, Patanè, Avola, and Ruberto (2012); antioxidant activity (% scavenging activity, DPPH) (Barbagallo, Di Silvestro, & Patanè, 2013). For RS and DPPH, absorbance was read in a spectrophotometer (Lambda 11, Perkin Elmer, San Jose, CA, USA) at 575 and 517 nm, respectively.

HPLC analyses were carried out on an Ultimate3000 instrument equipped with a binary high pressure pump, a Photodiode Array detector, a Thermostatted Column Compartment and an Automated Sample Injector (Thermo Scientific, Italy). Data were processed through a Chromeleon Chromatography Information Management System v. 6.80. Polyphenols were eluted according to Siracusa et al. (2012). For carotenes, a gradient of B (2% triethylamine in ethyl acetate) in A (acetonitrile:water 9:1) was used with the following program: t = 0 min, B = 30%; t = 13 min, B = 82%; t = 23 min, B = 30%. HPLC grade solvents were purchased from VWR (Milan, Italy). Quantification was carried out at 280 nm for naringenin using its corresponding analytical standard (Fluka, Milan, Italy) and at 330 nm for mono- and di-cinnamoylquinic acids, using chlorogenic acid and cynarin, respectively (Extrasynthese, Lyon, France). Quercetin was quantified at 370 nm using the corresponding commercial standard (Fluka), whilst all glycosilated flavonols were quantified at 350 nm using rutin (Fluka) as reference. Carotenes were quantified at 472 and 454 nm; commercial all-*trans* lycopene and β-carotene (Sigma, Milan, Italy) were used as standards. Both TP and carotenes were expressed as mg/g FW.

Pectin methyl esterase (PME, E.C. 3.1.1.11) and polygalacturonase (PG, EC 3.2.1.15) were also determined. Extracts were prepared according to Stevens et al. (2004) modified, and assayed according to Fachin et al. (2002) and Gross (1982), respectively. The catecholase activity of polyphenol oxidase (PPO, E.C. 1.14.18.1) was tested according to Spagna, Barbagallo, Chisari, and Branca (2005). Results were expressed as μkat/kg FW.

All analyses were carried out in triplicate.

2.3. Statistical analysis

Data were subjected to a one-way analysis of variance (ANOVA) using CoStat version 6.003 (CoHort Software). Differences between means were evaluated for significance using the Duncan's test ($P \leq 0.05$) (Snedecor & Cochran, 1989).

3. Results and discussion

Long storage tomato provided moderate fruit yields (≤25 t/ha), mostly deriving from its traditional method of cultivation (irrigation at transplant, only). Nonetheless, total yield did not differ from that of the dry control, where, however, the stressful conditions determined a 45% yield loss (Table 1).

TSS yield is a valuable parameter in processing industry (Johnstone, Hartz, Le Strange, Nunez, & Miyao, 2005). A greater TSS content compensated for the moderate yields in both landraces, resulting in TSS yields (>1.4 t/ha) higher than that of the dry control.

The small size (<20 g) is typical of long storage tomato fruits. In both landraces, fruit firmness was as high as that of the irrigated control, whose great fruit firmness is probably the result of a breeding program for this trait.

TS content of local types did not differ from that of the dry control but was greater than that of the irrigated control (Table 2). Tomatoes high in TSS require less energy to evaporate water, thus improving the efficiency throughout the industrial process (Johnstone et al., 2005).

TSS of local types (>8 °Brix) were greater than minimum (4.6° Brix) sought by the processing industry (Siviero, 1998). Water stress imposition during fruit sizing and ripening improves TSS but induces unacceptable yield losses in tomato (Patanè & Cosentino, 2010). However, although long-storage tomato plants grew under severe soil water deficit for most of growing season, TSS were high but yield losses were negligible. High TSS and high RS content (>53 g/kg) in their fruits, also reveal great tastiness.

TA did not differ among tomatoes. The pH was significantly lower in local types, whilst the dry control produced fruits with a pH close to the maximum recommended (4.30), according to the