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Spanish traditional tomato. Effects of genotype, location and agronomic conditions on the nutritional quality and evaluation of consumer preferences

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ABSTRACT

Traditional tomatoes are highly valued for their organoleptic quality and cultural links with a territory. At present, strong competition has put these crops at risk, and it is necessary to differentiate the local cultivars and improve their nutritional value.

This work focused on the nutritional study of four selected lines of a local tomato grown in two locations and in two agronomic conditions to nutritionally characterize the tomatoes and to study the effect of location and cultivation on nutritional parameters.

Data on nutritional characterization revealed significant effects of location and treatment in most compounds. Tomatoes grown in traditional areas showed a significantly higher concentration of some phenolic acids and beta-carotene. Lycopene contents were not location dependent. The open field test showed significant differences in all the components. Regarding the best nutritional genotypes, all the components were dependent on lines, and significant differences were confirmed between them.

1. Introduction

Recently, an increasing awareness of the importance of antioxidants in the diet has led to the expansion of "functional foods", nutraceutical markets, and the targeting of nutritional quality. As a consequence, the development of crop varieties with improved nutritional value has now become a priority. The composition of bioactive compounds of different fruits and vegetables is varied, both qualitatively and quantitatively. Moreover, the content of these substances can also be affected by the environmental and nutritional conditions of crops (agronomic conditions), as well as treatments made during the handling of fruits and vegetables at the post-harvest stage and processing to obtain derived foods. In addition, there are factors intrinsic to the plant itself (genetic), leading to the composition in these substances being different not only between different genera or species but also between varieties of the same species.

Tomato is an excellent source of nutrients and bioactive antioxidant compounds that are important for human health, including minerals, vitamins C and E, beta-carotene, lycopene, flavonoids, organic acids, phenolics and chlorophyll (Navarro-González & Periago, 2016; Siddiqui, Ayala-Zavala, & Dhua, 2015; Weisburger, 2002). The chemical composition of the tomato fruit depends on factors such as cultivar, maturity and the environmental conditions in which they are grown (Coyago-Cruz et al., 2018; Hernández-Suarez, 2011). The quality of food is the set of properties that make them accepted by consumers. These properties include those perceived by the senses (sensory qualities) as hygienic, nutritional and commercial properties. In tomato, these are determinants of quality, organoleptic properties, and the set of attributes of appearance, texture, smell, colour or taste that are perceived by the senses. Consumer choice is determined both by external parameters, such as shape, colour and absence of damage, and internal parameters, such as taste, aroma and texture parameters (Azodanlou, Darbellay, Luisier, Villettaz, & Amado, 2003). Of all these attributes, flavour normally creates a greater impact on the consumer. The tomato flavour is directly related to its chemical composition (mainly sugars and organic acids), which varies depending on the type and degree of maturity of the fruit (Piombino et al., 2013).

Consumer complaints regarding the taste of modern commercial varieties have fostered the development of niche markets for heirloom, local or traditional varieties. These varieties have shown high levels of variation in agromorphological, genetic and organoleptic traits, but little is known about the variation in the concentrations of functional

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compounds (Cortes-Olmos, Leiva-Brondo, Rosello, Raigon, & Cebolla-Cornejo, 2014). In this study, a Spanish traditional tomato variety, "Rosa de Barbastro", characterized by pink colour, large fruits (from 500 to 900 g) and much appreciated flavour has been studied. It is characterized as an aromatic, fleshy, compact, and sweet tomato with little acidity and few seeds. Its wide acceptance in the market is due to its interior, with a characteristic taste and texture and a predominance of sweetness to acidity. Carravedo-Fantova (2006) considers is a great quality product.

In the present work, the nutritional quality (bioactive compounds) in the germplasm of four "Rosa de Barbastro" tomato lines located in two cultivated plots (different soil and climate) and under two agronomic conditions (open field and greenhouse) is studied. The hypotheses were that, in general, local tomato lines from the Agrifood Research and Technology Centre of Aragón (CITA), grown in Barbastro (traditional growing area) and in open field could shown best bioactive components that those grown in other location and in greenhouse, and that, in particular, the different genotypes could show a variable response under the experimental conditions. According to the sensorial quality it could be more appreciated by consumers versus other commercial varieties. The goal was to include these results in the breeding programme to increase the concentration of these nutritionally valuable compounds.

2. Materials and methods

2.1. Chemicals

Folin-Ciocalteu phenol reagent (2N), beta-carotene (synthetic, > 95%), lycopene (from tomato, > 90%), caffeic acid (> 98%), chlorogenic acid (titration, > 95%), *p*-coumaric acid (> 98%), *trans*-ferulic acid (> 99%), DL-dithiothreitol (> 98%, HPLC), acetone, acetonitrile (HPLC grade), dichloromethane (HPLC grade), ethanol (HPLC grade), acetic acid and hexane (HPLC grade) were purchased from Sigma-Aldrich (Madrid, Spain). Methanol (HPLC grade), meta-phosphoric acid, sodium carbonate anhydrous, sodium chloride and sodium sulphate anhydrous were purchased from Panreac (Barcelona, Spain).

2.2. Tomato samples

In this study, four selected lines (Table 1) from the breeding programme (Centro de Investigación y Tecnología Agroalimentaria de Aragón, CITA) (Aguiar, Bruna, Llamazares, & Mallor, 2014) of the tomato variety "Rosa de Barbastro" were grown in two locations: one in the area where this is traditionally cultivated, located in Barbastro (Huesca, Spain, long.: 42.018611/lat.: 0.130833/alt.: 365 m), and the other in CITA experimental fields located in Montañana (Zaragoza, Spain, long.: 41.726944/lat.: −0.81/alt.: 230 m). In both locations, two assays were performed that differed in the production system: in the open field and under unheated plastic tunnel conditions (greenhouse). Hence, a total of four assays were carried out. Regionally recommended cultural practices, including fertilizer and plant protection measures, were followed. Fertilizers were applied in fertigation, through the drip irrigation system. Three soluble fertilizers were used, at the dose recommended by the manufacturer, according to the physiological stage of plant development. The NPK complex fertilizer 13-40-13 was applied from 20 May to 7 June, to favour rooting and to stimulate growth during the first stages of the crop cycle; the complex fertilizer 15-10-15 was applied from 10 June to 1 July to maintain the crop; and the complex fertilizer 15-5-30 from 3 July to harvest time, to favour flowering and ripening of the fruits.

For pest and disease control, the following products, at the dose recommended by the manufacturer, were applied: Propamocarb fosetilato (by fertigation, 2 May and 9 May) to control root and/or stem rot; Foli-stop (2 may and 9 may) to control fungus diseases; *Bacillus thuringiensis kurstaki* 24% (by spraying, 5 August) to control *Heliothis armigera*; and Azadiractin 1% and *Beuveria bassiana* 2,3% (by spraying, 5 August) to whitefly control. Moreover, during cultivation, the following biological control methods were used: blue and yellow sticky traps for monitoring thrips and whiteflies, respectively; funnel traps for monitoring and control *Heliothis armigera*; and traps with pheromones to catch adults of *Tuta absoluta*. Additionally, a control tomato from the *Caramba* variety was grown in both locations under greenhouse conditions.

In February 2014, seeds were sown in a cold greenhouse and grown until the 2–3 leaf stage to be transplanted in May 2014. A randomized block design, replicated three times, was adopted, with 6.3 m^2 plots with a plant density of 3.2 plants/m^2. All fruits evaluated were harvested at the pink ripe stage. Before analysis, all tomato samples were ground and frozen and stored at −20 °C until analysis.

Table 1
Selected lines of tomato "Rosa de Barbastro" from the breeding programme (CITA).

Selected line	Genetic code	Selected by
Line 1	BGHZ5204_13_01	Good organoleptic qualities
Line 7	BGHZ3576_47_07	High commercial production
Line 8	BGHZ3576_59_08	High commercial production.
Line 11	BGHZ3576_69_11	Good organoleptic evaluation, high production values and optimum evaluations of fruits in the laboratory

2.3. Nutritional quality

2.3.1. Determination of phenolic acids

All samples of tomato "Rosa de Barbastro" were crushed and frozen after collection. Vallverdú-Queralt, Jauregui, Di-Lecce, Andrés-Lacueva, and Lamuela-Raventos (2011) and Vallverdú-Queralt, Rinaldi-de-Alvarenga, Estruch, and Lamuela-Raventos (2013) developed a procedure for the extraction and isolation of phenolic compounds from samples of gazpacho and tomato juice. This procedure has been applied with slight modifications.

Tomato samples (12 g) were centrifuged for 15 min (4000 rpm). The supernatant was removed, and 2.5 mL of 70% MeOH in Milli Q water was added to the pellet. The tubes were sonicated for 15 min and centrifuged for 15 min. The supernatant was reserved, and the extraction was repeated with 2.5 mL of 70% MeOH. Both methanol extracts were mixed. The extract was filtered and analysed by HPLC-DAD (Haghi & Hatami, 2010). The HPLC analysis was performed with HPLC Waters 600 equipment with a Photodiode Array Detector Waters 996 (Milford, Massachusetts, USA) and Phenomenex C_{18} column (250 × 4.6 mm i.d., 5 μm). The column was maintained at room temperature, and elution was carried out with a linear gradient. The mobile phase was 4% (v/v) tetrahydrofuran in acetonitrile and 0.4% phosphoric acid in water (35:65) at a flow rate of 1 mL/min. The injection volume of all samples was 50 μL, and each sample was analysed in triplicate. The spectral data of signals from the DAD detector were collected during the entire run in the range of 240–400 nm.

The analytes were identified by matching the retention times and spectral characteristics against those of standards. The linear range of quantification of phenolic acids (caffeic acid, chlorogenic acid, *p*-coumaric acid and *trans*-ferulic acid) was prepared from 0.5 to 50.0 μg/g in methanol.

2.3.2. Determination of total phenolic content

The total phenolic content was measured on the methanolic extract obtained for the determination of the polyphenols in the tomato samples using the Folin-Ciocalteu colourimetric method (Kaur et al., 2013) with slight modifications. First, 0.1 mL of the methanol extract was placed in a glass tube and 0.5 mL of Folin-Ciocalteu reagent and 2.9 mL of distilled water were added. The tube was shaken vigorously for 30 s