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Organic acids and sugars composition of harvested pomegranate fruits

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Abstract For two consecutive seasons, 40 Spanish pomegranate cultivars ( cvs) were analysed and their individual organic acids and sugars compositions were examined. Intervarietal differences in acidity content reported by different authors were confirmed. According to organoleptic characteristics and chemical compositions three groups of varieties were established: sweet (SWV), sour-sweet (SSWV) and sour (SV). On average, for two seasons, total organic acids on a dry basis ranged between 0.317 g/100 g (SWV) and 2.725 g/100 g (SV). Citric, malic, oxalic, acetic (first reported here), fumaric, tartaric and lactic acids were detected, although lactic and fumaric were not quantifiable. On average, for both seasons, citric acid was predominant with a range of 0.142–2.317 g/100 g (average content for all CVS, 0.282 g/100 g). Malic acid was the second most abundant, with a range of 0.135–0.176 g/100 g (average of 0.139 g/100 g). Total sugars ranged between 11.43 g/100 g and 13.5 g/100 g. Glucose, fructose, sucrose and maltose were detected, although maltose (first reported here) was not quantifiable. Fructose ranged between 5.96 g/100 g and 7.04 g/100 g, with an average of 6.58 g/100 g, quite similar to that of glucose (6.14 g/100 g). Sour cv showed the lowest fructose and glucose contents. The average sucrose content was 0.01 g/100 g. Other differences among the groups of cvs were detected. Low total sugars and high acids were found in SV. The SSWV group had higher sugars than the SV. However, no difference in total sugars between SSWV and SW was found. A lower acids content than SV but higher than SW was found in the SSWV group. No other studies have been published so far on the individual organic acids and sugars of pomegranate fruit.

Key words Pomegranate · Punica granatum (Punicaceae) · Sugars · Organic acids · Fruit quality

Introduction

Part of the south of Spain has a serious problem with the process of desertification of the agricultural lands, extending to almost all Mediterranean countries. Alternatives for economic agricultural exploitation of this area are very limited. In this sense pomegranate trees (Punica granatum, Punicaceae), specially adapted to saline and poor soils in semiarid climates, could be an adequate cultivation choice for this area, and thus contribute to the reduction of the risk of desertification. Pomegranate trees are also generally very well adapted to the Mediterranean climate, being a typical cultivation of this Spanish zone as well as of many other Mediterranean countries.

The separated edible fresh part of the pomegranate fruit is mainly consumed directly, but is also used after separation of seeds, for the preparation of fresh juice or canned beverages, even alcoholic beverages, jellies, jams and for flavouring and colouring drinks. The edible part of the fruit contains considerable amounts of sugars, vitamins, polysaccharides, polyphenols and minerals. In spite of its importance as a semiarid cultivar (cv), little effort has been made in the study of the chemical composition of the edible part of the pomegranate. Some studies have focused on establishing a chemical composition table, mainly for oriental cvs. Studies based on general analysis [total sugars, reducing and non-reducing sugars, total nitrogen, soluble
solids content (ssc), titratable acidity (TA), pectin content and ash), of the fruit and its juice have been conducted [1–17]. Some chemical changes during ripening and cold storage in Spanish pomegranate cvs, including colour and pigmentation, total lipids and fatty acids composition, have been more recently studied [18–21]. However, as far as we know, there are no references in the scientific literature to studies of the individual sugars and organic acids of pomegranate fruit.

The aim of the present work was to study the individual organic acids and sugars of 40 pomegranate cvs, growing under Mediterranean climate conditions.

Materials and methods

Plant material. During two consecutive seasons, pomegranate fruits were hand-harvested in September and October, from randomly selected trees in commercial or experimental orchards, in the typical growing area of the Spanish provinces of Alicante and Murcia on the Mediterranean coast of Spain. Fruits were harvested when fully mature, according to commercial practice, to ensure their best flavour and colour, since being non-climacteric they do not ripen off the tree [19]. Fruit were transported by ventilated car to the laboratory, where pomegranates with defects (sunburns, cracks, cuts and bruises in the husk) were discarded. A total of 40 pomegranate cvs were selected. The general description of these different cvs has been reported, and they have been classified according to the external characteristics of the tree as well as to external and internal characteristics of the fruit [21–23].

The results were characterised by chemical and physical parameters (size, weight, seeds, SSC, pH, TA, organic acids, sugars and fatty acids content). Some of the results have been partially reported [20–23].

The most important group is that of sweet cvs, comprising different clones of Mollar de Elche (ME), Mollar de Albaltera (MA), Mollar de Orihuela (MO), Albar de Blanca (AB), San Feliciano de Blanca (SFB), Piñón Tierno de Ojós (PTO), Piñón Duro de Ojós (PDO) and Casta del Reino de Ojós (CRO). The sweet varieties (SWV) group is the most abundant and practically the only one of interest to the fresh market. The main characteristics are SSC ranging between 14.3 Brix and 16.8 Brix, TA between 0.16 g/100 g and 0.42 g/100 g, and a ratio of SSC/TA at commercial harvest, also known as the maturity index, ranging approximately between 32 and 96. Differences in weight, size and external appearance among groups of pomegranate cvs have not yet been observed.

Clones of PTO and Agridulce de Ojós (ADO) comprised the sour-sweet varieties (SSSV) group, and had lower commercial interest (only occasional) for fresh consumption. The main characteristics of this group were SSC ranging between 14.0 Brix and 15.1 Brix, TA between 0.53 g/100 g and 0.85 g/100 g, and a maturity index, with an approximate range of 17–28.

Finally, Borde de Albaltera (BA) and Borde de Blanca (BB) comprised the sour varieties (SV) group, commonly used for rootstock, ornamental and even industrial purposes. The main characteristics of this group were SSC ranging between 14.0 Brix and 15.5 Brix, TA between 2.3 g/100 g and 3.0 g/100 g, and a maturity index, with an approximate range of 32–96.

Chemical analysis. Chemical composition was determined on the juice obtained by squeezing the seeds (arils). According to [24], ten fruits from each cv were weighed and hand peeled and the arils were weighed. The arils were squeezed with a commercial turmix blender (Moulinez, France). The juice was pooled, filtered through filter paper and used for chemical analysis.

For organic acids and sugars analysis the juice sample was centrifuged (2 min at 12000 rpm), filtered through a Sep-Pak C18 cartridge (Millipore, Milford, USA) to remove interferences and stored at –20 °C until analysis [25]. The extracts were analysed on a Waters HPLC equipment, with an Ion 300 column, (Supelco, Barcelona, Spain), 1% H$_2$SO$_4$ as a mobile phase and UV-Vis detector. Individuals sugars were determined in the clarified juice using the same HPLC equipment, with a uBondapak-NH$_2$ column (Waters), acetonitrile/H$_2$O (85:15, v/v) as mobile phase and a refractive index detector. Values were given on a dry weight basis.

Statistical analysis. For statistical analysis the SPSS statistical package was used. To establish the level of significance of differences between the three groups of cvs for each individual organic acid and sugar, an analysis of variance was conducted. When significant differences occurred (P < 0.05), means were separated by Duncan’s New Multiple Range Test.

Results and discussion

Organic acids content

The highest organic acids content, 2.92 g/100 g, was found in BA1 (sour cv) and the lowest, 0.22 g/100 g in MO2 (sweet cv) (Table 1). The average value for each group is shown in Table 2. The average of total organic acids content (as the sum of individuals acids) in the two seasons was around 0.47 g/100 g and varied from 0.32 g/100 g for the SWV group to 2.72 g/100 g for the SV. Confirming organoleptical characteristics, the SV group had the highest acids contents and SWV the lowest.

Citric, malic, oxalic, acetic, fumaric, tartaric and lactic acids were detected in fruits. Due to their low levels, lactic and fumaric acids could not be quantified. On average for two seasons, citric was the predominant acid with an average content of 0.28 g/100 g followed by malic acid with an average of 0.14 g/100 g, and oxalic acid (0.03 g/100 g) (Table 2). Among the SWV cvs SFB1 showed the highest citric acid content (0.32 g/100 g) and ME2 and ME3 the lowest (around 0.09 g/100 g). On the other hand, AB1 showed the highest malic acid content (0.21 g/100 g) followed by MA4 (0.19 g/100 g) while SFB1 and ME10 had the lowest (around 0.1 g/100 g). The highest oxalic acid content was found in ME13 (0.07 g/100 g), and the lowest in SFB1 and ME20 (around 0.01 g/100 g). The highest citric acid content among the SSWV cvs was found in ADO4 (0.7 g/100 g), while in PTO7 only 0.4 g/100 g was detected. Malic acid was 0.17 g/100 g in PTO8 and 0.15 g/100 g in PTO7, while oxalic acid was highest in PTO7 and ADO4 with around 0.02 g/100 g followed by PTO8 with 0.01 g/100 g. The highest tartaric acid content (0.05 g/100 g) was found in ME16, a sweet variety. There were 18 SWV, 1 sour (BB1) and the 3 SSV without tartaric acid. Fumaric acid could be quantified in 3 SWV (ME3, ME5 and ME10) and detected only as traces in 30 cvs. Fumaric acid was not detected in the sour-sweet ADO4, or in six SWV (Table 1). Lactic acid was not quantified in