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SHORT COMMUNICATION

EVALUATION OF THE CHEMICAL QUALITY OF A NEW TYPE OF SMALL-SIZED TOMATO CULTIVAR, THE PLUM TOMATO (*LYCOPERSICON LYCOPERSICUM*)

VALUTAZIONE DELLA QUALITÀ CHIMICA DI UNA NUOVA TIPOLOGIA DI CULTIVAR DI POMODORINO, IL POMODORO DATTERINO (*LYCOPERSICON LYCOPERSICUM*)

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ABSTRACT

The chemical-nutritional attributes were evaluated in plum tomato, a new type of oblong, small-sized tomato that was recently introduced in the European market. Six different cultivars, namely, Dasher, Iride, Navidad, Sabor, 292 and 738, were tested and compared with a cherry-type tomato (cv. Cherubino) which was grown in the same greenhouse under the same conditions. The plum tomato showed important marked differences with respect to the cherry type: more intense

RIASSUNTO

Sono stati valutati gli attributi chimici e nutrizionali di un nuovo tipo di pomodoro di piccola pezzatura, chiamato Datterino, recentemente introdotto nel mercato europeo. Sono state considerate sei differenti cultivar (Dasher, Iride, Navidad, Sabor, 292 e 738) e confrontate con una cultivar di pomodoro ciliegino (cv. Cherubino) coltivata nella stessa serra e nelle medesime condizioni. I risultati hanno mostrato alcune differenze significative rispetto alla tipologia ciliegino: un più intenso colore

- Key words: ascorbic acid, carotenoids, cherry tomato, phenolics, plum tomato -

red colour, lower acid content and a higher lycopene content. The quality attribute values for cv. 738 were higher than the average values for the other cultivars. In contrast, the cherry-type variety had slightly higher levels of ascorbic acid and β-carotene than the plum tomatoes.

rosso, una minore quantità di acidi ed un maggiore contenuto di licopene. Gli attributi di qualità della cv. 738 sono stati superiori ai valori medi. Il ciliegino, invece, ha mostrato quantità leggermente più elevate di acido ascorbico e di β-carotene.

INTRODUCTION

The nutritional value of tomato is due to the beneficial effects of some health-promoting constituents, (vitamins, fibre and carotenoids) which in general, help inhibit oxidative processes and in particular, help prevent some types of cancer and cardiovascular diseases, (PARFITT *et al.*, 1994; GIOVANNUCCI, 1999; LAVELLI *et al.*, 1999, 2000; RAO and AGARWAL, 2000).

It is well established that small-sized tomatoes are usually characterized by higher levels of dry matter and soluble solids than normal-sized tomatoes; these differences are due to higher content of sugars and organic acids, which, in turn, are the major factors in determining the greater sweetness, sourness and overall flavor intensity (PICHA, 1986; LEONARDI *et al.*, 2000; PAGLIARINI *et al.*, 2001).

A new hybrid of small-sized tomato called "plum tomato" has recently been introduced on the market and has aroused great consumer interest. As indicated by the breeders, the plum tomato variety originated from inter-specific crossbreeding among *Lycopersicon lycopersicum*, *Lycopersicon pimpinellifolium* (Red Currant-type) and *Lycopersicon chesmanii* (PASSERI, 2003). The shape of a plum tomato is similar to a small plum or date, hence the Italian name "Datterino". The small size (10-15 g) and very pleasant taste make it a valuable and special product. Due to these characteristics, demand for plum tomato has increased rapidly in the last few years.

To date, no study has been performed on plum tomatoes, apart from a recent study on the effect of packaging on their shelf life (MURATORE *et al.*, 2005). In the present paper, the level of the most important constituents (sugars, acids, phenolics and carotenes) of six different plum tomato cultivars was assessed and compared with the results of a cherry-type tomato which was chosen as a standard because of its small size and high quality. The quantitative distribution of sugars, ascorbic acid, phenolics and carotenes in cherry tomatoes is not only dependent on the cultivar (HART and SCOTT, 1995; ABUSHITA *et al.*, 2000; LEONARDI *et al.*, 2000; ARENA *et al.*, 2003), but also on agronomic factors (LA MALFA *et al.*, 1995; DE PASCALE *et al.*, 2001), ripening stage and post-harvest storage (GIOVANELLI *et al.*, 1999; ARIAS *et al.*, 2000; RAFFO *et al.*, 2002). In order to minimize the effects that were not due to the cultivar, it was compared directly with the cherry-type tomato. The cherry-type tomato was transplanted and grown in the same greenhouse, under the same agronomic conditions, and its samples were harvested at the same commercial ripening stage, following the indications of the producer.

MATERIALS AND METHODS

Sampling and sample preparation

The following six plum tomato cultivars were tested: Dasher, Iride, Navidad, Sabor, 292 and 738; the cherry-type variety Cherubino was used as a reference. Each sample of the tomato varieties consisted of about 50 fruits (800-1,000 g) collected from different plants. Nine different samples of each plum and cherry tomato variety were harvested at the commercial ripening stage, from December 2002 to April 2003 (the sampling dates were: Dec. 6 and 18 2002; Jan. 7, 15 and 28 2003; Feb. 12 2003; Mar. 4 and 13 2003; Apr. 5 2003). Overall, 63 samples were examined.

Carpometric and colourimetric measurements were taken and the pH, acidity, soluble solids and dry matter values were determined on fresh tomatoes, while reducing sugars, phenolic compounds, ascorbic acid and carotenoids were determined just after thawing tomato samples which had been stored at -18°C.

Physical measurements

The length, width and weight were measured on five fruits randomly chosen from each sample; the mean values and standard deviations were then calculated. The CIE chromatic coordinates L*, a* and b* were also determined on the same five fruits by testing four different points on the tomato surface, using a portable colorimeter mod. NR-3000 (Nippon Denshoku Ind. Co. Ltd.).

Chemical determinations

All chemical determinations were carried out on two lots of fifteen randomly selected fruits. Each analysis was performed in duplicate.

The pH was measured on homogenized samples using a Mettler Toledo MP220 pH-meter, previously calibrated with buffer solutions. The acid contents were determined by titration with 0.1 N NaOH and are expressed as mg of monohydrate citric acid per 100 g of fresh tomato. Soluble solids were measured on homogenized and filtered samples with a refractometer (Zeiss, mod. 16531) and are expressed as degrees Brix at 20°C. Dry matter was determined using about 2 g of homogenized sample after drying in a ventilated oven at 70°C until constant weight was reached.

Ascorbic acid was extracted from the sample as described by NISPEROS-CARRIEDO *et al.* (1992), and quantified by HPLC by calibration with solutions of a pure standard (Extrasynthése, Genay, France).

Total phenolics were extracted by rinsing the homogenized samples (5 g) with warm water, filtering on paper, and collecting the extract in a 250 mL volumetric flask. A four-fold diluted sample was analyzed using the Folin-Ciocalteau method (SINGLETON and ROSSI, 1965), and results are expressed as mg of gallic acid per 100 g of fresh product.

Glucose and fructose were extracted from homogenized tomato samples (10 g) with warm water, filtering on paper and collecting the extract in a 250 mL volumetric flask; the extract was then diluted five-fold. Determination of each reducing sugar was performed by an enzymatic-spectrophotometric method using the test combination kit (Boehringer Mannheim, Germany).

Carotenoids were extracted and separated by HPLC using the procedure of DE SIO *et al.* (1999). Detection was performed at 450 nm for lutein and β-carotene, at 470 nm for lycopene, at 285 and 350 nm for phytoene and phytophluene, respectively. Quantification was made with the external standard method using pure β-carotene, lutein (Extrasynthése, Genay, France) and lycopene (Sigma-Aldrich, Milan, Italy).

Statistical analysis

Experimental data were elaborated by ANOVA, using the Statgraphic Plus software (Manugistic Inc. Rockville, MD, USA). The method used to discriminate among the means (Multiple Range Test) was Fisher's Least Significant Difference (LSD) procedure at 95.0% confidence level.

RESULTS AND DISCUSSION

Physical characterization

The cultivars of plum and cherry tomatoes were preliminarily characterized according to weight, dimension, shape and colour (Table 1).

The Iride, Sabor and 738 cultivars had a higher length/width ratio due to their long, narrow shape. Sabor is bigger and heavier than the other cultivars. The average weight of a plum tomato, excluding Sabor, is 13.5 g, while that of the cherry-type variety is 18.8 g. Plum- type tomatoes are smaller, and this attribute is appreciated by consumers from a merely aesthetic point of view.

The colour parameters L* and b* showed no significant variation among the cultivars, whereas the red parameter a* changed from 8.8 for cherry to 12.2 for Navidad. Plum tomato cultivars were characterized by a more intense red hue than the cherry-type, as indicated by the higher $(a^*/b^*)^2$ ratio, which is an index of red-colour development (ARIAS *et al.*, 2000).

Chemical characterization

Table 2 reports the chemical characteristics of each cultivar. The pH and acidity values were similar for all the plum tomatoes, but the cherry-type tomato was the most acidic. Sabor had the lowest soluble solids and dry matter values, while 738 had the highest values (9.1 and 11.1 mg/100 g, respectively). The cherry-type tomato had mean values that are very similar to most of those of the plum tomatoes, but the values were lower than those for cultivar 738.

The glucose and fructose levels were always high, with fructose being slightly higher (~7%). Cultivar 738 had the highest total sugar content, which corresponds to having the highest dry matter and soluble solids, of which sugars made up about 55% and 67%, respectively. Reducing sugars amounted to 6.13 g/100 g for cv. 738, and the mean value for the plum-type cultivars, excluding Sabor, was 5.70 g/100 g. This is a very

Table 1 - Carpometric and colourimetric characteristics of plum and cherry tomato cultivars.

Variable	Dasher	Iride	Navidad	Sabor	292	738	Cherry
Weight (g)	16.1^{bc}	9.7^{a}	11.6^{a}	26.3^{e}	16.2^{c}	13.9^{b}	18.8^{d}
Length (cm)	3.5^{c}	3.2^{a}	3.2^{b}	4.5^{d}	3.5^{c}	3.5^{c}	2.9^{b}
Width (cm)	2.7^{c}	2.2^{a}	2.4^{b}	3.1^{d}	2.8^{c}	2.5^{b}	3.2^{d}
L*	24.7^{ab}	24.5^{a}	26.1^{b}	26.1^{b}	24.9^{ab}	23.9^{a}	24.1^{a}
a*	10.0^{bc}	10.0^{b}	12.2^{e}	11.1^{d}	10.1^{bcd}	11.0^{cd}	8.8^{a}
b*	20.6^{ab}	20.8^{ab}	21.5^{b}	21.0^{ab}	20.1^{ab}	19.6^{a}	19.4^{a}
$(a^*/b^*)^2$	0.24^{ab}	0.23^{ab}	0.32^{d}	0.28^{bcd}	0.25^{abc}	0.31^{cd}	0.21^{a}

(a) Each value is the average of nine samples. Means in the same row followed by a common letter are not significantly different (P<0.05).

high sugar concentration in comparison with the values reported by PICHA *et al.* (1986), PAGLIARINI *et al.* (2001) and RAFFO *et al.* (2002) in some cherry-type tomato cultivars. The sugars/acidity ratio value in the cherry-like Cherubino was low because it had the highest acidity, while Sabor had the lowest ratio because it had the lowest concentrations of sugars.

The mean ascorbic acid content was slightly higher in the cherry-like Cherubino (31.3 mg/100 g) than Dasher (28.5 mg/100 g), Navidad (25.0 mg/100 g), 292 (26.1 mg/100 g) and 738 (25.1 mg/100 g), whereas it was significantly higher than Iride and Sabor. These values are comparable with those reported in the literature (RAFFO *et al.*, 2002; ARENA *et al.*, 2003). However, the mean value for the cherry-type, was characterized by a high standard deviation, and was not statistically different from Dasher and 292.

The phenol compounds in fruits and vegetables are of special importance from a nutritional point of view, especially for their antioxidant capacity. The phenolic fraction of tomato includes different flavonoid glycosides and esters of hydroxycinnamic acids, prevalently represented by the derivatives of naringenin, quercetin and caffeic acid, characterized by high antioxidant activity (HOLLMAN *et al.*, 1996; CROZIER *et al.*, 1997; STEWART *et al.*, 2000; RAFFO *et al.*, 2002). The level of phenolic substances in plum tomatoes was very high, ranging from 42.5 mg/100 g for cv. Sabor to 74.9 mg/100 g for cv. 738, while the cherry-type Cherubino averaged 63.9 mg/100 g, which was higher than that observed in the cherry tomato cv. Naomi (ARENA *et al.*, 2003). It has been noted that cherry tomatoes grown in warm, sunny countries are richer in polyphenols, particularly in quercetin derivatives (STEWART *et al.*, 1997). Moreover, since polyphenols are located prevalently in the pericarp of the fruit, the level of these compounds in small-sized tomatoes is higher than in normal-sized ones because of the greater skin/volume ratio (STEWART *et al.*, 1997).

The distribution trends of the major carotenoids differed between the plum tomato cultivars and the cherry-like variety. The mean lycopene content in the plum tomato cultivars was higher than that in the cherry-like variety (4.65 and 3.43 mg/100 g, respectively). The highest concentration was estimated in Sa-

Table 2 - Chemical characteristics of plum and cherry tomato cultivars.

Variable	Dasher	Iride	Navidad	Sabor	292	738	Cherry
pH	4.09^{ab}	4.13^{a}	4.12^{a}	4.21^{b}	4.10^{ab}	4.09^{ab}	4.05^{a}
Acids (g/100 g)	0.78^{cd}	0.73^{bc}	0.67^{ab}	0.64^{a}	0.74^{abc}	0.72^{bc}	0.85^{d}
°Brix	8.8^{b}	8.8^{b}	8.1^{b}	6.5^{a}	8.7^{b}	9.1^{b}	8.8^{b}
Dry matter (g/100 g)	10.8^{bc}	10.4^{bc}	9.7^{ab}	8.6^{a}	10.6^{bc}	11.1^{c}	10.8^{bc}
Glucose (g/100 g)	2.78^{bc}	2.71^{bc}	2.48^{b}	2.02^{a}	2.85^{bc}	2.99^{c}	2.86^{bc}
Fructose (g/100 g)	2.85^{b}	2.92^{b}	2.81^{b}	2.22^{a}	2.96^{b}	3.14^{b}	3.16^{b}
Total sugars/acids	7.26^{ab}	7.65^{abc}	7.96^{bc}	6.70^{a}	7.86^{bc}	8.53^{c}	7.20^{ab}
Ascorbic acid (mg/100 g)	28.5^{c}	18.1^{ab}	25.0^{bc}	13.4^{a}	26.1^{c}	25.2^{bc}	31.3^{c}
Phenol compounds (mg/100 g)	68.8^{bc}	69.7^{bc}	61.2^{b}	42.5^{a}	67.5^{bc}	74.9^{c}	63.9^{bc}
Lycopene (mg/100 g)	3.98^{ab}	4.45^{bc}	4.89^{bc}	5.22^{c}	4.57^{bc}	4.77^{bc}	3.43^{a}
β-Carotene (mg/100 g)	0.68^{ab}	0.80^{cd}	0.89^{de}	0.67^{a}	0.78^{bc}	0.80^{cd}	0.99^{e}

Each value is the average of nine samples separated into two lots; each lot was analyzed in duplicate. Means in the same row followed by a common letter are not significantly different (P<0.05).

bor, followed by Navidad and 738 (Table 2). In contrast, the cherry-like variety had higher β-carotene (0.99 mg/100g) than that observed in the plum-types (0.77 mg/100 g). Lycopene made up about 85% of the total carotenoids in the plum cultivars, except Sabor (88.6%), and 77.6% in the cherry type Cherubino. Conversely, β-carotene made up about 15% and 22.4% in plum and cherry-type tomatoes, respectively. Lutein was present at a concentration of about 0.1 mg/100 g, while traces of the colourless carotenoids (phytoene and phytofluene) were detected.

The plum tomato cultivars examined had high levels of sugars and health-promoting components (ascorbic acid, phenolic compounds and carotenoids). They also had an intense red colour and high sugars/acidity ratio. The quality parameters are compared in Table 3, where the + and – symbols indicate the highest and lowest mean values of each parameter for each plum and cherry tomato cultivar. Sabor is the least valuable cultivar, despite having had the highest lycopene content; while 738 is the most valuable having had the maximum values for most of the parameters. The cherry tomato Cherubino had the highest ascorbic acid and β-carotene contents, while cultivars Dasher and 292 were characterized by a balanced content of all the components. Finally, Navidad had the most intense red colour, and Iride is the most appealing because of its shape and being the smallest of the cultivars examined.

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Table 3 - Comparison of the characteristics of plum and cherry tomato cultivars.

Parameter	Navidad	Sabor	738	Cherry Cherubino
$(a^*/b^*)^2$	+			–
Solubile solids		–	+	
Dry matter		–	+	
Sugars/acidity ratio		–	+	
Ascorbic acid		–		+
Phenol compounds		–	+	
Lycopene		+		–
β-Carotene		–		+

The + or – signs denote the cultivar showing the highest or lowest mean value for each parameter, respectively. The cultivars Dasher, Iride and 292 are not reported because they showed intermediate values.

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