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CROP PRODUCTION AND MANAGEMENT - Article

Effect of two wild rootstocks of genus *Passiflora* L. on the content of antioxidants and fruit quality of yellow passion fruit

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ABSTRACT: The nutritional importance of the fruit of passionfruit has prompted studies to assess its composition and antioxidant content and to evaluate it as a functional food in fresh fruit and concentrated juice markets. Currently, the use of wild species as rootstock has been recommended mainly for their positive effects such as tolerance to disease attack and maintenance of fruit quality of grafted cultivars. The aim of this study was to determine the effect of wild species of *Passiflora gibertii* N.E. Br. and *Passiflora mucronata* Lam as rootstock on the content of antioxidants and fruit quality of *Passiflora edulis* f. *flavicarpa*. The experimental design was completely randomized with four treatments and 25 replications, with a total of 100 experimental units. As a control treatment, plants of *P. edulis* from seed and grafted on the same species were used. Significant correlations were observed among the contents of β-carotene, ascorbic acid, luminosity values, chroma and hue angle. For the combination *P. edulis/P. gibertti*, the contents of β-carotene and ascorbic acid were highly correlated with luminosity, chroma and hue angle of fruit juice. A similar behavior was observed for the combination *P. edulis/P. mucronata* Lam. The content of β-carotene in the fruit showed no statistical differences ($p < 0.05$), indicating no significant rootstock effect on the variables evaluated. The results indicate a potential wild rootstock use for its positive effects on grafted plants while maintaining the commercial quality of the fruits of passionfruit crops.

Key words: Passifloraceae, β-carotene, vitamin C, rootstock.

INTRODUCTION

The genus *Passiflora* is composed of about 530 species, 60 of which produce edible fruits (Ocampo et al. 2007) and few of these are cultivated. The market for fresh passion fruit is valued for desirable internal and external quality features of the fruit — the internal quality features are those related to taste (soluble solids and acidity) and juice content (yield), and the external ones are those related to good appearance (color of the skin, size, weight and absence of defects) — thus, meeting certain standards to achieve the desired quality in the markets (Ocampo et al. 2013).

A predominant feature is the presence of antioxidants in the fruits and in the substrates from the leaves of some species of *Passiflora*, according to Pabón et al. (2011), who found significant values for fruits of wild granadilla (*P. ligularis* Juss) and gulupa (*P. edulis* f. *edulis* Sims) leaves. Several studies have confirmed the health benefits provided by the intake of fruits and vegetables rich in antioxidants, mainly in reducing cardiovascular diseases (Wang et al. 2011) and diabetes (Ramful et al. 2010), and the anti-Parkinson's activity of the wild species *Passiflora incarnata* L. (Ingale and Kasture 2014); likewise, by-products of industrialized concentrated passionfruit juice, as the rind, could be considered a potential source of natural antioxidants for functional food and industrial applications, according to the results obtained by Wong et al. (2014). According to Silva et al. (2014), among the non-enzymatic antioxidants that have received the most attention for their possible beneficial effect for the body, are vitamins C and E, carotenoids and flavonoids. Tropical fruits are high in antioxidants, and their main antioxidants are phenolic compounds. In the case of passionfruit, antioxidants contribute to its therapeutic importance by the presence of numerous phytochemicals

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(Babbar et al. 2011). As responsible for being the precursor of vitamin A, essential for vision, β-carotene plays a key role in human health (Rotili et al. 2013). Other beneficial effects of carotenoids include anti-cancer and heart disease prevention properties, which has stimulated intensive research on the role of these compounds as antioxidants and as regulators of the immune system response.

Grafting is widely used in fruit-culture and in other perennial species to propagate superior genotypes, to control plant size, reduce juvenile period, improve the adaptation to adverse soil conditions and to provide tolerance to pests and diseases (Atucha et al. 2014; Machado et al. 2013; Salazar et al. 2015).

In *Passiflora* crops, tolerance of some wild species such as *Passiflora suberosa* L., *P. alata* Curtis, *P. coccinea* Aubl., *P. setacea* D.C. and *P. gibertii* N.E.Br. to premature death of the plants (*Fusarium* spp.) was reported by Silva et al. (2013). Thus, there have been several studies, as those reported by Cavichioli et al. (2011) and Salazar et al. (2015), evaluating the effect of rootstock and graft type on fruit quality of yellow passionfruit, finding that the rootstocks (*P. edulis, P. alata, P. mucronata* and *P. gibertii*) did not influence the content of soluble solids (SS), titratable acidity (TA) and the SS/TA ratios. Similarly, the grafting method did not affect the diameter, length, weight of the fresh fruit, weight and thickness of the rind, and juice yield. However, little information is available on the effect of wild species of *Passiflora* as rootstock for cultivation of passionfruit and their influence on the antioxidant properties of the fruit. Thus, the aim of this study was to determine the effect of two wild species as rootstocks on the content of antioxidants and fruit quality of yellow passion fruit.

MATERIAL AND METHODS

Study area

The study was conducted in a protected environment with a low-density polyethylene covering with a thickness of 150 µm and side anti-aphid greenhouse mesh for citrus fruit in the fruit-culture sector of the Universidade Federal de Viçosa (UFV), Viçosa (MG), Brazil. Geographically, the experimental area is located at a latitude of 20°45’20” south and a longitude of 42°52’40” west, with an altitude of 650 m.a.s.l., with an average annual temperature of 19 °C. According to Köppen’s classification, the weather is Cwa-type, mesothermal, with rainy summers and cold, dry winters (Matarazzo et al. 2013).

Plant material

The experimental design was completely randomized with four treatments and 25 replications, totaling 100 plots. Each plot was represented by a plant in a pot of 30L. The rootstocks evaluated were: *Passiflora edulis* f. *flavicarpa*, *Passiflora gibertii* and *Passiflora mucronata*.; *P. edulis* plants from seed and grafted on the same species were used as a control treatment.

Methodology

For the production of plants used as rootstock, the seeds of *P. edulis*, *P. mucronata* and *P. gibertii* were obtained from the *Passiflora* collection of the fruit-culture sector of the UFV, as well as the vegetative buds used for grafting. The production of seedlings in the nursery began with seed germination in washed sand in plastic boxes of 40 cm of width × 20 cm of height × 50 cm of length. After complete expansion of cotyledonary leaves, 150 seedlings of each species were transplanted to plastic bags of 10 cm × 23 cm. At 60 days after planting, central-slit-type grafting at 10 cm from the root collar of the plant was conducted. Vegetative buds, with two knots, were removed from the middle portion of the productive branches of five adult yellow passionfruit plants. With the first shoots of the graft, the plants were transplanted at four months of age to pots of 30L in a greenhouse.

The substrate was formed by a mixture of soil, sand and chicken manure in a ratio of 3:1:1 by volume. Each pot was supplemented with 100 g of calcium carbonate as corrective measure according to the soil analysis, 1,000 g of manure and 300 g of simple superphosphate. The plants were staked with plastic fiber attached to a 12-caliber steel wire located at an elevation of 2m. Pruning of side branches (deshooting) was performed every 15 days or according to the development of the plant.

When the plants reached 15 cm of height, 60 days after transplantation, the first fertilization was performed with 5 g of ammonium sulfate and 10 g of potassium chloride; after 30 days, a second fertilization was performed, providing 10 g of ammonium sulfate and 15 g of potassium chloride, for a total of 15 g of N and 20 of P_2O_5, considering that ammonium sulphate and potassium chloride contain approximately →

20% N and 60% K_2O, respectively. Additionally, it was necessary to fertilize with 21 g of ammonium sulfate diluted in 1 L of water per plant and 13 g of agricultural gypsum beginning 60 days after transplantation, every 15 days for 250 days. It was also necessary to apply the acaricide abamectin (18 g of active ingredient per L) 60 days after transplantation. Cultural practices and plant management were performed in accordance with technical recommendations for the cultivation of passion fruit (Meletti 2011). A drip irrigation system was used, where each irrigation line had two drips with discharges of 1 $L \cdot h^{-1}$ arranged around each plant, which was irrigated daily.

Chemical characterization

To evaluate the antioxidant composition and quality of the fruit, 172 flowers on each plant were pollinated. Artificial pollination was done manually between 14 and 17 h, when there were open flowers between August and December 2012, for an average of ten fruits per plant; thus, ten fruits per plot were evaluated for analysis.

To evaluate carotenoids, about 2.0 g of juice were weighed, which were homogenized in a beaker with 80% acetone. The ketone extract was filtered through filter paper (8 μm), and the volume was completed to 25 mL in a tube (Silva et al. 2014). The absorbance was determined at 470, 646.8 and 663.2 nm, and carotenoid levels were determined according to the Lichtenthaler equations (1987). The results were expressed in mg per 100 g of juice.

Total SS were determined with three drops of juice, after extraction, using a digital refractometer. TA was determined with the juice of each of the fruits, obtained by 5 mL of juice and transferred to an Erlenmeyer of 250 mL, completing the volume to 100 mL with distilled water. Three drops of the indicator phenolphthalein at 1% were added to this solution, proceeding to stirring titration with NaOH 0.1 N solution, previously standardized with potassium hydrogen phthalate. The results were expressed in g of citric acid per 100 g of juice. The SS/TA ratio was obtained by the quotient between the two characteristics.

The ascorbic acid content was determined by titration with Tillman's reagent [2,6 dichlorophenolindophenol (sodium salt) 0.1%]. The results were expressed in mg per 100 L of ascorbic acid per 100 g of sample.

The coloration of the juice and the rind of the fruit were analyzed with a MINOLTA CR-10, based on the values of L, C (b) and h^o, where L indicates the luminosity (0 = black and 100 = white), C represents chroma, $h°$ is the hue angle and b represents the chromaticity coordinates (+a = red, −a = green, +b = yellow and −b = blue). These values were converted to color angle, $\lambda° = \tan^{-1} b/a$, which indicates the hue angle of the sample (0° or 360° = red, 90° = yellow, 180° = green, and 270° = blue) (Silva et al. 2014). To determine the coloring of the rind, two readings were taken on opposite sides of each fruit. To define the color of the juice, it was extracted previously and poured into a beaker of 100 mL, where the reading was done with the apparatus at 1 cm from the surface of the juice.

Data analysis

The data were evaluated by analysis of variance using SAS statistical software (SAS Institute 2002); then, evidence of comparative averages was performed by the Duncan's test at a level of significance of 5%, and a Pearson's linear correlation between variables was performed.

RESULTS AND DISCUSSION

The antioxidant composition of passionfruit juice was evaluated by the content of β-carotene and ascorbic acid. These compounds were quantified in the fractions of juice and are related to its antioxidant biochemical mechanism (Pérez-Jiménez et al. 2008). The β-carotene content of passionfruit juice was not significantly changed by the different combinations of rootstocks (Table 1). It is noticeable that, despite the passionfruit plants' suffering due to a cut by the grafting (wound) and cicatrization processes as described by Salazar et al. (2015), as well as oxidative reactions of →

Table 1. Characterization of antioxidant (β-carotene and ascorbic acid) and chemical content in fruits of passionfruit plants (*Passiflora edulis* Sims) grafted on *P. edulis* Sims, *P. gibertti*, *P. mucronata* and non-grafted (by seed), in Viçosa (MG).

Species	β-carotene*	Ascorbic acid*+
P. edulis/*P. gibertti*	1.0490a	29.37c
P. edulis/*P. mucronata*	1.3362a	30.93b
P. edulis/P.edulis	1.4537a	29.64bc
P. edulis (non-grafted)	1.0585a	36.06a
CV (%)	**31.59**	**23.62**
SD	**0.33**	**3.44**

*Values followed by different letters differ significantly ($p < 0.05$) according to Duncan's test. +Taken and complemented from the work of Salazar et al. (2015). CV = Coefficient of variation; SD = Standard deviation.

maturation metabolism in early stages, there was retention of β-carotene in the juice. Regarding the levels of β-carotene, the fruits analyzed in this study were compared, as a reference, to carrots, which are known by presenting concentrations of this carotenoid. Campos et al. (2006) concluded that, out of the seven vegetables studied, carrots had the highest levels of β-carotene, with an average of 5.18 mg.

According to Table 1, the contents of ascorbic acid found in the fruit of *P. edulis* with all combinations of rootstocks and *P. edulis* Sims (without grafting) exceed the value of 20 mg of ascorbic acid per 100 g of juice. The highest values of ascorbic acid were found in non-grafted *P. edulis*, followed by *P. edulis*/*P. mucronata* (36.06 *versus* 29.37 mg 100 g of juice, respectively; $p \leq 0.05$) (Table 1). In contrast, the combinations *P. edulis*/*P. gibertti* and *P. edulis*/*P. edulis* showed the lowest values of ascorbic acid (29.37 and 29.64 mg 100 g of juice). These results are promising because all combinations had more than 20 mg per 100 g of juice, the minimum market value required for passion fruit (Santos et al. 2009). In general, these results suggest that phytogenetic resources can be utilized as rootstock without a negative effect on fruit market quality. The content values of ascorbic acid ranged from 29.37 to 36.06, denoting a higher content in *P. edulis* (not grafted), followed by the combination *P. edulis*/*P. edulis* (autograft) and with the lower contents of rootstock in combinations of wild species (*P. gibertti* and *P. mucronata*). Souza et al. (2012) evaluated the chemical composition, bioactive compounds and the present antioxidant activity in the pulp of five types of fruits of Brazilian Cerrado, including the species *Passiflora alata* Dryand, which showed β-carotene content from 1.31 ± 0.03 mg per 100 g considered low by researchers, as well as ascorbic acid with 24.66 ± 4.29 mg per 100 g of juice. According to Ramful et al. (2011), fruits are classified according to the content of ascorbic acid in three categories: low (< 30 mg per 100 g), medium (30 – 50 mg per 100 g) and high (> 50 mg per 100 g). According to this classification, the fruits of the combination *P. edulis*/*P. mucronota* and *P. edulis* (ungrafted) qualify as with medium content and combinations *P. edulis*/*P. gibertii* and *P. edulis*/*P. edulis* are considered low.

Other authors such as Coelho et al. (2010) reported a decrease in ascorbic acid in the early stages of passionfruit ripening at 22 °C. These same authors reported ascorbic acid levels similar to those found in this study, varying from 25 to 30 mg per 100 mL. According to Lee and Kader (2000), the content of ascorbic acid in the fruit is strongly influenced by normal metabolism (maturation and senescence) and other types of post harvest stress. Thus, the levels of ascorbic acid in the organs of the plant are tightly controlled by the levels of synthesis, degradation, transport and recycling within the cell (Rotili et al. 2013). Due to the antioxidant properties of ascorbic acid, the route of recycling is particularly important in the fruit during the body's response to oxidative stress, when the reduced ascorbic acid is oxidized to the unstable form of dehydroascorbic acid, which can be easily degraded. Conforming with Stevens et al. (2008), the reduced form of ascorbic acid can die out if the oxidized forms are not recovered by reductase enzymes (monodehydroascorbate and dehydroascorbate reductase), genetically expressed in response to oxidative stress.

All the fruits of passionfruit in the different combinations of rootstocks studied in this work showed low concentrations of β-carotene compared to carrots; fruits from combinations *P. edulis*/*P. edulis* and *P. edulis*/*P. mucronata* showed the highest numerical levels of β-carotene with 1.45 and 1.34 mg per 100 g, respectively.

As reported by Uenojo et al. (2007), carotenoid levels in fruit cells remain relatively constant until the onset of senescence, and two types of enzymes are responsible for the oxygenation and degradation of carotenoids: lipoxygenase derived from chloroplasts, which catalyze the conversion of unsaturated lipids into aroma compounds; and peroxidase, from mitochondria. β-carotene retention in the juice of the fruits of grafted plants in wild *Passiflora* reveals the benefit of maintaining their nutritional bioavailability.

Significant correlations were observed among the contents of β-carotene, ascorbic acid and luminosity values (*L*), chroma (*C*) and hue angle (*h*°) (Table 2). For the combination *P. edulis*/*P. gibertti*, the contents of β-carotene and ascorbic acid were highly correlated with luminosity, chroma and hue angle of fruit juice with values of 44.02, 10.00 and 94.45°, respectively, indicating that the juice of the fruits of this combination have a low amount of saturation or pigment, as well as a yellow color (> 90°). A similar behavior was observed with the combination *P. edulis*/*P. mucronata* in the content of ascorbic acid and a highly significant correlation with the hue angle of juice with a value of 94.45°; *L*, *C* and *h*° of the rind of the fruits of this combination, with values of 70.93, 43.15 and 92.31°, respectively, indicate that the juice of the fruits has an intense yellow color (> 90°), and the rind has a high saturation of pigments and an intense yellow color. In this same combination, the content of β-carotene was significantly correlated with the content of titratable acidity with values of 4.72 g per 100 g of citric acid. →

Table 2. Pearson's linear correlation coefficient between the chemical and physical variables of the fruits of passionfruit (*Passiflora edulis* Sims) grafted on *P. edulis* Sims, *P. gibertii*, *P. mucronata* and non-grafted (by seeds), in Viçosa (MG).

Species	Variables	*L* (Juice)	*C* (Juice)	*h*° (Juice)	*L* (Rind)	*C* (Rind)	*h*° (Rind)	Relation soluble solids/acidity	Soluble solids	Titratable acidity	Ascorbic acid
P. edulis/ P. gibertti	β-carotene	−0.43**	−0.38**	−0.12^{ns}	−0.12^{ns}	−0.02^{ns}	0.04^{ns}	−0.03^{ns}	0.05^{ns}	0.10^{ns}	−0.11^{ns}
	Ascorbic acid	−0.11^{ns}	−0.03^{ns}	0.40**	−0.17^{ns}	0.01^{ns}	0.01^{ns}	0.08^{ns}	0.20^{ns}	0.15^{ns}	
	Titratable acidity	−0.01^{ns}	0.15^{ns}	0.23^{ns}	0.30*	0.42**	−0.39**	−0.61**	0.37**		
	Soluble solids	0.25^{ns}	0.35*	0.01^{ns}	0.32*	0.45**	−0.36**	0.49**			
	Relation soluble solids/ acidity	0.17^{ns}	0.13^{ns}	−0.23^{ns}	−0.03^{ns}	0.01^{ns}	0.04^{ns}				
	h° (Rind)	−0.12^{ns}	0.05^{ns}	0.75^{ns}	−0.66**	−0.84**					
	C (Rind)	0.08^{ns}	−0.08^{ns}	−0.01^{ns}	0.67**						
	L (Rind)	0.24^{ns}	0.06^{ns}	−0.08^{ns}							
	h° (Juice)	−0.18^{ns}	0.02^{ns}								
	C (Juice)	0.78**									
P. edulis/ P. mucronata	β-carotene	0.06^{ns}	−0.02^{ns}	−0.05^{ns}	−0.04^{ns}	0.08^{ns}	−0.10^{ns}	−0.18^{ns}	0.068^{ns}	0.25*	0.15^{ns}
	Ascorbic acid	−0.16^{ns}	0.01^{ns}	0.23*	−0.35**	−0.33**	0.32**	0.040^{ns}	−0.026^{ns}	−0.05^{ns}	
	Titratable acidity	0.16^{ns}	0.08^{ns}	−0.11^{ns}	0.36**	0.32**	−0.36**	−0.87**	0.16^{ns}		
	Soluble solids	0.14^{ns}	0.11^{ns}	−0.09^{ns}	0.27*	0.31**	−0.38**	0.32**			
	Relation soluble solids/ acidity	−0.03^{ns}	−0.02^{ns}	0.02^{ns}	−0.22^{ns}	−0.15^{ns}	0.16^{ns}				
	h° (Rind)	−0.04^{ns}	−0.07^{ns}	0.19^{ns}	−0.78**	−0.92**					
	C (Rind)	0.02^{ns}	0.06^{ns}	−0.18^{ns}	0.77**						
	L (Rind)	0.15^{ns}	0.11^{ns}	−0.14^{ns}							
	h° (Juice)	−0.34**	0.20^{ns}								
	C (Juice)	0.42**									
P. edulis/ P.edulis	β-carotene	−0.10^{ns}	−0.15^{ns}	−0.01^{ns}	0.16^{ns}	0.18^{ns}	−0.18^{ns}	0.34*	0.22^{ns}	−0.20^{ns}	−0.37*
	Ascorbic acid	0.03^{ns}	0.21^{ns}	0.15^{ns}	−0.50**	−0.43**	0.29^{ns}	−0.11^{ns}	−0.27^{ns}	−0.14^{ns}	
	Titratable acidity	0.29^{ns}	0.32*	0.12^{ns}	0.13^{ns}	0.09^{ns}	−0.09^{ns}	−0.71**	0.14^{ns}		
	Soluble solids	−0.11^{ns}	−0.18^{ns}	0.22^{ns}	0.33*	0.37*	−0.30*	0.59**			
	Relation soluble solids/ acidity	−0.32*	−0.39**	−0.14^{ns}	0.17^{ns}	0.22^{ns}	−0.17^{ns}				
	h° (Rind)	0.44**	0.30*	0.21^{ns}	−0.82**	−0.82**					
	C (Rind)	−0.33*	−0.24^{ns}	−0.10^{ns}	0.91**						
	L (Rind)	−0.30*	−0.19^{ns}	−0.19^{ns}							
	h° (Juice)	0.24^{ns}	0.61**								
	C (Juice)	0.65**									

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Table 2. Continuation...

Species	Variables	*L* (Juice)	*C* (Juice)	*h*° (Juice)	*L* (Rind)	*C* (Rind)	*h*° (Rind)	Relation soluble solids/acidity	Soluble solids	Titratable acidity	Ascorbic acid
P. edulis (non-grafted)	β-carotene	0.33^{ns}	0.23^{ns}	−0.15^{ns}	0.14^{ns}	0.17^{ns}	0.45^{ns}	0.29^{ns}	0.42^{ns}	−0.09^{ns}	0.57^{ns}
	Ascorbic acid	−0.07^{ns}	−0.11^{ns}	0.11^{ns}	−0.07^{ns}	−0.06^{ns}	0.18^{ns}	0.68*	0.05^{ns}	−0.49^{ns}	
	Titratable acidity	0.62^{ns}	0.65*	−0.27^{ns}	0.03^{ns}	−0.25^{ns}	0.25^{ns}	−0.91**	0.68*		
	Soluble solids	0.65*	0.58^{ns}	−0.39^{ns}	−0.31^{ns}	−0.13^{ns}	0.83**	−0.36^{ns}			
	Relation soluble solids/ acidity	−0.50^{ns}	−0.57^{ns}	0.24^{ns}	−0.28^{ns}	0.08^{ns}	0.12^{ns}				
	h° (Rind)	0.36^{ns}	0.24^{ns}	−0.27^{ns}	−0.62^{ns}	−0.10^{ns}					
	C (Rind)	0.01^{ns}	0.01^{ns}	−0.23^{ns}	0.34^{ns}						
	L (Rind)	−0.21^{ns}	0.56^{ns}	0.10^{ns}							
	h° (Juice)	−0.65*	−0.65*								
	C (Juice)	0.99**									

*$p < 0.05$; **$p < 0.01$; ^{ns} not significant at $p < 0.05$.

With the combination *P. edulis* / *P. edulis* (autograft), the content of β-carotene was significantly correlated with the contents of ascorbic acid (29.64 g per 100 g of citric acid) and, in turn, the content of ascorbic acid was highly correlated with luminosity values and the chroma of the rind of the fruit with values of 71.29 and 38.88, respectively, indicating that the rind of the fruit has high saturation of pigments. Several authors have reported positive correlations between ascorbic acid and antioxidant activity (Contreras-Calderón et al. 2010; Rufino et al. 2010), while others have found no correlation (Almeida et al. 2011).

Finally, the combination *P. edulis* (ungrafted) obtained no significant correlation with the content of β-carotene and ascorbic acid. Perhaps this phenomenon is due to uneven ripening and harvest of the fruits because of the early flowering of grafted plants and the late flowering of non-grafted ones, as reported by Salazar et al. (2015). In the current research, harvest was carried out for five months beginning 190 days after transplantation.

Our results conform with those of Giorgi et al. (2005), who compared the effects induced by five of the most common rootstocks on peach (cv. 'Suncrest') plant development and yield, as well as on fruit quality, across two seasons of full production. These authors observed that, while firmness, soluble solids, and the ratio between total soluble solids and acidity in the fruits were affected only slightly by the different rootstocks, the total acidity of the fruit varied significantly according to the rootstock. Likewise, Drogoudi and Tsipouridis (2007) determined the variability in the antioxidant content and physical characters in fruit from nine clingstone peach cultivars/genotypes (*Prunus persica* L. Batsch) grafted on three rootstocks. These authors concluded that, while the effects of rootstock on the fruit antioxidant contents were not pronounced, a pronounced cultivar effect on the fruit antioxidant content was found. The relative low effect observed for rootstocks on the peach antioxidant content may be attributed to the close genetic origin of the studied rootstocks; nevertheless, effects on fruit weight were documented. Daza et al. (2008) analyzed the influence of eight different rootstocks on several fruit quality parameters of 'Pioneer' Japanese plum. These authors found that the effect of the different rootstocks on most of the analysed quality parameters was variable because of a strong interaction rootstock *versus* year. However, several parameters, such as fruit shape, soluble solid concentration, acidity and maturity, did not show significant differences year-by-year. On the other hand, Bassal (2009) evaluated the vegetative growth, yield and fruit quality of 'Marisol' clementine, as a newly introduced cultivar in Egypt, budded on four commercial rootstocks (Sour orange, Cleopatra mandarin, Carrizo citrange and 'Swingle' citrumelo). The results of

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this investigation showed that the tree size, yield, and fruit quality of 'Marisol' clementine can be controlled by the proper selection of rootstock. Rato et al. (2008) compared the effects induced by two different plum rootstocks (GF8-1 and GF10-2) and two different soils (Haplic Luvisol and Vertic Luvisol) on growth, fruit yield, mineral composition and fruit quality of plums. At harvest, soluble solids content and soluble solids content/titratable acidity ratio were not affected by soil type or rootstock.

In our research, of all the grafting combinations tested, passionfruit juice grafted in wild species of the genus *Passiflora* had a content of β-carotene, ascorbic acid (≥ 20 mg ascorbic acid per 100 g of juice) and fruit quality similar to those that were not grafted. Therefore, these fruits can have a nutritional and economic value equal to that of non-grafted plants.

CONCLUSION

The content of β-carotene in the fruit showed no statistical differences among the grafting treatments, indicating no significant rootstock effect on the evaluated fruit quality variables. The results thus indicate the potential of wild rootstock use for its positive effects, without affecting the commercial quality of the fruits of passionfruit crops.

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