Assessment of Twenty Two Citrus Cultivars (Oranges, Mandarins and Lemons) for Quality Characteristics and Phytochemical's Concentration.

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Abstract

Twenty two citrus cultivars belonging to three citrus species, namely, orange (*Citrus sinensis* (l.) Osbeck)(eleven cultivars), mandarin (*Citrus reticulata* L)(four cultivars) and lemon (*Citrus limon* L)(seven cultivars) were assessed for fruit quality characteristics and juice phytochemicals at maturation. Titratable acidity, pH, total soluble solids, *β*-carotene, total phenolic compounds, total o-diphenols, total flavonoids, and antioxidant capacity based on DPPH and FRAP assays were assayed. Lemon varieties were characterized by the lowest juice pH and by high titratable acidity. Total soluble solids were high in mandarins, followed by oranges and lastly by lemons. Carotenoids were determined in highest concentration in mandarin varieties while the lowest concentration was found in lemons. Oranges were characterized by high concentration of total phenols, with Salustiana exhibiting the highest value. Valencia clones exhibited the highest concentrations of both o-diphenols and flavonoids. On the other hand Clementine mandarins and lemons were characterized by high antioxidant capacity, higher than that observed in most of the orange varieties assayed and of Encore and Kara mandarins. The principal component analysis (PCA) revealed an interesting classification of the varieties assayed. Lemon varieties were grouped together; Kara and Encore mandarins belonged to the same group while Clementine mandarins were grouped with orange varieties.

INTRODUCTION

Among fruits, Citrus is the most widely produced fruit, as a group of several species, and it is grown in more than 80 countries (Ladaniya, 2008). Citrus products must be highlighted, as they are a major source of antioxidant compounds intake in the diet of developed countries (Ramful et al., 2011). The study of the polyphenolic and carotenoid composition of fruits is of great interest owing to the qualitative and quantitative differences appearing as a function of the species, cultivar, degree of ripening, and environmental conditions of growing, ripening, and storage (Obenland et al., 2011). It is therefore of major importance to be able to assess differences between species and cultivars in terms of fruit/juice quality characteristics and concentration of antioxidant compounds.

The aim of the present trial was to assess a number of citrus cultivars belonging to three different citrus species (namely orange, mandarin and lemon) in terms of juice quality characteristics and try to assemble a pattern describing species and cultivars in a simple way.

MATERIALS AND METHODS

The experiment was conducted at the orchard of Agricultural University of Athens (Latitude 37^0 58' N, Longitude 23^0 32' E, elevation 30m) during the growing season of 2009-2010. Eleven orange cultivars, four mandarin and seven lemon ones were sampled in the present experiment. The orange cultivars were Shamouti, Salustiana, Washington Navel, Navellina, Navelate, New Hall, Moro, Valencia Gambel, Valencia Olinda, Valencia Cutter and Valencia Frost. Mandarin cultivars used were Kara, Encore, Clementine SRA 63 and the Greek one Clementine Porou, while lemon cultivars used were Interdonato, Villa Franca, Santa Teresa, Lisbon and the Greek ones Adamopoulou, Karesteno and Magleno. Fruits were harvested at full maturity stage and a portion of the hand squizzed juice was immediately put into freezer (for analysis of titratable acidity (TA), total soluble solids (TSS) and pH values) while another part was diluted 1:1 with methanol and then put into freezer till analyses of total phenols, total o-diphenols, total flavonoids (according to Roussos, 2011) and antioxidant capacity, based on DPPH and FRAP assays (Klimczak et al., 2007). For the determination of *β*-carotene 5 mL of fruit juice solution were extracted with 20 mL of acetone:hexane solution (4:6) and *β*-carotene concentration was determined spectrophotometrically according to Navarro et al. (2010).

RESULTS AND DISCUSSION

All lemon cultivars assayed in this trial exhibited the lowest juice pH values followed with significant differences by those of mandarin and oranges (Table 1). The TSS values were high in mandarins followed by those in oranges. Lemons exhibited very low values of TSS with significant differences from both mandarins and oranges. Similar results have been reported also by Ramful et al. (2011).

Table 1. Juice quality characteristics (pH, total soluble solids (TSS, ^{0}Brix), titratable acidity (TA, % citric acid) and β-carotene (mg L^{-1}).

Species	Varieties	pH	TSS	TA	TSS/TA	β-carotene
Oranges	New Hall	3.83 ab	11.4 bcd	0.83 d	13.8 b	0.12 c
	Salustiana	3.82 ab	10.7 bcd	1.19 cd	9.0 bc	0.05 c
	Washington Navel	3.91 a	10.9 bcd	1.04 cd	10.7 bc	0.08 c
	Navelate	3.76 abc	10.5 cd	1.07 cd	8.9 bc	0.07 c
	Shamouti	3.67 abc	10.3 cd	1.23 cd	8.3 bc	0.08 c
	Navellina	3.7 abc	10.5 cd	1.17 cd	9.1 bc	0.08 c
	Moro	3.53 c	10.3 cd	1.49 cd	6.9 cd	0.07 c
	Valencia Cutter	3.52 c	11.9 abcd	1.87 bcd	6.5 cd	0.29 ab
	Valencia Frost	3.51 c	11.4 bcd	1.62 cd	7.3 cd	0.31 ab
	Valencia Olinda	3.48 c	11.5 bcd	1.85 bcd	6.3 cd	0.28 ab
	Valencia Gampbell	3.57 bc	10.9 bcd	1.55 cd	7.1 cd	0.27 b
Mandarines	Clementine Porou	3.85 ab	12.6 abc	0.72 d	19.3 a	0.06 c
	Clementine SRA63	3.71 abc	13.3 abc	1.30 cd	11.9 bc	0.12 c
	Encore	3.75 abc	14.4 a	1.13 cd	12.8 bc	0.43 a
	Kara	3.86 ab	13.7 ab	1.10 cd	12.3 bc	0.39 ab
Lemons	Interdonato	3.05 d	3.0 f	1.89 bcd	1.7 d	0.003 c
	Santa Teressa	3.01 d	4.67 ef	2.96 abc	1.6 d	0.002 c
	Villa Franca	2.89 d	5.97 e	3.67 a	1.7 d	0.007 c
	Adamopoulou	3.0 d	4.2 ef	3.41 ab	1.2 d	0.001 c
	Karesteno	2.99 d	5.4 ef	4.24 a	1.3 d	0.007 c
	Magleno	3.02 a	5.53 ef	3.60 a	1.8 d	0.01 c
	Lisbon	2.99 d	4.33 ef	3.52 a	1.2 d	0.004 c

Means within the same column, followed by the same leter do not differ significantly according to Tukey's HSD test at α=0.05.

Lemon cultivars presented the lowest TSS, similar to those reported by Georgiou (2009). Valencia clones presented high TSS values compared to other orange cultivars, without though significant differences. Titratable acidity values were low in oranges and mandarins, without significant differences, while lemons exhibited the highest values, in accordance with the literature (Georgiou, 2009; Uzun et al., 2009). The TSS/TA ratio was highest in Clementine Porou mandarin followed by New Hall and the other mandarin and orange cultivars. The highest *β*-carotene concentration was determined in Valencia clones and in Kara and Encore mandarins, while all other cultivars exhibited 3-7 fold lower *β*-carotene concentration than that determined in the pre-mentioned cultivars.

Salustiana orange exhibited the highest total phenol concentration, while Valencia Olinda the highest total o-diphenol concentration (Table 2). The highest flavonoid content was determined in the juice of Encore mandarin, while FRAP was highest in Clementine SRA 63. Higher total phenol and flavoinoid concentration in orange and mandarins compared to lemons has been also reported by Ramful et al. (2011). It is noteworthy that lemon cutlivars presented high antioxidant capacity by both assays.

Table 2. Juice total phenols (mg equivalent tannic acid), total o-diphenols (mg equivalent caffeic acid) and total flavonoids (mg equivalent caffeic acid) concentration and antioxidant activity based on DPPH and FRAP assays.

Species	Varieties	Total phenols	Total o-diphenols	Total flavonoids	FRAP	DPPH
Oranges	New Hall	37.4 b	4.32 def	1.43 e	469 ef	86.8 ab
	Salustiana	49.5 a	3.62 ef	1.88 de	481 ef	85.3 ab
	Washington Navel	33.75 bc	3.43 f	1.23 e	487 ef	73.5 c
	Navelate	32.8 bc	3.14 f	1.22 e	465 ef	78.8 bc
	Shamouti	33.6 bc	4.27 def	1.37 e	365 ef	73.7 c
	Navellina	30.9 bc	5.33 def	1.68 de	530 ef	93.6 a
	Moro	28.4 bc	7.56 bc	2.66 cd	566 ef	81.6 abc
	Valencia Cutter	35.7 bc	7.59 bc	3.84 c	487 ef	91.6 ab
	Valencia Frost	33.4 bc	8.58 b	5.31 b	307 ef	93.2 a
	Valencia Olinda	33.0 bc	11.1 a	6.37 b	658 def	90.0 ab
	Valencia Gampbell	32.3 bc	8.5 b	5.64 b	459 ef	86.9 ab
Mandarines	Clementine Porou	29.9 bc	3.24 f	1.08 e	1230 bcd	95.8 a
	Clementine SRA63	33.4 bc	2.88 f	0.79 e	1890 a	95.8 a
	Encore	27.6 bc	6.38 cd	7.86 a	264 f	45.6 d
	Kara	25.0 c	4.8 def	6.08 b	313 ef	53.3 d
Lemons	Interdonato	25.2 c	4.04 ef	3.11 c	1210 bcd	95.0 a
	Santa Teressa	32.4 bc	5.84 cde	3.84 c	1510 ab	91.7 ab
	Villa Franca	28.3 bc	4.68 def	3.39 c	1410 abc	92.2 ab
	Adamopoulou	29.8 bc	4.3 defe	3.81 c	757 cdef	90.1 ab
	Karesteno	27.4 bc	4.0 ef	3.60 c	982 bcdef	94.1 a
	Magleno	24.5 c	4.35 def	3.65 c	1060 bcde	88.2 ab
	Lisbon	25.9 bc	3.98 ef	3.53 c	1370 abc	90.9 ab

Means within the same column, followed by the same leter do not differ significantly according to Tukey's HSD test at α=0.05.

The scatter plot of the PCA revealed interesting relationships (Fig. 1), since lemons were grouped together at the far negative side of component 1 (showing low pH, TSS, and TSS/TA values and high FRAP values). Valencia clones were grouped together at the positive sides of both components (exhibiting high pH, TSS, TSS/TA, total flavonoids, *β*-carotene values and low TA and FRAP values), the other orange varieties and clementines were mainly grouped at the negative side of component 2 and positive of component 1 (showing high pH, TSS, TSS/TA values and low TA, FRAP, *β*-carotene and total flavonoid values). The rest of mandarin cultivars were at the positive sides of both components (exhibiting high pH, TSS, TSS/TA, total flavonoids, *β*-carotene values and low TA, FRAP values), diametrically opposite to that of clementines, which resembled more to orange varieties assayed in this trial.

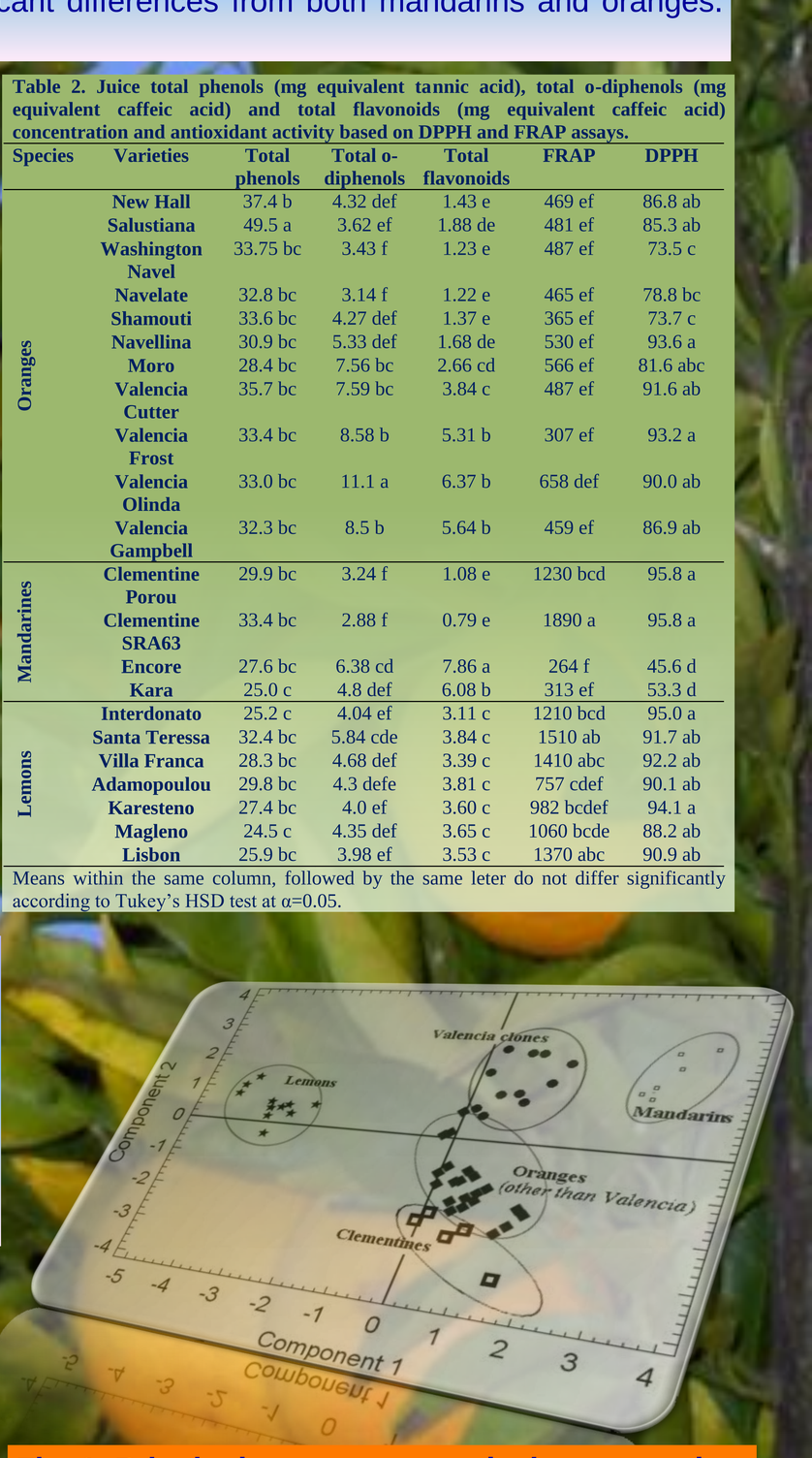

Fig. 1. Principal component analysis scatter plot.

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