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Comparative and organic analysis and characterization of varieties of tangerines

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ABSTRACT

The Brazilian production of citrus fruits is of great importance and the consumer market is quite demanding. Despite of this market, there are very few commercial varieties available and the information on them is insufficient. The objective of this work was to evaluate 26 varieties of tangerine, in order to identify early or late varieties, in relation to ‘Ponkan’, that can be used for “in natura” consumption and as raw material for the Juice and Drug industries. The varieties were harvested at ripening stage, considered the ideal stage for commercialization. The tangerines’ pH, titratable acidity (TA) and soluble solids (SS) content, ratio SS/TA, vitamin C content, and total extractable polyphenols, total antioxidant activity, number of seeds, juice yield, and peel color were evaluated. In addition, the characterization of the organic compounds, obtained from extracts analyzed by mass spectrometry, were conducted using electrospray ionization (ESI) technique. The experiment was performed in a completely randomized design, the data were submitted to analysis of variance, and the means were compared by Scott-Knott test. The tangerines ‘Clemenules’, ‘Tangor Robson’, ‘Imazu Ponkan’ and ‘Nankan 20’ are alternatives to ‘Ponkan’ for “in natura” consumption. However ‘Dekopon’ and ‘Ortanique’ are qualified for industry. The tangerines 'Clementina x Murcott' and 'Clementina Palazelli' present in their peel chemical profiles that must be studied and can be exploited by pharmacological sciences.

1. Introduction

Brazil is the world's largest producer of oranges and the second largest of tangerines (EPAMIG, 2015). Tangerines are the second most important group of citrus fruits in the world citriculture, occupying in a wide range of climatic adaptation among the cultivated citrus, since they are also tolerant to high and low ambient temperature levels (Jackson, 1991).

Citrus, especially sweet oranges and tangerines, are part of the diet of consumers because they have attractive colors and pleasant flavor and aroma (Zou et al., 2016). In addition to having a source of vitamins and fibers, citrus fruits are recognized for containing secondary metabolites including antioxidants such as ascorbic acid, phenolic compounds, flavonoids and limonoids, which are important for human nutrition (Jayaprakasha and Patil, 2007; Couto and Canniatti-Brazaca, 2010).

The quality of citrus fruits is of extreme importance to improve their commercialization, both for the “in natura” consumption as for the industrial processing, making the internal and external characteristics of the fruits be used, aiming at better appearance and organoleptic quality. Among the internal characteristics are yield, pH, titratable acidity, soluble solids, sugars and vitamin C, and the external ones include the shape, size and coloration (Villas Boas et al., 1998).

Among the citrus varieties the tangerine ‘Ponkan’ (*Citrus reticulata* Blanco) stands out for “in natura” consumption as one of the most popular tangerines and appreciated by the consumer, for having refreshing taste as other sensorial characteristics that please the palate, besides ease of peeling. Thus, the demand for varieties that are similar or superior chemical, physical and bioactive is increasing, making the study of tangerines and hybrids relevant for the expansion of the producer and consumer market (Borges and Pio, 2003).

The secondary metabolisms present in citrus peel have also great relevance. It should be noted that the ISO 14000 (Kawabata, 2008) suggests that industries need to have adequate waste management. Thus, some compounds present in the peel of the citrus fruits present an antibacterial (Ashok Kumar et al., 2011), antifungal (Liu et al., 2012),

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antioxidant (Choi et al., 2000), insecticide (Siskos et al., 2008), anti-inflammatory activities (Mabry and Ulubelen, 1980), among others, which are of interest to pharmaceutical industries, which are already using these extracts in drug composition (Bisignano and Saija, 2002). Thus, the peel can be an alternative income for both producers and industries, due to the use of the citrus compounds and the reduction of industrial waste. Thus, the trend towards full use of waste is an ever-increasing need in modern industry worldwide, especially where it should develop environmental management systems based on ISO 14000 (Kawabata, 2008).

These secondary metabolites, present in the peel of citrus fruits, such as terpenoids, carotenoids, coumarins, furanocoumarins and flavonoids, mainly flavonones, and polymethoxylated flavones, are rare in other plants (Ahmad et al., 2006) and responsible for their protection against biotic and abiotic factors. Despite the extensive bioactivity, only recently its antimicrobial characteristics were more exploited (Fisher and Phillips, 2008).

Facing the need to obtain new varieties of tangerines for "in natura" consumption and as raw material for juice and drug industry, this work evaluated 26 varieties of tangerine, in order to identify early or late varieties, in relation to 'Ponkan', that can be used for "in natura" consumption and as raw material for juice and drug industry.

2. Material and methods

2.1. Fruit material

Twenty-six varieties of tangerines were evaluated, in addition to conventional and organic 'Ponkan' tangerines, which were characterized (Table 1) and used in the comparison of the results for beeing the most consumed variety. The experiment was carried out in the period from March to August 2016, due to the specific periods of availability of the tangerine varieties, which were obtained directly at the collection sites shortly after harvest. The materials used were collected in the following places and time:

- Conventional 'Ponkan' tangerine: Goias Food Supply Center (CEASA - GO), located in Goiânia - GO (latitude 16° 37′36.09″S and longitude 49° 12′13.03″W and tropical climate with dry season accordin1g to Köppen e Geiger (1928)), in June 2016;
- Organic 'Ponkan' tangerine: 'Nossa Senhora Aparecida' Farm, located in Hidrolândia - GO (latitude 16° 57′44.30″S and longitude 49° 11′3.13″ W and tropical climate with dry season according to Köppen e Geiger (1928)), in June 2016;
- Tangerines 'Hino Akebono', 'Oogui Wase', 'Ogata', 'Iwaki', 'Híbrido 21′ were harvested in April 2016; 'Clementina x Murcott', 'Oota Poncan', 'Nankan 20′, 'Clementina Palazelli', 'Ankou Tangor', 'Imazu Poncan', 'Cravo', 'Robson', were harvested in May 2016; 'Ortanique Tangor', 'Poncan Embrapa', 'Tangor Nova', 'Hybrid 34′, 'Clemenules', 'BRS Page', 'Miyauti', were collected in June 2016, and 'Montenegrina', 'Decopon', 'Clementina','Tangor Lee', 'Kyomi Tangor', 'Tangor Ellendalle', were harvested in July 2016. These materials were collected at the Germplasm Bank of 'Agência Goiana de Assistência Técnica, Extensão Rural e Pesquisa Agropecuária' - EMATER, Located in Anápolis - GO (latitude 16° 20′0.41″S and longitude 48° 57′3.02″ W and tropical climate with dry season according to Köppen e Geiger (1928)).

Table 1
Characterization of conventional and organic 'Ponkan' tangerine varieties.

Variables	Conventinonal Ponkan	Organic Ponkan
pH	4.17 ± 0.05	3.99 ± 0.03
Titratable Acidity (%)	0.46 ± 0.02	0.65 ± 0.03
SS (%)	10.06 ± 0.13	11.90 ± 0.09
Ratio	21.78 ± 0.95	18.46 ± 0.92
Vitamin C (%)	42.28 ± 1.66	51.27 ± 1.89
Total extractable polyphenols (mg gallic acid $100g^{-1}$)	17.00 ± 0,58	18.72 ± 1.56
Total antioxidant activity (μM ferrous sulphate g^{-1})	9.98 ± 0.06	10.21 ± 0.19
Number of seeds	12.73 ± 4.12	9.67 ± 3.22
Juice yield (%)	35.78 ± 5.28	34.18 ± 7.23
L	57.55 ± 5.29	50.23 ± 7.46
Hue Angle	77.39 ± 6.17	83.62 ± 7.69
Chroma	88.94 ± 12.07	77.51 ± 12.65

Averages followed by standard deviation.

The fruits of all varieties were harvested in the early hours of the morning, at maturation stage considered ideal for commercialization, defined from the maturation index (SS/TA > 9.5), according to the standardization established for commercialization in the domestic market (Brasil, 2000). For each variety, approximately 70 fruits were collected, packed in plastic boxes, and sent to the Laboratory of the Horticulture Sector of the Federal University of Goiás (UFG), Goiânia - GO.

In the laboratory, the tangerines were selected by size, peel color, and absence of defects, to make the batch even more homogeneous, separating 30 fruits for each variety. After washing, with water and neutral detergent, the fruits were evaluated for physical, chemical and bioactive characteristics, and for organic compounds present in the peel.

2.2. Evaluations

2.2.1. Physical evaluations

2.2.1.1. Juice yield. Thirty replicates for each variety studied. The juice yield was calculated by the equation: (weight of juice x 100)/total weight of the fruit. The weight of the juice was obtained after extraction in an electric juice extractor, which was weighed in semi-analytical balance. The total weight of the fruit was obtained through the individual weighing in semi-analytical balance. The juice yield was expressed as a percentage (%).

2.2.1.2. Peel color. Was evaluated using a Color Quime II Spera colorimeter (Hunter Lab Reston, VA), expressed in luminosity (L*), hue angle (ºHue), and chromaticity (Chroma). The reading was performed in triplicate in each of the 30 fruits previously selected.

2.2.2. Chemical evaluations

2.2.2.1. pH. Was obtained according to the methodology described by IAL (2008). Ten replicates were used with three fruits each.

2.2.2.2. Titratable acidity (TA). Was determined by titration with 0.1 N sodium hydroxide solution (NaOH), and using phenolphthalein as indicator. Ten grams of tangerines juice diluted in 0.05 L of distilled water were used. The results were expressed as percent citric acid (% citric acid) (AOAC, 1997- method 942.15). Results obtained from 10 replicates with 3 fruits each.

2.2.2.3. Soluble solids content (SS). Was quantified in drops extracted from the juice, using a refractometer, and the results were expressed as percentage (%) (AOAC, 1997 - method 932.12). Results obtained from 10 replicates with 3 fruits each.

2.2.2.4. Ratio. Was quantified by dividing soluble solids (SS) and titratable acidity (TA), according to IAL (2008).

2.2.3. Evaluation of bioactive compounds

2.2.3.1. Vitamin C content. Was determined by titration with 0.002 M potassium iodate solution. Ten grams of tangerines juice diluted in 0.05 L of distilled water were used. Then were added 1 ml of potassium iodide solution (10 W/v %), 1 ml of starch solution (1 W/v %), and