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Phenolic compounds, organic acids and antioxidant activity of grape juices produced from new Brazilian varieties planted in the Northeast Region of Brazil

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ABSTRACT

The phenolic compounds, organic acids and the antioxidant activity were determined for grape juice samples from new Brazilian varieties grown in the Sub-middle São Francisco Valley in the Northeast Region of Brazil. The results showed that the Brazilian grape juices have high antioxidant activity, which was significantly correlated with the phenolic compounds catechin, epicatechin gallate, procyanidin B1, rutin, gallic acid, caffeic acid, *p*-coumaric acid, pelargonidin-3-glucoside, cyanidin-3-glucoside, cyaniding-3,5-diglucoside and delphinidin-3-glucoside. The produced juice samples showed higher concentrations of *trans*-resveratrol than those observed in juices made from different varieties of grapes from traditional growing regions. Organic acids concentrations were similar to those of juices produced from other classical varieties. It was demonstrated that it is possible to prepare juices from grapes of new varieties grown in the Northeast of Brazil containing a high content of bioactive compounds and typical characteristics of the tropical viticulture practised in the Sub-middle São Francisco Valley.

1. Introduction

The global production of grape juices is estimated to be around 11–12 million hectoliters and the main producer and consumer countries are the United States of America, Brazil and Spain (OIV, 2013). In Brazil grape juice production has been increasing for some years, and Rio Grande do Sul State is the main producer of grapes and their derivatives, where the production increased from 126.9 million L in 2008 to 220 million L in 2012 (Mello, 2013). Brazilian grape juices are produced from American hybrid grapes (*Vitis labrusca*) of the varieties Isabel, Bordô and Concord (Rizzon & Miele, 2012). In contrast, in the United States grape juices are mainly produced from Concord cultivars and Muscadine (*Vitis rotundifolia*) varieties (Iyer, Sacks, & Padilla-Zakour, 2010).

The Sub-middle region of the São Francisco Valley (SFV), located in the Northeast of Brazil at latitude 8 to 9°S and longitude 40 W, with a tropical semi-arid climate, has received considerable interest from the wine production sector. This region is the second biggest producer of refined grapes and wines in Brazil, and represents more than 95% of the national grape exportation (Mello, 2013). Recently, there has been notable investment in the large-scale commercial production of grape juice in this region. An important difference between the tropical viticulture practised in the SFV and that of other traditional regions of the world is that in the SFV each vine can produce two harvests per year. Also, since this is a region with hot weather, high luminosity and abundant water for irrigation, wineries operate according to a particular scheme, evaluating the best period in which to harvest the grapes and to

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prune the vines. Also, the "step" system can be applied, where the harvesting is distributed within a certain period (e.g., one month, several months or the whole year) (Camargo, Tonietto, & Hoffmann, 2011). Thus, it is possible to prepare grape juices throughout the year.

The vines planted in the Sub-middle SFV whose grapes are destined for the production of juices are of the cultivar Isabel Precoce (*V. labrusca*) and the hybrids BRS Cora and BRS Violeta. Also, although still in an experimental phase, the hybrid BRS Magna is planted, which is one of the new Brazilian varieties developed with the aim of improving the quality of grape juices (Camargo et al., 2011; Ribeiro, Lima, & Alves, 2012; Ritschel et al., 2012). Isabel Precoce is originally from a spontaneous somatic mutation of the variety Isabel and it offers good productivity, anticipated maturation and the same characteristics as the original cultivar (Camargo, 2004). The hybrid varieties BRS Cora and BRS Violeta are used to improve the colour of juices when required, and the use of a proportion of 15–20% in the juice formulation is recommended (Camargo, Maia, & Nachtigal, 2005). In relation to climate, the hybrid variety BRS Magna is widely adaptable and it is used for the production of juice with good colour and also with the typical aroma of *V. labrusca* (Ritschel et al., 2012). The first large-scale commercial juice production plants in the São Francisco Valley used mixtures of 80% Isabel Precoce with 20% BRS Cora or 20% BRS Violeta, to obtain products with good colour intensity.

Grape juices are rich in phenolic compounds and different studies have demonstrated that these substances possess biological activity related to health benefits for the consumers (Krikorian et al., 2012; Vauzour, Rodriguez-Mateos, Corona, Oruna-Concha, & Spencer, 2010). The phenolic compounds in grape juices, mainly the flavonoids flavanols, flavonols and anthocyanins, are associated with improved health, along with other compounds which are not flavonoids, such as phenolic acids and the stilbene resveratrol (Ali, Maltese, Choi, & Verpote, 2010; Krikorian et al., 2012; Sautter et al., 2005; Xia, Deng, Guo, & Li, 2010). The flavonols are represented mainly by kaempferol, quercetin and myricetin and simple *ortho*-methylated derivatives such as isorhamnetin, which have received considerable interest due to their antioxidant properties (Mudnic et al., 2010). Among the flavanols, (+)-catechin, (−)-epicatechin and procyanidins have gained attention due to their antioxidant, antimicrobial and bactericidal activity (Xia et al., 2010). The principal anthocyanins found in juices are malvidin, cyanidin, delphinidin, petunidin, peonidin and pelargonidin. The consumption of these anthocyanins is associated to biological activities, such as antioxidant capacity and prevention of cardiovascular diseases (Oh et al., 2008; Xia et al., 2010). Phenolic acids, such as gallic, caffeic and chlorogenic, have been studied for their antioxidant capacity and for acting as venous dilators (Mudnic et al., 2010). Also, stilbenes, particularly *trans*-resveratrol (*trans*-3,5,4′-trihydroxystilbene), have been associated with many health benefits including bactericidal, fungicidal, cardio-protection and anticancer activity as well as increased longevity in humans (Ali et al., 2010).

Several types of biological activity are related to phenolic compounds and antioxidant capacity, which is the one most commonly investigated, is mainly associated with flavonoid compounds, although this property has also been reported for non-flavonoids. The results obtained for the quantification of antioxidant activity can vary according to the method used (Muselík, García-Alonso, Martín-López, Žemlička, & Rivas-Gonzalo, 2007). For grape juices several techniques have been tested (Burin et al., 2010; Dani et al., 2007; Dávalos, Bartolome, & Gómez-Cordove's, 2005). The International Organization of Vine and Wine (OIV) recommends the use of a sensitive colorimetric free radical scavenger method using 2,2-diphenyl-1-picrylhydrazyl reagent (DPPH) (Organisation Internationale de la Vigne et du Vin, 2011).

Other interesting and important compounds in grape juices are the organic acids, due to their influence on the organoleptic properties such as flavor, taste, colour and aroma. They also affect the juice stability and are used as indicators of microbiological alterations in the beverage. In particular, the presence of acetic acid is an indicator of unwanted microbiological changes (Ali et al., 2010). The organic acids in grape juices are similar to those found in the must of fresh grapes, with tartaric and malic acids being predominant and succinic and citric acids being present in smaller amounts (Soyer, Koca, & Karadeniz, 2003). These compounds are associated with the typical characteristics of grape juices (Camargo, 2004).

Several factors including the grape variety, processing technique, viticultural practise and geographical region exert a significant influence on the phenolic composition and antioxidant activity of juices (Dani et al., 2007; Fuleki & Ricardo-da-Silva, 2003; Leblanc, Johnson, & Wilson, 2008; Natividade, Corrêa, Souza, Pereira, & Lima, 2013; Talcott & Lee, 2002). In order to evaluate the bioactive phenolic potential of grape juices, the objective of this investigation was to determine *in vitro* the phenolic compounds and organic acids content, along with the antioxidant activity, of juices produced from *V. labrusca* grapes of the varieties and hybrids planted at the Sub-middle region of the São Francisco Valley in the Northeast region of Brazil.

2. Materials and methods

2.1. Chemicals

Ethyl alcohol, potassium persulfate and Folin–Ciocalteu reagent were obtained from Merck (Darmstadt, Germany). Trolox (6-hydroxy-2,5,7,8-tetramethylchroman-2-carboxylic acid), 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2-azino-bis(3-ethylbenzthiazoline-6-sulfonic acid) (ABTS) were purchased from Sigma–Aldrich (St. Louis, MO, USA). Methanol, acetonitrile and 85% phosphoric acid were obtained from Vetec Chemistry Ltda (Rio de Janeiro, Brazil), J.T. Baker (Phillipsburg, NJ, USA) and Fluka (Switzerland), respectively. Tartaric, malic, citric, succinic, lactic, acetic and ascorbic acids were purchased from Vetec chemistry Ltda (Rio de Janeiro, Brazil). Ultra-pure water was obtained by purification using a Purelab Option Q Elga System (USA). Malvidin 3,5-diglucoside, cyanidin 3,5-diglucoside, malvidin 3-glucoside, cyanidin 3-glucoside, peonidin 3-glucoside, delphinidin 3-glucoside and pelargonidin 3-glucoside, kaempferol 3-glucoside, myricetin, quercetin, rutin (quercetin 3-rutinoside), isorhamnetin 3-glucoside, (+)-catechin, (−)-epicatechin, (−)-epicatechin gallate, (−)-epigalocatechin, procyanidins A2, B1 and B2, and *trans*-resveratrol were purchased from Extrasynthese (Genay, França). Gallic acid, cinnamic acid and caffeic acid were purchased from Chem Service (West Chester, USA). *p*-Coumaric and chlorogenic acid were obtained from Sigma–Aldrich (St. Louis, MO, USA).

2.2. Grape samples

The grapes of the Isabel Precoce and BRS Violeta varieties were collected from a specific area destined for the production of commercial juice at the Fazenda Fujiyama which forms part of the Cooperativa Agrícola Nova Aliança (COANA), located at Projeto Senador Nilo Coelho – Núcleo 4, lote 56, Zona Rural, Petrolina, Pernambuco State, Brazil, situated at 09° 21′S latitude and 40° 40′W longitude, at an altitude of approximately 360 m. The grapes of BRS Cora and BRS Magna varieties were harvested at the experimental vineyard Fazenda Timbaúba Agrícola located at Rodovia BR 122, km 174, PISNC Núcleo 11, Zona Rural, Petrolina Pernambuco State, Brazil, situated at latitude 09° 11′S and longitude 40°