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RESEARCH ARTICLE

PRODUCTION, CHARACTERIZATION AND SENSORY ANALYSIS OF WINES (*Vitis* spp.) FROM GRAPES PRODUCED IN A SUBTROPICAL REGION

*,[1]Tatiana Abreu Reis, [2]Gabriel Abreu Reis, [2]Rafaela Araújo Zambaldi Lima, [1]Renata de Paulo Rocha, [2]Antonio Decarlos Neto, [1]Taciene Carvalho Mesquita and [1]Luiz Carlos de Oliveira Lima

[1]Food Science Department – DCA, Federal University of Lavras - UFLA; PO Box 3037; Zip code 37200.000 - Lavras, Minas Gerais, Brazil

[2]Agriculture Department – DAG, Federal University of Lavras - UFLA; PO Box 3037; Zip code 37200.000 - Lavras, Minas Gerais, Brazil

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ABSTRACT

The aim of this study was to evaluate the physical, chemical and sensory characteristics of wines from different grape cultivars (*Vitis* spp.) produced in Lavras, in the southwest of Minas Gerais, Brazil. Grapes of cultivars 'Niagara Rosada', 'Bordo', 'Isabel Precoce', 'BRS Rúbea', 'BRS Cora' and 'Concord Clone 30', used to produce the experimental wines, were produced in the orchard of the University Federal of Lavras, from August to December 2013. The winemaking followed the methodology proposed by Malgarin *et al*., (2006), adapted. The analyses used to physically and chemically characterize the wines were: soluble solids (SS), titratable acidity (TA), SS/TA ratio, pH, total sugars, reducing and non-reducing sugars, dry extract, reduced dry extract, alcohol content, alcohol/reduced dry extract ratio, density, antioxidant activity by DPPH and β-carotene/linoleic acid methods, total phenolics, vitamin C, anthocyanins and color (L*, a*, b* and C). The sensory analysis acceptance test was performed with 50 tasters, who evaluated the attributes: appearance, aroma, taste, overall impression and purchase intention. The different wines produced are within the standards of wine identity and quality, proposed by Brazilian legislation and the values of the variables found in the samples are close to reference values presented in studies with wines from traditional wine-growing regions in Brazil. The wines were classified as dry table wines; the 'Niagara Rosada' wine was light-bodied and the others were considered more full-bodied. Due to the difference among cultivars, considering the biochemical aspect and the grape metabolism, the antioxidant activity, phenolic compounds content, ascorbic acid and anthocyanin content varied. These differences suggest the possible interference of soil and climate conditions on the cultivar adaptation response in the region where the experiment was conducted, especially the cultivars 'Bordô' and 'BRS Cora'. Overall, average sensory analysis scores of the samples fell between 4.56 and 7.22 on the hedonic scale, represented by the categories "neither liked nor disliked" and "liked moderately", respectively, highlighting the 'Bordô', 'Niagara Rosada', 'BRS Rúbea' and 'Concord Clone 30' cultivars, which were preferred by consumers regarding aroma and taste, overall impression and purchase intention attributes. Regarding purchase intent of the different wines, the tasters answered "do not know if I would buy" and/or "I probably would not buy", which may be related to the profile of the tasters. In this context, production of grapes from different cultivars (*Vitis* spp.) for wine production in subtropical regions can be conducted as an alternative for the development and establishment of rural populations, since climate conditions positively influence physicochemical composition and sensory aspects of cultivated grapes. This allows, therefore, the development of products derived from grapes, with competitive features which may be accepted by a different public, which has a preference for dryer wines.

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INTRODUCTION

The American grape is a fruit that has aroused interest because of its high productivity, rusticity and fruit use in various forms. The products obtained from its processing are greatly appreciated by consumers, who increasingly demand food products ready for consumption, especially those with high nutritional and technological value. Epidemiological studies have shown that a healthy diet, with high vegetable intake, can minimize the risk of chronic no communicable disease emergence (Cerqueira *et al*., 2007), contributing to improved life quality and successful aging (Terra *et al*., 2011). According to the Pan American Health Organization (2003), insufficient fruit consumption is among the ten most important

****Corresponding author: Tatiana Abreu Reis,***
Food Science Department – DCA, Federal University of Lavras - UFLA; PO Box 3037; Zip code 37200.000 - Lavras, Minas Gerais, Brazil.

risk factors for disease development. Some studies suggest that red wine consumption, in moderate doses, provides a protective effect on the cardiovascular system, causing an increase in HDL-c levels (Soares Filho *et al*. 2011; De Moraes and Locatelli, 2012; Chiva-Blanchet *et al*., 2013) and a reduction in LDL levels (Abe *et al*., 2007; Cerqueira *et al*., 2007). Furthermore, studies by Karling (2013) report multiple biological effects related to dietary phenolic compounds, such as antioxidant, antiinflammatory, antimicrobial and anticarcinogenic activity. Among the vegetable products, wine has attracted scientific interest as it presents a wide range of substances, highlighting the oxidants, reducing agents and catalysts, as well as phenolic compounds, tannins and anthocyanins, which contribute to the definition of its sensory characteristics such as taste, texture and color. However, it is known that the phenolic compounds composition and concentration are influenced by numerous factors, such as grape cultivar and climatic and cultivation conditions (Recamales *et al*., 2006; Orduña, 2010; Karling, 2013).

According to studies by Oliveira (2012), Brazilian red wines currently are at quality level comparable to major global wine producers. Soil, climate and production conditions provide favorable conditions for the grapes to develop high phenolic compound concentrations, which are potential bioactive compounds. As a result, wines produced from grapes planted and grown in Brazilian soil exhibit high levels of antioxidant phenolic compounds, comparable or even superior in some cases, to the average contents mentioned in the literature on wines from other countries. In this context, there is a need for studies that take this approach to wines produced in the Southwest region of Minas Gerais, thus contributing to viticulture implementation in this region. Thus, the aim of this study was to evaluate the physical, chemical and sensory characteristics of wines (*Vitis* spp.) made from grapes produced at the Federal University of Lavras, in the city of Lavras, southwest of Minas Gerais, Brazil.

MATERIALS AND METHODS

Grape production and harvest

The experiment was conducted in the years 2013 and 2014, at the Federal University of Lavras - MG, Brazil, located at Latitude 21:23° W and Longitude 44.98 °S at an altitude of 919 m. Grapes from 'BRS Cora', 'Isabel Precoce', 'BRS Rúbea', 'Bordô', 'Concord Clone 30' and 'Niagara Rosada' cultivars, used for wine production in this experiment were produced in the institution orchard, from August to December 2013. After the 2013-2014 crop harvest, manual stem removal and hygiene, the grapes were destined for winemaking.

Wine production

The wines were experimentally produced at the Fruit and Vegetable Postharvest Physiology Laboratory of the Food Science Department, Federal University of Lavras (UFLA – Lavras, MG), according to methodology proposed by Malgarin *et al*. (2006), adapted. For the wine production, de-stemming and must extraction were performed manually. Potassium metabisulfite was added ($K_2S_2O_5$) at a dosage of 6 g Kg^{-1} of must, and in order to achieve an alcohol content of approximately 10.5%, the proportion of 3.56 kg sucrose for each 100 liters of must was added (MALGARIN, *et al*., 2006). Maceration was carried out in a plastic container with a 10 L capacity. After the maceration period, with three daily remontages, the must was drained with subsequent filtration and separation. After 20 days of fermentation, the first racking was performed, filtering the liquid and topping up every two days. The second racking was performed after 25 days, filtering up again using organza, for a total of 45 days of fermentation. After the wine stabilization period (40 days), it were bottled and the analyses were performed.

Wine characterization analyses

Wine density determination followed methodology proposed by the Association of Official Analytical Chemists (A.O.A.C.) (1990). The pH measurement was made in the filtered wine, using a Tecnal (Tec 3M) pH meter with a glass electrode, according to AOAC (2007) recommendations. Wine soluble solids (SS) were determined in a homogenate filtered through filter paper, prepared in a 1:4 (10 ml of wine in 30 ml of distilled water) ratio using a digital refractometer ATAGO PR-100 and the results were expressed in %, according to AOAC (2007) methodology. Total acidity (TA) determination was done in the same homogenate prepared for SS measurement, following methodology proposed by AOAC (2007). Titration was carried out with sodium hydroxide (NaOH) solution 0.1 mol L^{-1}, and the results were expressed in percentage (%) of tartaric acid 100 mL^{-1}, considering the molecular weight of tartaric acid 150.09 g/mol. To calculate the SS/TA ratio, the total soluble solids content was divided by the titratable acidity. Total sugars, reducing and non-reducing sugars were quantified by the Somogy technique, adapted by Nelson (1944), and the determination was carried out in the ethanolic wine extract. Absorbance readings of the sample were taken at 510 nm in a Beckman 640 B spectrophotometer using a computerized system. Determination of wine samples dry extract and reduced dry extract was performed following the Adolfo Lutz Institute (1985) methodology.

Wine antioxidant activity determination was performed by the DPPH radical (2,2-diphenyl-1-picryl-hydrazyl) sequestration method by antioxidants according to Brand-Williams, Cuvelier and Berset (1995), adapted by Rufino *et al*. (2007a). To determine the antioxidant activity, the same extracts used for total phenolics determination were used, as suggested by Larrauri, Rupérez and Saura-Calixto (1997). Evaluation of wine antioxidant activity by β-carotene/linoleic acid system followed protocol recommended by Miller (1971) and adapted by Rufino *et al*. (2007b). Quantification of vitamin C (ascorbic acid) levels was carried by a colorimetric method, using 2,4-dinitrophenylhydrazine, according to Strohecker and Henning (1967). Total phenolic compounds were obtained according to the colorimetric method developed by Singleton and Rossi (1965), using the Folin-Ciocalteu reagent, in solution with at concentration of 10% (v/v). Total anthocyanins content analysis was performed following the pH differential method proposed by Giusti and Wrolstad (2001). To evaluate the wine coloration, a Minolta Colorimeter Model CR 400 was employed, using the Commission International de Eclairage system (CIE, 1978) to assess the L*, a* and b* coordinates. The a* and b* values obtained were used in the calculation of Hue angle and chromaticity, following recommendations by McGuire (1992). The Hue angle of the wines was calculated according to the following equation: $h^o = \tan^{-1}(b^*/a^*)$. Chromaticity was calculated by the equation: $C^* = \sqrt{a^{*2} + b^{*2}}$ To analyze the wine samples sensory attributes, tests were conducted at the Sensory Analysis Laboratory of the Department of Food Science at the Federal University of Lavras. The tests were approved by the Human Research Ethics Committee with Opinion Number: 728950 and report date: 7/25/2014. For such, affective methods suggested by Meilgaard *et al*. (1999) were employed. Sensory tests were performed - according to interest and availability - with 50 untrained tasters over 18years of age of both sexes, who reported to appreciate the drink Seccions were held in the Department of Food Science (DCA) - UFLA. Wines were laid out in 50 mL cups, coded with random three-digit numbers and served in compliance with the sample presentation order criteria suggested by Wakeling and Macfie (1995). Wine acceptability was measured by applying an Acceptance Test, in which the samples were evaluated on a 9 point hedonic scale, Score 1 representing "extremely disliked" and Score 9, "extremely liked". In this test we evaluated the following wine attributes: appearance, aroma, taste and overall impression. At the same time a Purchase Intent Test was performed, in order to identify consumer attitude towards the product assessed. For such, a structured 5-point scale was used, where Value 1 is "certainly would not buy" and the Value 5 is "certainly would buy".

Statistical Analysis

This study used a completely randomized design (CRD) containing 6 treatments, composed of wines from 6 different grape varieties, formulated 3 times, all the physical and chemical analyzes being performed in triplicate. The treatments were analyzed by the Scott-Knott average test (Scott and Knott, 1974) at 5% probability. For this, we used the ScottKnott package (Jelihovschi *et al*., 2014) from the R software (R Development Core Team, 2012).

Multivariate analysis was also performed on the results of acceptance/preference of sensory attributes, obtained from the affective test. A vectorial Internal Preference Map (MPI) was generated. The data set was arranged in a matrix with 6 lines (V1 to V6 treatments) versus 50 columns (consumers). Vectorial internal preference map plots were obtained using the SensoMaker software version 1.8 (PINHEIRO; NUNES; VIETORIS, 2013).

RESULTS AND DISCUSSION

Physicochemical characterization of the produced wines is extremely important because it helps the observation of aspects that make the product accepted, or not, by the consumer.

Table 1 shows the average values of soluble solids (TSS), titratable acidity (TA), SS/TA ratio and pH of the six different *Vitis* spp. wines elaborated.

Table 1. Average soluble solids SS (%), titratable acidity TA (% tartaric acid) SS/TA ratio and pH values of six different *Vitis* spp. Wines

Cultivar	Soluble Solids	Titratable Acidity	SS/TA	pH
BRS Cora	7.90a	3.05a	2.59c	3.39bc
Isabel Precoce	7.87a	2.95a	2.75bc	3.49a
BRS Rúbea	8.03a	2.40ab	3.35bc	3.29d
Bordô	7.87a	2.30ab	3.42b	3.38bc
Concord Clone 30	6.97b	2.05bc	3.40b	3.35cd
Niágara Rosada	6.43c	1.50c	4.29a	3.42ab
CV	1.28	11.59	8.61	0.73
Standard Error	0.136	0.158	0.154	0.014

Means followed by the same letter in the column do not differ by the Scott-Knott test at 5% probability.

There was statistical difference between the different wines regarding the soluble solids. The wines produced with BRS Cora, Isabel Precoce, BRS Rúbea and Bordô grape varieties showed the highest SS levels when compared to the others (Table 1). This parameter is positively correlated with the sample sugar content and therefore is generally accepted as an important quality characteristic, although they are directly influenced by cultivation conditions and cultivar (Silva *et al*., 2003a; Vilas Boas, 2014), which may explain the difference among samples. Malgarin and colleagues (2006) found values between 6.0 and 6.8 for this variable in their studies, which corroborate those of the present study. SS average values can be considered appropriate, since most *Vitis labrusca* cultivars generally present lower sugar production potential compared to *Vitis vinifera* (Rombaldi *et al*., 2004). As for the titratable acidity parameter, statistical difference between the different produced wines was observed. Wines made with BRS Cora and Isabel Precoce grape varieties showed the highest values, followed by wines elaborated with BRS Rúbea and Bordô varieties, which were statistically similar (Table 1). The titratable acidity of different produced wines ranged from 1.5 to 3.05 $g.L^{-1}$ of tartaric acid, values lower than those found in wines from *Vitis vinifera* and *Vitis labrusca* grapes, which range from 5.0 to 8.6 $g.L^{-1}$ (Lee *et al*., 2008; Son *et al*., 2009). According to studies from Girar and Mazza (1998), the presence of high levels of acidity in grape juice is justified by the predominance of organic acids in the drink, which can vary according to the cultivar. As they provide taste and flavor characteristics, the acid taste (sour) in wine can be modified by ethanol, sugar and cations (Avila, 2002). In general, the best wines are those with low acidity, however, regarding white wines, those slightly acidic are more desirable (Avila, 2002). The soluble solids/titratable acidity ratio (SS/TA) is an indication of quality since it relates the sugars and acids present in the fruit and thus defines the taste characteristics of the wine. The soluble solids/titratable acidity ratio presented statistical difference between wine formulations (Table 1). The wine made from Niágara Rosada grape had the highest value, while the wine made from BRS Cora presented the lowest ratio value. For pH analysis, the wine made from Isabel Precoce grape variety had the highest value, while the lowest value was observed for the wine made with BRS Rúbea variety. In wines, the hydrogen ions (H+) concentration is between 0.0001 and 0.001 $g.L^{-1}$, which corresponds to a pH variation between 3 and 4 (Hashizume, 1983), a 3.1 to 3.4 pH being desirable for white wines and 3.3 to 3.6 for red wines (Jackson, 2000).

Table 2. Average values for total, reducing and non-reducing sugars, dry extract, reduced dry extract, alcohol content, alcohol/ reduced dry extract ratio and density of six different *Vitis* spp. Wines

Cultivar	Total Sugars ($g.L^{-1}$)	Reducing Sugars ($g.L^{-1}$)	Non-reducing sugars ($g.L^{-1}$)	Dry Exctract $g.L^{-1}$	Reduced Dry Extract $g.L^{-1}$	Alcohol Content v/v	Alcohol/ Reduced dry extract	Density $g.mL^{-1}$
BRS Cora	0.32 bc	0.19 b	0.12 b	31.95 a	29.99 a	10.10 d	2.69 c	0.9991 a
Isabel Precoce	0.19 cd	0.15 b	0.03 b	30.22 ab	29.20 ab	10.53 b	3.09 bc	0.9985 ab
BRS Rúbea	0.45 b	0.30 a	0.14 b	29.28 ab	25.86 abc	10.30 c	3.57 ab	0.9977 b
Bordô	1.22 a	0.28 a	0.88 a	29.11 ab	17.98 d	10.10 d	4.23 a	0.9980 ab
Concord Clone 30	0.24 cd	0.18 b	0.05 b	24.54 bc	23.86 abc	9.80 e	3.48 ab	0.9976 b
Niágara Rosada	0.16 d	0.13 b	0.02 b	20.33 c	19.75 cd	10.80 a	4.24 a	0.9958 c
CV	11.42	12.23	30.01	7.62	9.43	0.23	7.77	0.04
Standard Error	0.028	0.014	0.036	1.213	1.323	0.013	0.159	0.001

Means followed by the same letter in the column do not differ by the Scott-Knott test at 5% probability.

The pH aims to quantify the hydrogen ions (H+) concentration in the product and is related to the drink stability, since the lower its value, the less subject the wine is to the action of spoilage microorganisms. The pH also affects the product taste and color, among other factors (Ough and Amerine, 1988). According to Rizzon and Salvador (1987a), the pH of table wines should not exceed 3.6, all samples of this study being within these parameters.

Table 2 presents the average values of reducing and non-reducing sugars, sucrose, dry extract, reduced dry extract, alcohol content, alcohol/reduced dry ratio and density of six different *Vitis* spp. wines.

It is observed that there was a statistical difference for total sugars (Table 2): the wine made from Bordô grape presented the highest value and that made from Niagara Rosada had the lowest value. For reducing sugars wine samples Bordô and BRS Rúbea showed the highest values when compared to the others. Regarding non-reducing sugars analysis, only the wine made from Bordô grape showed statistical difference, with higher levels when compared to other wines. Regarding the analyzed wine, all samples showed levels lower than 4 $g.L^{-1}$for reducing sugars, which is the maximum allowed by law - Decree No. 229 of 10/25/88 (Uvibra, 2007, Apud Tecchio, 2007). Higher levels of reducing sugars, besides indicating that the yeast did not complete the alcoholic fermentation, can endanger wine stability. The major sugars present in wine are glucose and fructose, which come from the grape. These are called reducing sugars and correspond to those that have turned into alcohol by yeast during fermentation (Silva *et al*., 2003b; Almeida, *et al*., 2011). These molecules present in wine are responsible for the drink sweetness sensation and for the suppressive effect of the acid taste (Nordeloos & Nagel, 1972). In some cases, when the wine undergoes the chaptalization step, sucrose presence can also be observed in the drink. Brazilian law determines that dry table wines must have a maximum level of 5 $g.L^{-1}$ of glucose, medium dry or demi-sec between 5.1 and 20 $g.L^{-1}$ and sweet, light or liqueur wines quantities above 20.1 $g.L^{-1}$ of glucose (Brasil, 1988). According to the results obtained in this study, the different wines produced can be classified as dry table wines. Table 2 shows that there was also statistical difference for dry matter analysis, where the wine made from BRS Cora grape had the highest value and that prepared from Niagara Rosada showed the lowest. The other samples presented intermediate content. As for the reduced dry extract, the wine made from BRS Cora grape also had the highest content and the lowest was observed in the wine made from Bordô grape. The total dry extract refers to the weight of the remaining dry residue after evaporation of wine volatile compounds. It is composed primarily of non-volatile acids, organic and mineral salts, phenolic compounds, nitrogen compounds, sugars, polysaccharides, tannins and pigments (Rizzon, 1996). The dry extract is related to the body and structure perception of the drink, and its content in the wine depends on the grape variety, its sugar content and chaptalization carried out in the wine processing. The reduced dry extract is the difference between the wine total dry solid content and sugar content. Brazilian wine legislation does not establish dry extract or reduced dry extract values. Hashizume (2001) stated that the extract content determines the wine body: beverages with less than 20 $g.L^{-1}$ of extract are considered light-bodied and above 25 $g.L^{-1}$, full-bodied. Thus, among the wines produced in this study only that from 'Niagara Rosada' grape is considered light-bodied and the others are considered more full-bodied.

Malgarin and colleagues (2006), in their studies with different microvinification processes of Bordô grapes, found values for this variable between 17.14 and 23.70 $g.L^{-1}$, which are lower than those observed in the present study, when compared to the same cultivar. The reduced dry extract values ranged between 17.98 and 29.99 $g.L^{-1}$, which corroborate studies from Uliana *et al*. (2015), who observed values from 20.8 to 26.1 $g.L^{-1}$, which are also close to those found in the literature for these types of wines (Rizzon *et al*., 2000; Tecchio *et al*., 2007). The wine total dry matter content has been considered as one of the main parameters which characterizes its quality, structure, body and even its genuineness and may vary depending on the winemaking techniques such as crushing, draining, maceration, maceration time, alcohol content; and also because these are factors that favor the extraction of grape mineral and organic matter (Sampaio, 2005). In the legislation, the alcohol/reduced dry extract ratio is more important than the total dry extract, because it allows to detect the addition of alcohol, water and sugar to the wine before bottling, among other frauds (Avila, 2002). Ordinance No. 229 of 10/25/88 (Uvibra, 2005), provides a maximum level of 4.8 for alcohol/reduced dry extract ratio for common red wine. This ratio represents the balance between wine fixed and volatile constituents (Rizzon and Miele, 1996). Thus, it is observed (Table 1) that the different wines produced are within the limits permitted by law and also in accordance with values found in the literature (Rizzon *et al*., 2000; Rizzon and Miele, 2006; Tecchio *et al*., 2007; Uliana *et al*., 2015). The wine alcohol content can be seen in Table 2. There was statistical difference among treatments; the wine made from Rosada Niagara had the highest alcohol content and that from the Concord Clone 30 grape showed the lowest value for this variable. However, all samples presented values within the range considered adequate by Brazilian law, which states that for table wines, the beverage alcoholic content should be between 8.6 and 14% by volume (Brazil, 2004). Values close to those in the present study regarding alcohol content were found in studies from Malgarin *et al*., (2006). Wine density showed significant difference (Table 2), and was higher for the wine from BRS Cora grape and lower for the wine from Niagara Rosada grape. In fully fermented and sugar-free wines the density is usually less than 1.0. In wines containing higher alcohol content, density ranges from 0.9975 to 0.9925. Consequently, wines with a higher sugar content and lower alcohol content will present densities greater than 1.0 (Vogt, 1972). According to Avila (2002), it should be considered that density varies depending on the wine dry extract, sugar and alcohol content. Studies from Uliana *et al*. (2015), working with wine from the Bordô cultivar, obtained density values that corroborate those of the present study for the same cultivar and density results correspond to those usually found in this type of wine (Rizzon *et al*., 2000; Rizzon and Miele, 2006; Tecchio *et al*., 2007). Most antioxidants present in citrus are Vitamin C and polyphenols, especially flavonoids. Vitamin C provides protection against uncontrolled oxidation in the cell aqueous medium due to its high reducing power. Polyphenols are substances with a high capacity to neutralize free radical molecules (Klimckac *et al*., 2007; Jayaprakasha and Patil, 2007). Antioxidants can be defined as substances that are present in low concentrations and when in contact with an oxidizable substrate, efficiently delay or inhibit the substrate oxidation (Sies and Sthal, 1995; Handelman, 2001). Studies by Antolovich *et al*. (2002) suggest that more than one antioxidant analysis method should be performed, as each method contributes to the elucidation of an aspect of the complex phenomenon of biological oxidation inhibition. Based on this assumption, among many available methods, the β-carotene/linoleic acid co-oxidation system and DPPH (2,2-diphenyl-1-picrylhydrazyl) free radical sequestration method can be highlighted, both being procedures which employ distinct action mechanisms (Frankel E Meyer, 2000; Aruoma, 2003). Phenolic compounds comprise a group of several substances found in food plants at concentrations that stimulate scientific interest mainly due to their antioxidant potential offered (Scalbert and Williamsom, 2000). Their variation is can occur due to a number of factors which may interfere with the wine phenolic content, for example, the grape cultivar used, degree of ripeness, agricultural practices and procedures adopted during production and storage (MALACRIDA AND MOTA 2005).

Thus, the antioxidant activity, vitamin C and total phenolic content of different *Vitis* spp. wines are shown in Table 3.

Significant differences were observed among the wines for the different antioxidant analyses (Table 3). For the DPPH method (% FRS), wines produced with the darker varieties, such as BRS Cora and Bordô, showed the highest values when compared to the others, which presented intermediate FRS%, whereas the wine made with the Niagara Rosada grape presented a negative value.

Table 3. Average values of antioxidant activity by DPPH (% Free Radical Scavenging) and β-carotene/linoleic acid (% Protection) methods, Vitamin C content (mg/100g) and total phenolics (mg.100 mL^{-1}) of six different *Vitis* spp. wines

Cultivar	DPPH (%FRS)	β-carotene/ linoleic acid (% Protection)	Vitamin C (mg.100 g^{-1})	Total Phenolics (mg.100 mL^{-1})
BRS Cora	13.54 a	46.58 a	51.34 b	280.14 ab
Isabel Precoce	8.75 bc	38.90 b	9.18 c	157.13 d
BRS Rúbea	7.30 c	39.38 b	46.51 b	233.57 c
Bordô	11.92 ab	47.33 a	137.96 a	311.51 a
Concord Clone 30	9.77 bc	45.11 ab	60.01 b	262.58 bc
Niagara Rosada	-4.28 d	39.91 b	2.13 c	85.17 e
CV	14.69	5.30	12.44	11.41
Standard Error	0.664	1.311	3.674	19.463

Means followed by the same letter in the column do not differ by the Scott-Knott test at 5% probability.

According to the β-carotene/linoleic acid method, it can be observed that the wines produced from darker cultivars such as BRS Cora, Bordô and Concord Clone 30 presented a 30% higher protection percentage when compared to the others. Values close to, but above those were described by Vilas Boas (2014), which in his studies of antioxidant activity in juices from Bordô, Isabel Precoce, and BRS Rúbea grapes and blends, observed average protection values of 51.61%. Vilas Boas (2014), also in his antioxidant activity studies in grape juice and blends, noted that most darker cultivars have higher antioxidant activity and Dávalos, Bartolomé and Gómez-Cordovés (2005) reported in their studies that higher antioxidant activity in red grape juices can be attributed to their higher content of total anthocyanins and phenolic compounds. Studies by Vargas, Hoelzel and Rosa (2008), working with red and white grape juices found FRS% ranging from 42% to 114%, with the lowest values related to white grape juice antioxidant activity. According to these authors, while polyphenols are the main determinants of juice antioxidant activity, vitamin C can also contribute to this parameter, but to a lesser extent. The vitamin C content of different wines presented statistical difference and is presented in Table 3. The wine produced with Bordô grapes showed the highest value and that made with Isabel Precoce and Niagara Rosada grapes showed the lowest. The other wines presented intermediate values and were similar.

Vitamin C is one of the micro-nutrients in higher amounts in grapes and this nutrient content contributes to the grape antioxidant activity, as reported by Sun *et al*. (2002). Because of the different cultivars, the results of the ascorbic acid content found in this work were different than that reported by Santana *et al*. (2008), who found average ascorbic acid levels of 17.54 mg.100 mL^{-1} for the Patricia cultivar, but they were higher than those reported by Detoni *et al*. (2005), who found levels around 1.0 mg.100 mL^{-1} for the Niagara Rosada cultivar and also higher than those reported by Pozzan, Braga and Salibe, (2012), who found levels ranging between 3.33 and 9.57 mg.100 g^{-1} for the Bordô cultivar. As for the phenolic compounds content, the produced wines presented significant difference (Table 3). The beverages produced with the Bordô and BRS Cora cultivars showed the highest values, those produced with also red cultivars, such as Concord Clone 30 and BRS Rúbea, showing intermediate values. Beverages elaborated with Isabel Precoce and Niagara Rosada cultivars had the lowest values, respectively, as these drinks have lighter color when compared to the previously cited. Values close to those in the present study were observed in a work by De Oliveira (2011) with fine table wines from different brands, indicating that they are an excellent source of phenolic compounds, with values ranging from 1410.83 to 3718.70 $mg.L^{-1}$. Differences in the amount of phenolic compounds present in wine depends not only on the type of grape used and the cultivation conditions, but also on several factors related to processing. Presence of seeds and stems in the must, maceration time and temperature, number of rackings made and other technological steps directly interfere in their phenolic content. Due to these factors mentioned, the amount of phenolics can vary considerably in red wine, but in general values between 1000 $mg.L^{-1}$ and 4000 $mg.L^{-1}$ are obtained (Mamede and Pastore, 2004). Total phenolic compounds content from several Brazilian red wines ranged from 1041.63 $mg.L^{-1}$ to 1958.78 $mg.L^{-1}$ in a study from Granato, Katayama and Castro (2010), whereas Minussi and colleagues (2003) obtained an average of 1920 $mg.L^{-1}$.

The variability of the phenolic compounds content in the different wines produced can be justified by a number of factors previously mentioned. The wide diversity among grape varieties results in fruit with different characteristics, both in terms of taste and color, which is certainly associated with the polyphenolic content and profile (Abe *et al*., 2007). According to studies by Abe *et al*., (2007), the more intense the grape color, the higher the phenolic content and its antioxidant capacity. It is known that anthocyanins are water soluble plant pigments that provide color to a variety of plants and belong to a class of flavonoid compounds, also known as polyphenols. In recent decades, interest in anthocyanins has increased due to their functional potential, collaborating to aid in health promotion (Andersen, 2009). The wine color is considered an important quality indicator, usually the first sensory attribute observed by the consumer. In addition, color tonality and intensity can provide information about the quality of the raw material used in its preparation. Variations in coloration of wines may be related to the grape cultivar used, and can be influenced by the cultivation techniques adopted (Gurak *et al*., 2010). Mean values for anthocyanins and colorimetric parameters L*, h^o (Hue angle) and C* (chroma) in six different *Vitis* spp. wines can be seen in Table 4.

There was a significant difference in anthocyanins in different wines (Table 4). The highest value was observed for the wine made from the Bordô grape. The beverages made from Concord Clone 30 and Niagara Rosada grapes had the lowest values, respectively. Considering the biochemical aspect of grape metabolism, these results are consistent with the expected, since as different grape varieties undergo maturation, the anthocyanin content becomes different (Pommer, 2003). According to Sampaio (2005), anthocyanin is the constituent most influenced by weather conditions. From the beginning of ripening on, there is an increase in anthocyanin content soon after the color change and that increase is significantly greater in berries exposed to light than in those under shade.

Table 4. Mean values of anthocyanins (mg/100g), and colorimetric parameters L*, Hue° and C* (chroma) in six different *Vitis* spp. wines

Cultivar	Anthocyanins ($mg.100\ g^{-1}$)	L*	*h*°	*C**
BRS Cora	30.55 bc	27.42 c	38.03 b	73.43 a
Isabel Precoce	33.23 b	46.47 b	29.52 c	62.01 b
BRS Rúbea	26.83 cd	27.17 c	35.44 b	72.46 a
Bordô	92.99 a	14.19 d	27.83 c	52.02 c
Concord Clone 30	23.68 d	26.40 c	35.42 b	71.73 a
Niagara Rosada	0.20 e	96.12 a	68.49 a	8.01 d
CV	5.90	11.98	5.55	5.17
Standard Error	1.178	2.740	1.935	1.687

Means followed by the same letter in the column do not differ by the Scott-Knott test at 5% probability.

They reach their highest peak and decrease at full maturity and during over-ripeness. Differences among anthocyanin content reflects possible interference of climatic conditions on cultivar adaptation response to climate, rainfall and altitude. Anthocyanin accumulation in the berries is also influenced by the vegetative vigor, a fact that is associated with increased phenolic compound synthesis in the skin, probably as a result of less shade falling on the bunches, which leads to less competition between plant vegetative and reproductive organs for light, being more efficient in anthocyanins synthesis (Mota *et al*., 2009). Reference values from studies by Pozzan Braga and Salibe (2012) with anthocyanins of the skin of Bordô grapes on different rootstocks and in harvest periods ranged between 55.15 and 307.35 $mg.100\ g^{-1}$, and thus corroborate those of the present study. When referring to instrumental color analysis, the color parameters L*, a*, b*, h^o (Hue angle) and C* (chroma) cannot be individually analyzed because they represent a color solid in the color space. Regarding the wine color, the lightness (L*) showed statistical difference among treatments (Table 4). The wine made from Niagara Rosada had the highest value, indicating a wine with lighter color, followed by the wine made from Isabel Precoce, which showed intermediate color. Wines produced with BRS Cora, BRS Rúbea and Concord Clone 30 grapes presented values tending to a more red tonality and were considered similar to each other, while that made from Bordô grapes had the lowest lightness value, which indicates that it is the darkest wine.

Readings of the L* (lightness), a* and b* parameters were used to calculate the Hue angle, that is, the tonality or shade. Anthocyanins are the major phenolic compound subfamily responsible for red wine color. The a* and b* parameters indicate the relationship between yellow anthocyanins and red anthocyanin (Mazza *et al*., 1999; Ribéreau-Gayon *et al*., 2006; Calvão, 2013). Hue values (h^o) ranged from 27.83 to 68.49 (Table 4). According to the CIELAB system, if the angle is between 0° and 90°, the higher the value, the more it tends toward yellow and the lower the value, the more it tends toward red. Based on this, the sample that presented the highest value was the wine made from Niagara Rosada, tending toward yellow, that is, a light colored wine. As for the other samples, they tended toward red, as they are darker wines, which explain the high anthocyanin concentrations. In this study, C* values presented significant difference among treatments (Table 4). Wines produced from BRS Cora, BRS Rúbea and Concord Clone 30 grapes showed the highest values, and the wine made from Niagara Rosada cultivar had the lowest value, tending toward achromatic. Sensory analysis is the interpretation of stimuli caused to individuals by their interaction with products or foods, that result from various sensations originated from physiological reactions, generating an interpretation of the product intrinsic properties in the individual (Tech, 2013). Sensory analyses are performed from simple and efficient questionnaires to be answered by the tasters.

The results of the survey referring to gender, age and wine consumption frequency of the sensory analysis (acceptance test and purchase intent) participants are elucidated in Figure 1.

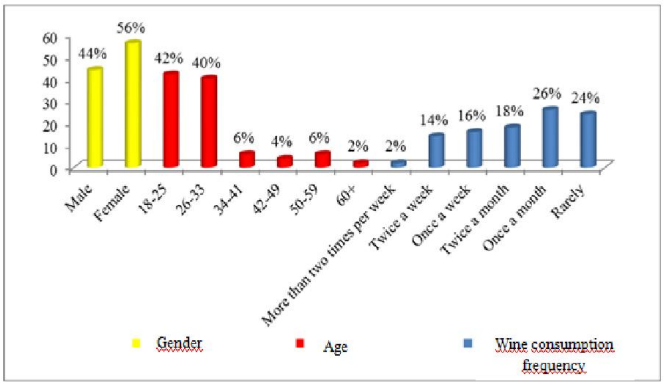


Figure 1. Profiles of tasters in the sensory analysis of six different wines (*Vitis* spp.)

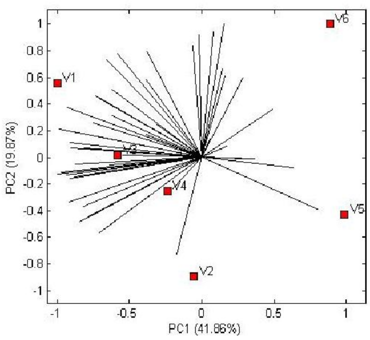
Of the 50 tasters who participated in the sensory analysis of different wines, 56% were female and 44% male, 42% were between 18 and 25 years of age and 40% were between 26 and 33 and the others were over 34 (Figure 1). When asked about their wine consumption frequency, 26% said they consumed at least once a month and 24% rarely. A more than biweekly wine consumption frequency was only 2% (Figure 1). Among the sensory tests available to measure consumer acceptance and preference in relation to one or more products, the structured nine point hedonic scale is one of the most used due to its results reliability and validity and its simplicity to be taken by the tasters (Stone & Sidel, 1993; Minim, 2006). Sensory analysis average values for appearance, aroma, taste and overall impression attributes and purchase intention of the six different *Vitis* spp. wines are in Table 5. According to the statistical analysis, there were differences among treatments for sample acceptance regarding appearance, aroma, taste, overall impression and purchase intention. Regarding the appearance, the wines produced with Bordô, Concord Clone 30 and BRS Rúbea cultivars (Table 5) showed the best results and were slightly and moderately liked by the tasters, when compared to wines made from BRS Cora, Niagara Rosada and Elizabeth Precoce cultivars, which tasters did not like nor dislike. As for the aroma of the beverages, those prepared from Concord Clone 30, Niagara Rosada, Bordô and BRS Rúbea cultivars presented higher values, indicating that the tasters slightly to moderately liked the product when compared to those produced from Isabel Early and BRS Cora cultivars, for which the tasters were neutral in relation to the product acceptance. Regarding the taste, tasters evaluated the produced wines on the scale "did not like nor dislike" for wines elaborated from Bordô, Niagara Rosada, BRS Rúbea and Concord Clone 30 cultivars and on the scale "slightly dislike" for wines elaborated from Isabel Precoce and BRS Cora cultivars. Overall, the average scores for overall impression stood in the hedonic scale between 4.56 and 6.12, listed in the category from "neither liked nor disliked" to "slightly liked", respectively. Therefore, the drinks that showed the highest values were prepared from Bordô, Niagara Rosada, BRS Rúbea and Concord Clone 30 cultivars. Those with the lowest values were elaborated from Isabel Precoce and BRS Cora cultivars. When asked about the purchase intention of the different wines, tasters answered "do not know if I would buy" and "I probably would not buy", standing on a hedonic scale between 2.18 and 3.12, respectively. Besides data analysis by the mean test, in order to analyze the affective data, taking into account the individual response of each consumer and not just the average of the group of consumers who analyzed the products, a technique called Vectorial Internal Preference Mapping was carried out (Marketo *et al*., 1994). This technique uses multivariate analysis to obtain a graphical representation of the differences in acceptance between the produced wines by identifying the individual and their preferences (REIS, 2006).

Table 5. Mean sensory analysis values for appearance, aroma, taste and overall impression attributes and purchase intention of six different *Vitis* spp. Wines

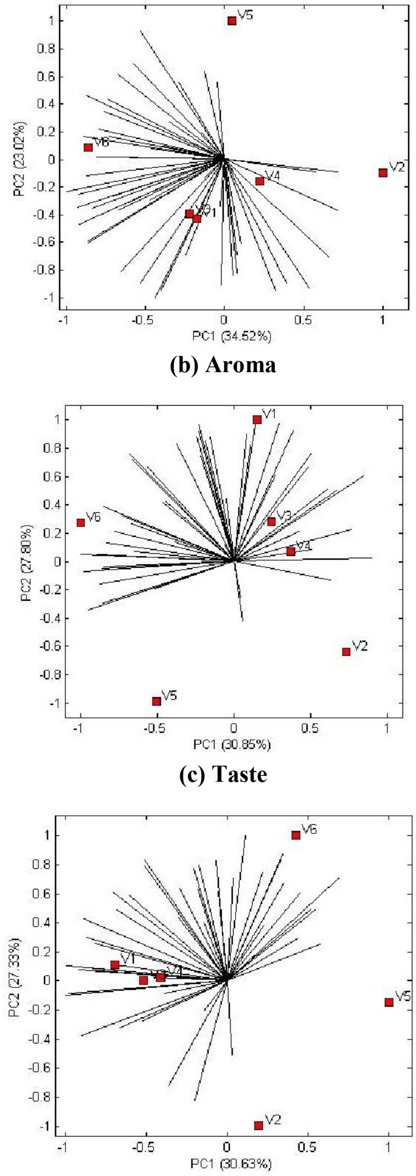
Cultivar	Appearance	Aroma	Taste	Overal Impression	Purchase Intention
Bordô (V1)	7.22 a	6.90 a	5.76 a	6.12 a	3.12 a
BRS Cora (V2)	5.96 b	5.36 b	3.78 b	4.56 b	2.18 b
Concord Clone 30 (V3)	6.88 a	6.92 a	5.16 a	5.54 a	2.80 a
BRS Rúbea (V4)	6.66 a	6.36 a	5.22 a	5.76 a	2.86 a
Isabel Precoce (V5)	5.26 b	5.88 b	4.38 b	4.84 b	2.28 b
Niágara Rosada (V6)	5.68 b	6.92 a	5.56 a	5.88 a	3.00 a
CV	29.70	27.81	43.55	35.61	43.78
Standard Error	0.263	0.251	0.306	0.274	0.167

Means followed by the same letter in the column do not differ by the Scott-Knott test at 5% probability.

Figure 2 shows the vectorial Internal Preference Maps (IPM) for (a) appearance, (b) aroma, (c) taste and (d) overall impression of six different *Vitis* spp. wines.



a) Appearance



(b) Aroma

(c) Taste

(d) Overall Impression

Figure 2. Internal Preference Map (IPM) for (a) appearance, (b) aroma, (c) taste and (d) overall impression attributes of six different *Vitis* spp. wines: Bordô (V1), BRS Cora (V2), Concord Clone 30 (V3), BRS Rúbea (V4), Isabel Precoce (V5) and Niagara Rosada (V6)

Regarding appearance, the map (Figure 2) indicates that wines produced from Bordô, Concord Clone 30 and BRS Rúbea cultivars were preferred by tasters, as a higher concentration of vectors involving these samples indicates preference for them, when compared to wines made from BRS Cora Niagara Rosada and Isabel Precoce cultivars. As for the aroma, wines prepared from Concord Clone 30, Niagara Rosada, Bordô and BRS Rúbea cultivars presented, in the same map, higher vector density, indicating the preference for these samples when compared to wines developed from Isabel Precoce and BRS Cora cultivars. Regarding the taste attribute, tasters preferred the wines produced from Bordô, Niagara Rosada, BRS Rúbea and Concord Clone 30 cultivars over those elaborated from Isabel Precoce and BRS Cora cultivars, since a higher incidence of vectors near the former group can be seen on the map (Figure 2).

In order to assess sample overall acceptance, taking into account the opinion of each tester, the map (Figure 2) reveals that there was a centralization of vectors for wines produced from Bordô, Niagara Rosada, BRS Rúbea and Concord Clone 30 cultivars, when compared to those produced from Isabel Precoce and BRS Cora cultivars.

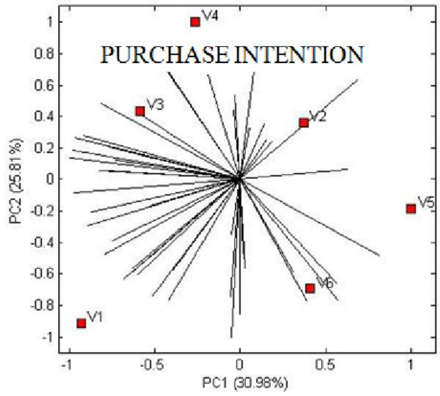


Figure 3. Internal Preference Map (MPI) for the purchase intent of six different *Vitis* spp. wines: Bordô (V1), BRS Cora (V2), Concord Clone 30 (V3), BRS Rúbea (V4), Isabel Early (V5) and Niagara Rosada (V6)

Based on sample spatial separation and vector distribution, it is suggested that wine samples made from Bordô, Concord Clone 30, BRS Rúbea and Niagara Rosada cultivars were more likely to be purchased by consumers compared to the other formulations. This statement is consistent with the average test (Table 5) carried out previously, which can be seen on the map (Figure 3).

Conclusion

The different wines produced are within the wine identity and quality standards proposed by the Brazilian legislation and the values of the variables found in the samples are close to reference study values of wines from traditional viticulture regions in Brazil.The different wines were classified as dry table wines, and the wine from 'Niagara Rosada' was light-bodied while the others were considered more full-bodied. Due to differences among cultivars, considering the biochemical aspect and the grape metabolism, the antioxidant activity varied, as well as the phenolic compound, ascorbic acid and anthocyanin content. These differences reflect the possible interference of soil and climate conditions on the cultivar adaptation response in the region where the experiment was conducted, especially for the 'Bordô' and BRS Cora' cultivars. Overall, sample average scores for sensory analysis were listed in the category "neither liked nor disliked" to "moderately liked". Regarding purchase intention of the different wines, tasters responded "do not know if I would buy" and/or "I probably would not buy", which may be related to the profile of the tasters. Bordô, Niagara Rosada, BRS Rúbea and Concord Clone 30 cultivars should be highlighted, since they were preferred by the consumers in relation to aroma, taste, overall impression and purchase intent. In this context, production of grapes from different cultivars (*Vitis* spp.) for wine production in subtropical regions can be undertaken as an alternative for development and establishment of rural populations, as climate conditions positively influence physicochemical composition and sensory aspects of cultivated grapes. This allows, therefore, the development of products derived from grapes, with competitive features which may be accepted by a different public, which has a preference for dry wines.

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