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BIOACTIVE COMPOUNDS IN WINES PRODUCED IN A NEW AREA FOR VITIVINICULTURE IN BRAZIL

COMPOSTOS BIOATIVOS EM VINHOS PRODUZIDOS EM NOVA ÁREA DE VITIVINICULTURA NO BRASIL

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ABSTRACT: Wines are known for its high content of bioactive compounds that can be influenced by the region and climate where the grapes are produced. New regions of production are normally developed using techniques and standards for other traditional regions, but is important to characterize the wine profile, which is different according to the *terroir*, and can be important for future geographic indications. The aim of this study was to evaluate color, antioxidant activity, anthocyanin content and phenolic compounds profile in wines produced in Minas Gerais State, Brazil. Wines were produced in different wineries of the same region using the varieties Syrah, Merlot, Cabernet Sauvignon, Cabernet Franc (red), Chardonnay and Sauvignon Blanc (white) and Syrah (rose), from municipalities of Cordislândia, Boa Esperança and Três Corações, located in the south of Minas Gerais State, Brazil. Wines produced in Minas Gerais State presented contents of t-resveratrol, total phenolics, anthocyanins, flavonols, flavanols and phenolic acids consistent to the contents observed in wines from traditional regions of production. However, the *terroir* and the grape variety can result in a differentiation of compounds observed in wines. Syrah red wines produced in Boa Esperança stood out with higher amounts of anthocyanins (24.29 mg L^{-1}), phenolic acids (123,19 mg L^{-1}) and flavonols (35.55 mg L^{-1}), when compared to wines from the same variety from other municipalities and other evaluated red wines. Sauvignon Blanc wines from Boa Esperança presented higher contents of phenolic acids and total flavonols, when compared to wines of the same variety produced in Cordislândia. Chardonay wines presented higher total phenolics content, when compared to ohther evaluated white wines. Rose wine produced in the South of Minas Gerais presented the phenolic acids content of 36,33 mg L^{-1} and total flavonols content of 29,7 mg L^{-1}. The highest antioxidant activity using the DPPH method, (% of free radicals scavenging - FRS) was observed for Syrah wines from Três Corações, (75.37%), but not different from Cabernet Sauvignon wines from Cordislândia (72.50%), values that can be correlated with the largest content of phenolics observed in wines as phenolic compounds (3009 mg L^{-1}). No differences were observed in the contents of the antioxidant activity of white wines. This results indicate that the studied wines present the necessary nutritional and beneficial characteristics to compete in the supply of bioactive compounds during consumption, when compared to wines produced in traditional and different regions in Brazil and other countries.

KEYWORDS: *Vitis vinifera*. Bioactive compounds. Resveratrol. Quality. Brazilian wines.

INTRODUCTION

Grapes and grape-products deserves special attention for its numerous health benefits, such as inhibiting cancer cells growth, as in the colon, breast and thyroid (SAHPAZIDOU et al, 2014; MAZUÉ et al, 2014.), preventing cervical cancer (Chen, Liu AND ZHENG et al., 2014), presenting anti-inflammatory effects (DECENDIT et al., 2013), improving cardiovascular oxidation (HORt et al., 2012) and acting in a reduction of low density lipoproteins (LDL) and increasing high density lipoproteins (HDL) (EVANS et al., 2014).

Minas Gerais State is not a traditionally known producer of grapes and wines, having different soil and climatic conditions when compared to the major producing regions in Brazil, such as the Rio Grande do Sul State and The São Francisco River Valley. Thus, the evaluation of bioactive compounds in wines produced in the South of Minas Gerais State is extremely important to provide to growers and consumers the information regarding the quality of the product of the region. It is also important to know the potential of wines produced according to the reverse cycle technique, which allows the harvest of grapes during

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winter, period without rain incidence, different from the summer period that is used in the South of the country.

Phenolic compounds have pronounced antioxidant activity and are widely present in wines. Recent studies with resveratrol (CHEN et al, 2014; BRESCIANI et al, 2014), proanthocyanidins (FERNÁNDEZ IGLESIAS et al, 2014), rutin (CHOI et al, 2013), among others, show the beneficial action of these compounds in the body. Phenolic compounds can be divided into two groups: flavonoids and no flavonoids, both with low molecular weight compounds, being secondary metabolites present in fruits and vegetables (VOLP et al., 2008).

Among the flavonols, quercetin, kaempferol and myricetin are possibly the best known. In the class of flavanols, are present the catechins and epicatechins, observed mainly in grape seeds, which are the major phenolic compounds responsible for wines taste and astringency (ABE et al., 2007). The biosynthesis and accumulation of anthocyanins are affected by many factors, such as variety, light, and moisture. Moisture plays a crucial role in the biosynthesis of anthocyanins in grape fruit. The anthocyanin compounds in wines are mainly derived from grape berries. Therefore, there is a correlation of the individual anthocyanin contents between grape berries and wines (JU et al., 2019).

The characterization of fine wines from Minas Gerais, specially from the southern part of the State, is a research field that remains unexplored, with no reports of typicality, phenolic content and functional potential of the products. In this context, there is a need for studies that presents this approach, contributing to the implementation and consolidation of the wine production in this region. The objective of this study was to evaluate the antioxidant activity, phenolic profile and anthocyanins content in different wines produced in the south of Minas Gerais State, Brazil.

MATERIAL AND METHODS

The wines were produced in different wineries in the southern part of Minas Gerais State, Brazil and after bottling, were evaluated at the Federal University of Lavras – UFLA, Brazil. Red wines from grapes of the varieties Syrah, Merlot, Cabernet Sauvignon and Cabernet Franc, white wines from grapes Chardonnay and Sauvignon Blanc and rosé wines from the Syrah variety were evaluated. The wines were produced in wineries located at the municipalities of Cordislândia, Boa Esperança and Três Corações, MG, being the following treatments: STBE (Syrah Red Wine from Boa Esperança), STTC (Syrah Red Wine from Três Corações), STCO (Syrah Red Wine from Cordislândia), MECO (Merlot Red Wine from Cordislândia), CSCO (Cabernet Sauvignon Red Wine from Cordislândia) and CFCO (Cabernet Franc Red Wine from Cordislândia); Whites: SBBE (Sauvignon Blanc from Boa Esperança), SBCO (Sauvignon Blanc from Cordislândia) and CHCO (Chardonnay from Cordislândia); Rosé: SRBE (Syrah Rose From Boa Esperança).

To color of the wines were evaluated using a Minolta colorimeter CR 400 model by searching the L* coordinate, measuring the lightness or brightness of the sample, ranging from black (0) to white (100). The phenolic compounds were obtained according to the colorimetric method developed by Singleton and Rossi (1965), using the Folin-Ciocalteu reagent, in a solution with a concentration of 10% (v/v). The extraction procedure involved sequential steps of centrifugation and filtration to obtain a better extraction of phenolic compounds as described in Larrauri, Saura-Calixto and Rupérez (1997). The absorbance values obtained in the test at 765 nm were compared with a calibration curve obtained for gallic acid, and results were expressed in mg L^{-1} of gallic acid equivalents (GAE).

The anthocyanins analysis was performed according to the differential pH method proposed by Giusti and Wrolstad (2001). Wine samples were homogenized in KCl buffer (0.025 M, pH = 1.0) and CH_3COONa (0.4 M, pH = 4.5) and the readings were performed at 520 nm and 700 nm in a spectrophotometer. The pigment concentration in the wines was expressed as equivalents of cyanidin-3-glucoside in mg L^{-1}.

The phenolic compounds were determined by HPLC (WATERS, model e2695 Aliance), equipped with a quaternary solvent pump and automatic injector, coupled with DAD and fluorescence detection (FD), according to the methodology described by Natividade et al. (2013). The data collection and analysis were carried in October using the Empower™ 2 software (Milford, USA). In the DAD, the detection of compounds was Performed at 220 nm for gallic acid (LOD = 0:07 mg L^{-1} R^2= 0.998), (_) - gallate epicatechin (LOD = 0:07 mg L^{-1} R^2= 0.991) (_) - epigalocatechin (LOD = 0:19 mg L^{-1} R^2= 0.999) and procyanidin B1 (LOD = 0:03 mg L^{-1} R^2= 0.999); 320 nm for t-resveratrol (LOD = 0.01 mg L^{-1} R^2= 0.999), caffeic acid (LOD = 0:08 mg L^{-1} R^2= 0.998), cinnamic acid (LOD = 0:11 mg L^{-1} R^2 = 0.999), p-coumaric acid (LOD = 0:05 mg L^{-1} R^2= 0.999) and chlorogenic acid (LOD

= 0:02 mg L^{-1} R^2 = 0.998); 360 nm for the flavonols kaempferol (LOD = 0:06 mg L^{-1} R^2= 0.998), myricetin (LOD = 0.01 mg L^{-1} R^2= 0.999), quercetin (LOD = 0.002 mg L^{-1} R^2= 0.999) rutin (LOD = 0:04 mg L^{-1} R^2= 0.999) and isorhamnetin (LOD = 0.01 mg L^{-1} R^2= 0.998); and 520nm for the anthocyanins malvidin 3,5-diglucoside (LOD=0:06 mg L^{-1} R^2= 0.999) Cyanidin 3,5-diglucoside (LOD = 0:04 mg L-1 R2 = 0.998), malvidin-3-glucoside (LOD = 0:03 mg L^{-1} R^2= 0.997) Cyanidin 3-glucoside (LOD = 0:11 mg L^{-1} R^2= 0.998) peonidin-3-glucoside (LOD = 0.01 mg L^{-1} R^2= 0.997) delphinidin 3-glucoside (LOD = 0:09 mg L^{-1} R^2= 0.999) and 3-Pelargonidin glucoside (LOD = 0:04 mg L^{-1} R^2= 0.983). In the FD, the photon excitation was carried out at 280 nm and the emission at 320 nm for (+) - catechins (LOD = 0.01 mg L^{-1} R2 = 0.988), procyanidin B2 (LOD = 0.001 mg L^{-1} R^2= 0.983), procyanidin A2 (LOD = 0.003 mg L^{-1} R^2= 0.990) and (_) - epicatechin (LOD = 0.01 mg L^{-1} R^2 = 0.983).

The used column was a Gemini-NX C18, 150 x 4.60 mm, with 3 uM of internal particles, and the pre-column was a Gemini-NX C18, 4.0 x 3.0 mm, both manufactured by Phenomenex®. The oven temperature was maintained at 40°C and the volume of injection was 10 µL (juice previously filtered through 0.45 µM membrane; Allcrom-Phenomenex, USA) and the flow rate was 0.5 mL min^{-1}. The mobile phase consisted of 0.85% phosphoric acid solution (solvent A) and acetonitrile (solvent B). The gradient elution was: 0 min: 100% A; 10 min: 93% A and% B 7; 20 min: 90% A and 10% B; 30 min: 88% A and 12% B; 40 min: 77% A and 33% B; 45 min: 65% A and 35% B and 55 min: 100% B

The determination of the antioxidant activity of the samples was performed by the DPPH (2,2-diphenyl-1-picryl-hydrazyl) scavenger method of antioxidants according to Rufino et al. (2007a). For purposes of comparison with literature results, the percentage of scavenging of free radicals (%SRL) was calculated using the formula suggested by Duarte-Almeida et al. (2006): % SRL = (Ac - Am) x 100 / Ac, where 'Ac' is the control Abs and 'Am' is the sample Abs. In this parameter, high values indicate a higher antioxidant capacity of the studied sample.

The evaluation of the antioxidant activity of juices by β-carotene / linoleic acid system followed a protocol recommended by Rufino (2007b). The extract sample was obtained according to the methodology of Larrauri, Rupérez and Saura-Calixto (1997). The results were expressed as the % of protection against oxidation.

Data were collected from 10 wines produced in the south of Minas Gerais, State, Brazil, named as STBE (Syrah Red Wine from Boa Esperança), STTC (Syrah Red Wine from Três Corações) , STCO (Syrah Red Wine from Cordislândia), MECO (Merlot Red Wine from Cordislândia), CSCO (Cabernet Sauvignon red wine from Cordislândia) and CFCO (Cabernet Franc red wine from Cordislândia); Whites: SBBE (Sauvignon Blanc from Boa Esperança), SBCO (Sauvignon Blanc from Cordislândia) and CHCO (Chardonnay from Cordislândia); Rosé: SRBE (Syrah Rose From Boa Esperança). The obtained results for the studied variables were submitted to variance analysis (ANOVA) and compared by Tukey´s at 5% of probability.

RESULTS AND DISCUSSION

Total phenolics and flavanols

The mean values and standard deviations for the total phenolic content and flavanols are presented in Table 1.

The observed amounts for total phenolics presented significant differences among the evaluated samples. Phenolic values observed in red wines are in accordance to literature for wine produced in traditional regions of Brazil, such as the regions of the São Francisco Valley and at Rio Grande do Sul State, ranging from 1410.83 to 3718.70 mg L^{-1} (OLIVEIRA et al 2011) and the region of Santa Catarina State, with values ranging from 474.94 to 4060 mg L^{-1} (BRIGHENTI et al 2014; Santin et al 2009). The values found in this study are even greater than the wines from São Paulo State wines with values ranging from 965 to 1230 mg L^{-1} (CASTILHOS; BIANCHI, 2012). The values are also in accordance with the total phenolic content of wines from different world production varieties and regions, such as Croatia (GENERALIĆ et al., 2019) and Spain (CASTRO-SOBRINO et al., 2019). The concentration of phenolic compounds in grapes is influenced by the grape variety, by environmental and climatic conditions (GARRIDO; BORGES, 2013; HE et al., 2010).

According to Miele et al. (2014), the presence of these compounds in grapes depends on various factors, such as terroir, grape variety, rootstock, soil physicochemical characteristics, climate factors during the growing cycle (mainly during grape ripening) and the crop practices used in vineyards. The association of these factors can influence the presence, concentration, diversity and characteristics of the phenolic composition of grapes

and wines. During the maceration and fermentation process, the phenolic compounds are extracted from grape berries and can influence wine characteristics (CASTRO-SOBRINO et al., 2019; TEIXEIRA et al., 2013). The final concentration of the phenolic compounds are related to oenological parameters (CASTRO-SOBRINO et al., 2019), which can vary according to the winery.

Regarding the total flavanol content (Table 1), highest values were observed in MECO wines for catechin (5.93 mg L^{-1}) and STBE wines presented the highest values for epicatechin (3.73 mg L^{-1}), epicatechin gallate (2.23 mg L^{-1}), epigallocatechin (11.90 mg L^{-1}) and procyanidin A2 (1.66 mg L^{-1}), and larger mean values of total flavanols (35.54 mg L^{-1}). Wine samples were not different regarding the procyanidin B1 levels. The CFCO and STBE wines presented the higher procyanidin B2 contents, with no statistical difference, reaching values of 8.70 and 8.56, respectively. Table 2 shows the contents of total phenolic and flavanols in white wines.

Table 1. Phenolic compounds and L* values for wines from Minas Gerais State, Brazil.

Wine	STBE	STTC	STCO	MECO	CSCO	CFCO
Flavanols						
(+)-Catechin	2.93±0.05^{d}	4.26±0.05^{c}	4.23±0.05^{c}	5.93±0.05^{a}	2.83±0.05^{d}	4.76±0.05^{b}
(-)-Epicatechin	3.73±0.05^{a}	3.30±0.00^{b}	2.40±0.00^{d}	3.36±0.05^{b}	1.80±0.00^{e}	2.53±0.05^{c}
(-)Epicatechin gallate	2.23±0.45^{a}	1.46±0.12^{bc}	1.66±0.15^{ab}	1.46±0.21^{bc}	0.66±0.12^{d}	0.73±0.40^{cd}
(-)Epigallocatechin	11.90±0.17^{a}	5.50±0.53^{b}	5.33±0.29^{b}	5.56±0.55^{b}	5.56±0.15^{b}	5.20±0.10^{b}
Procyanidin A2	1.66±0.05^{a}	0.70±0.00^{f}	1.10±0.00^{d}	1.30±0.00^{c}	1.53±0.05^{b}	1.00±0.00^{e}
Procyanidin B1	4.53±0.05^{a}	3.83±0.12^{a}	4.13±0.05^{a}	2.10±2.25^{a}	2.63±0.12^{a}	4.06±0.12^{a}
Procyanidin B2	8.56±0.05^{a}	2.23±0.05^{c}	6.46±0.05^{b}	3.26±1.79^{c}	4.00±0.00^{c}	8.70±0.00^{a}
Total flavanols quantification	35.54±0.87	21.28±0.87	25.31±0.59	22.97±4.90	19.01±0.49	26.98±0.72
Anthocyanins						
Calistefin	1.93±0.05^{b}	1.30±0.00^{d}	2.10±0.00^{a}	1.03±0.05^{e}	1.66±0.05^{c}	1.56±0.05^{c}
Mirtilin	0.90±0.00^{d}	1.00±0.00^{c}	1,40±0.00^{b}	0.80±0.00^{e}	1.60±0.00^{a}	1.00±0.00^{c}
Kuromanin	ND	0.36±0.05^{a}	ND	0.30±0.00^{a}	0.30±0.00^{a}	ND
Peonidin 3-glucoside	1.20±0.00^{a}	0.40±0.00^{c}	0.60±0.00^{b}	0.40±0.00^{c}	0.40±0.00^{c}	0.60±0.00^{b}
Petunidin	0.43±0.05^{c}	0.40±0.00^{c}	ND	1.00±0.00^{a}	0.60±0.00^{b}	ND
Oenin	19.83±0.05^{a}	6.20±0.10^{e}	10.76±0.05^{b}	4.06±0.05^{f}	9.03±0.05^{d}	9.30±0.00^{c}
Total anthocyanin quantification	24.29±0.15	9.66±0.15	14.86±0.05	7.59±0.10	13.59±0.10	12.46±0.05
Phenolic Acids						
Gallic acid	12.23±0.15^{e}	42.30±0.52^{a}	31.13±0.55^{c}	34.63±0.32^{b}	25.20±0.17^{d}	30.46±0.15^{c}
Caffeic acid	8.56±0.05^{a}	2.20±0.00^{c}	6.46±0.05^{b}	3.26±1.78^{c}	4.00±0.00^{c}	8.70±0.00^{a}
Cinnamic acid	0.60±0.00^{ab}	ND	0.60±0.00^{ab}	0.50±0.00^{bc}	0.40±0.05^{c}	0.70±0.00^{a}
Chlorogenic acid	0.70±0.00^{e}	4.66±0.05^{a}	1.63±0.05^{d}	2.50±0.00^{c}	2.86±0.05^{b}	2.76±0.05^{b}
Syringic acid	0.76±0.05^{ab}	0.76±0.23^{ab}	0.70±0.00^{ab}	0.96±0.05^{a}	0.46±0.11^{b}	0.76±0.05^{ab}
Total phenolics acids quantification	22.85±0.25	49.92±0.80	40.52±0.65	41.85±2.15	32.92±0.38	43.38±0.25
Total monomeric anthocyanins[ŧ]	123.19±4^{a}	102.07±7^{b}	78.34±1^{c}	57.62±3^{d}	100.24±2^{b}	73.98±8^{c}
Total phenolic[§]	2717±33^{b}	3009±46^{a}	2376±72^{c}	2856±19^{ab}	2753±135^{b}	2387±91^{c}
L* values	11.17±0.00^{bc}	11.15±0.03^{c}	11.13±0.00^{c}	11.24±0.03^{a}	11.17±0.01^{bc}	11.22±0.01^{ab}

Means followed by the same letters in the same line do not differ according to Tukey´s test at 5% probability. ND – not detected; STBE: Syrah (Boa Esperança); STTC: Syrah (Três Corações); STCO: Syrah (Cordislândia); MECO: Merlot (Cordislândia); CSCO: Cabernet Sauvignon (Cordislândia); CFCO: Cabernet Franc (Cordislândia);[ŧ]Total monomeric anthocyanins quantified by the technic of difference of pH and expressed as equivalent to cyanidin 3-glucoside;[§]Total phenolics measured with Folin–Ciocateau expressed as mg L^{-1} equivalent to gallic acid

No significant differences were observed for the total phenolic content among the studied white wines, with values ranging from 334.33 mg L^{-1} (SBCO) to 375.33 mg L^{-1} (SBBE). Oliveira et al (2011) studying white wines produced in northeast of Brazil, observed total phenolic values ranging from 278.73 to 548.42 mg L^{-1}. Castilhos and Bianchi (2011) observed phenolic contents ranging from 178 to 367 mg L^{-1}. Higher catechin (3:50 mg L^{-1}), epicatechin (20.1 mg L^{-1}), epicatechin gallate (3.1 mg L^{-1}), mean values of total quantified flavanols (11.62 mg L^{-1}) and epigallocatechin (1:33 mg L^{-1}) amounts were observed in CHCO wines. Regarding the A2 procyanidin contents, no statistical differences were observed between the wines, with contents ranging from 0.46 to 0.50 mg L^{-1}. Contents of 1.00 mg L^{-1} of procyanidin B1 were observed in SBBE and CHCO (1.00 mg L^{-1}) wines.

Higher procyanidin B2 contents were observed in SBBE samples (6.10 mg L^{-1}). On Table 3, is possible to observe the total phenolic content and flavanols of the evaluated rosé wine.

The total phenolic content observed was 632.33 mg L^{-1} and among the flavanols, the compound procyanidin B2 was observed in higher values (15:33 mg L^{-1}), followed by epigallocatechin (6.60 mg L^{-1}). The quantified total flavanol content to SRBE wine was 29.70 mg L^{-1}. It is known that the degree of polymerization (DP) of flavanol compounds influences the perceived bitter and astringent sensations of flavanol-rich foods (GRIFFIN et al., 2019).

Content of anthocyanins and L * values of red wines

Differences in the content of monomeric anthocyanins (Table 1) were observed for the evaluated red wines samples. Higher values were found in STBE (123.19 mg L^{-1}) wines, followed by STTC (102.07 mg L^{-1}) and CSCO (100.24 mg L^{-1}). Lower values for monomeric anthocyanins was observed in MECO wine, with contents of 57.62 mg L^{-1}. Oliveira et al (2011) found monomeric anthocyanin values ranging from 9.14 to 156.48 mg L^{-1} in red wines produced in Brazil.

Regarding the anthocyanin content detected by HPLC in red wines, it was observed that the STCO wine showed higher calistefin values (2.10 mg L^{-1}) and the CSCO wine showed higher myricetin values (1.60 mg L^{-1}). As for curomanin levels, STTC, MECO and CSCO showed the highest values, with no statistical differences, and values of 0.36, 0.30 and 0.30, respectively. It is noteworthy that curomanin levels were not detected in STBE, STCO and CFCO wines. The higher petunidin contents for MECO samples (1.00), and the compound was not detected in STCO and CFCO wines. STBE wines presented higher levels of peonidin (20.1 mg L^{-1}) and oenin (19.83 mg L^{-1}), as well as higher anthocyanin values detected by HPLC (24.29 mg L^{-1}). Regarding the rose wine (Table 3), the oenin was observed in higher amounts (25.83 mg L^{-1}) when compared to other anthocyanins studied, and the total anthocyanins were quantified in the amount of 31.8 mg L^{-1}.

Urvieta et al. (2018) observed that wines from grapes produced in different regions and altitudes of Argentina presented different amounts in anthocyanins content, with higher amounts associated to higher altitudes. Anthocyanins from plants are a group of important phenolic compounds which belong to the flavonoid family. They are the main pigments responsible for the color of red wines and are extracted from the wine must, being transformed during wine making and aging (LIU et al., 2019).

The L* values of red wines are also shown in Table 1. Lower values were found in STCO (11.13) and STTC (11.15) wines, indicating darker wines than the other studied wines. Higher L* values were observed in MECO wines (11.24), indicating a lighter color, that can be correlated with the anthocyanin content and was the lowest found among the studied samples (57.62 mg L^{-1}). It is known that anthocyanins are directly related to grapes and the derived products. White wines (Table 2) showed no differences regarding the L* values, with average values of 35.28 (SBCO) and 37.47 (SBBE and CHCO). The rose wine (Table 3) presented L* of 13.66, values between the observed for this variable for red and white wines.

Table 2. Phenolic compounds and L* values for wines from Minas Gerais State, Brazil

Wine			
	SBBE	SBCO	CHCO
Flavonols			
(+)-Catechin	0.60±0.00^{b}	0.56±0.05^{b}	3.50±0.00^{a}
(-)-Epicatechin	0.60±0.17^{b}	0.73±0.05^{b}	1.20±0.00^{a}
(-)Epicatechin gallate	ND	ND	1.03±0.05^{a}
(-)Epigallocatechin	ND	ND	1.33±0.12^{a}
Procyanidin A2	0.50±0.00^{a}	0.46±0.05^{a}	0.50±0.00^{a}
Procyanidin B1	1.00±0.00^{a}	0.60±0.00^{b}	1.00±0.00^{a}
Procyanidin B2	6.10±0.10^{a}	0.50±0.00^{c}	3.06±0.05^{b}
Total flavonols quantification	8.80±0.27	2.85±0.15	11.62±0.22
Flavonols			
Quercetin	0.60±0.00^{b}	0.93±0.05^{a}	0.36±0.05^{c}
Quercetin Piranoside	0.30±0.00^{a}	ND	ND
Phenolic Acids			
Gallic acid	ND	ND	12.33±0.25^{a}
Caffeic acid	6.10±0.10^{b}	7.10±0.00^{a}	3.06±0.05^{c}

Cinnamic acid	ND	0.40±0.00[b]	0.53±0.05[a]
Chlorogenic acid	5.60±0.17[b]	3.40±0.00[c]	7.73±0.05[a]
Syringic acid	ND	ND	ND
Total phenolics acids quantification	11.7±0.27	10.90±0.00	23.65±0.40
Resveratrol	ND	0.40±0.00[b]	0.50±0.00[a]
Total phenolic[§]	375.33±6[a]	334.33±13[a]	360.66± 21[a]
L* values	37.47±0.58[a]	35.28± 2.13[a]	37.47± 2.40[a]

Means followed by the same letters in the same line do not differ according to Tukey´s test at 5% probability. ND – not detected; SBBE: Sauvignon Blanc (Boa Esperança); SBCO: Sauvignon Blanc (Cordislândia); CHCO: Chardonnay (Cordislândia); [t]Total monomeric anthocyanins quantified by the technic of differential pH and expressed as cyanidin 3-glucoside equivalent; [§]Total phenolics measured with Folin–Ciocateau expressed as mg L^{-1} gallic acid equivalent.

Phenolic acids

The observed contents of phenolic acids in the evaluated red wines are shown in Table 1 and ranged from 23.12 to 42.30 mg L^{-1} of gallic acid, 2.20 to 8.56 mg L^{-1} of caffeic acid, 0.40 to 0.70 mg L^{-1} of cinnamic acid, 0.70 to 4.66 mg L^{-1} of chlorogenic acid and 0.46 to 0.96 mg L^{-1} of syringic acid. The total amounts of phenolic acids ranged from 22.85 mg L^{-1} (STBE) to 49.92 mg L^{-1} (STTC), and the higher gallic acid content (42.30 mg L^{-1}) and chlorogenic acid (4.66 mg L^{-1}) were found for STTC wines. The CFCO and STBE samples showed the highest caffeic acid values, reaching 8.70 and 8.56 mg L^{-1}, respectively. MECO wine showed the greatest syringic acid content, with values of 0.96 mg L^{-1} and CFCO wines with the highest cinnamic acid contents (0.70 mg L^{-1}).

Regarding the bioactive contents in white wines (Table 2), the wine CHCO presented the highest gallic acid (12.33 mg L^{-1}), cinnamic acid (12.53 mg L^{-1}), chlorogenic acid (7.73 mg L^{-1}) contents, and larger values of total phenolic acid (23.65 mg L^{-1}). Higher caffeic acid levels were found in SBCO wines (7.10 mg L^{-1}). Syringic acid contents was detected in white wines. Among the phenolic acids, rose wine (Table 3), showed higher concentrations of caffeic acid (15:33 mg L^{-1}), followed by gallic acid (12.73 mg L^{-1}), and the total phenolic acids content observed was 36.33 mg L^{-1}. Padilha et al. (2017) observed a total amount of phenolic acids in Brazilian wine samples ranging from 41.30 to 228.7 mg L^{-1} and observed that caftaric acid was the main quantified, demonstrating that the terroir and the grape can strongly influence the total content of phenolic acids.

Table 3: Phenolic compounds and L* values of a rosé wine from Minas Gerais State, Brazil.

	Wine
	SRBE
Flavanols	
(+)-Catechin	2.20±0.00
(-)-Epicatechin	1.43±0.12
(-)Epicatechin gallate	1.70±0.44
(-)Epigallocatechin	6.60±0.17
Procyanidin A2	0.77±0.12
Procyanidin B1	1.67±0.58
Procyanidin B2	15.33±0.06
Total flavonols quantification	29.7±1.49
Anthocyanins	
Calistefin	3.10±0.00
Mirtilin	1.20±0.00
Kuromanin	ND
Peonidin 3-glucoside	1.67±0.06
Petunidin	ND
Oenin	25.83±0.05
Total anthocyanin quantification	31.8±0.11
Phenolic Acids	
Gallic acid	12.73±0.12
Caffeic acid	15.33±0.07
Cinnamic acid	0.70±0.00
Chlorogenic acid	7.57±0.21

Syringic acid	ND
Total phenolics acids quantification	36.33±0.40
Total monomeric anthocyanins[t]	38.72±0.98
Total phenolic[§]	632.33±42
L* values	13.66±0.24
% FRS	13.48±0.30
% Protection	28.36±1.37

SRBE: Syrah rose (Boa Esperança)

The values obtained for flavonols and in red wines are shown in Figure 1, with differences between the evaluated samples. The average values ranged from 0.36 to 0.76 mg L^{-1} to kaempferol, 0.76 to 3.93 mg L^{-1} to myricetin, 0.43 to 3.33 mg L^{-1} to quercetin, 3.4 to 6.2 mg L^{-1} to isohramnetin, 0.23 to 0.56 mg L^{-1} for rutin and 3.36 to 6.86 mg L^{-1} for quercetin pyranoside. The isohramnetin piranoside and quercetin were observed in samples, with considerable contents. Kaempferol and quercetin showed higher values in MECO wines, reaching 0.76 mg L^{-1} and 3.33 mg L^{-1}, respectively. Quercetin piranoside was found in higher levels for MECO (6.86 mg L^{-1}) and CFCO (6:50 mg L^{-1}) wines. Myricetin has been found in higher amounts in the STTC sample (3.93 mg L^{-1}). CSCO wines showed higher isohramnetin contents (6.2 mg L^{-1}) and for rutin, higher values were observed in MECO (0.50 mg L^{-1}) and CFCO (0.56 mg L^{-1}) wines. Oliveira et al., (2019) studying Brazilian tropical wines produced in different altitudes observed an effect of the altitude on the contents of kaempferol (1.1 to 3.5 mg L^{-1}), isorhamnetin (4.6 to 16.5 mg L^{-1}) and quercetin (6.0 to 25.8 mg L^{-1}) with higher values from wines produced with grapes from lower (350 m) altitude. The Minas Gerais State are characterized by regions with higher altitudes, which can explain the values in accordance to the observed by Oliveira et al. (2019) in wines from a region with 1100 m at Bahia, Brazil.

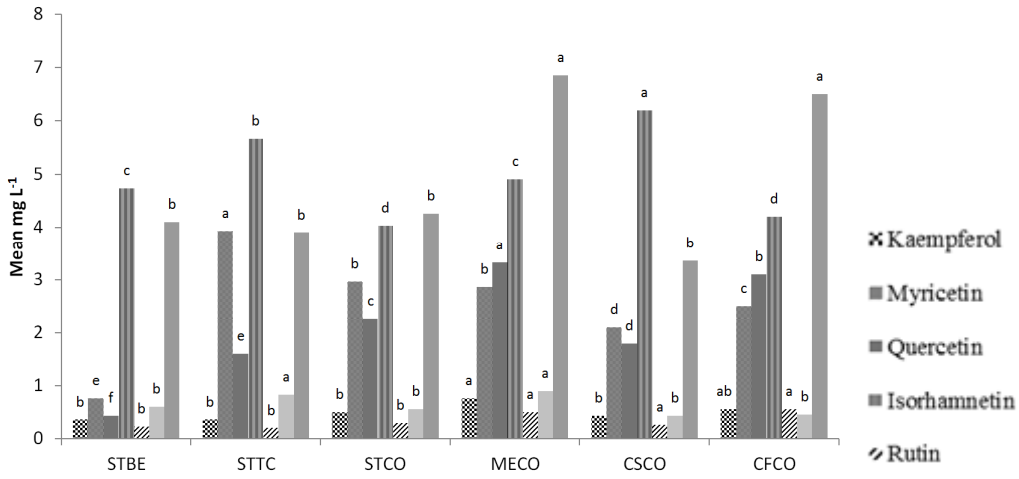

Figure 1. Mean values for flavonols and trans-resveratrol in wines produced in Minas Gerais, Brazil. STBE: Syrah (Boa Esperança); STTC: Syrah (Três Corações); STCO: Syrah (Cordislândia); MECO: Merlot (Cordislândia); CSCO: Cabernet Sauvignon (Cordislândia); CFCO: Cabernet Franc (Cordislândia).

According to the data presented in Table 2 for white wines, is possible to observe higher quercetin contents in SBCO wines (0.93 mg L^{-1}) and quercetin piranoside contents were only observed in SBBE wines (0.30 mg L^{-1}). Among the flavonols of the rosé wine (Table 4), the highest contents were observed for isohramnetin (1.00 mg L^{-1}), followed by quercetin (0.83 mg L^{-1}) and the values of flavonols achieved 3.3 mg L^{-1}.

The higher levels of t-resveratrol were observed in MECO (0.90 mg L^{-1}) and STTC (0.83 mg L^{-1}) red wines. For the white wines (Table 2), the highest t-resveratrol values were observed in CHCO (0.50 mg L^{-1}) and the compound was not identified in SBBE wines. In the rose wine (Table 4), the t-resveratrol content found was 0.43 mg L^{-1}. Caliari et al. (2014) analyzing classical and innovative varieties produced in Brazil, found t-resveratrol values ranging from 0.08 to 0.48 mg L^{-1}. Meng et al (2012) analyzing wine produced in China found values ranging 0.08 to 0.70 mg L^{-1}. Several studies demonstrated the beneficial effect of

resveratrol in health, either by preventing a number of disorders or for a treatment of different diseases (TURNER et al, 2015; IDO et al, 2015; LIU et al, 2015; CHEN et al, 2014). Resveratrol (trans-3,4′,5-trihydroxystilbene) is a stilbene that can be found in a large number of plant products, including the skins and seeds of grapes and wines. There are scientific evidence has demonstrated that resveratrol can act with biological function preventing diseases (MARTINÉZ et al., 2018).

Table 4: Mean values for flavonols and trans-resveratrol in wine SRBE produced in Minas Gerais, Brazil.

Wine	
SRBE	
Flavonols	
Kaempferol	0.30±0.00
Myricetin	ND
Quercetin	0.83±0.06
Quercetin Piranosideo	0.73±0.07
Isorhamnetin	1.00±0.00
Rutin	0.17±0.06
Total flavonols quantification	3.03±0.19
t-Resveratrol	0.43±0.06

SRBE: Syrah rose (Boa Esperança)

Antioxidant activity of red wines

In Figure 2 is possible to observe the antioxidant activity of red wines by the DPPH method.

The highest antioxidant activity (% of free radicals scavenging - FRS) was observed for STTC wine (75.37%), but not different from CSCO (72.50%), values that can be correlated with the largest content of phenolics observed in wines as phenolic compounds (3009 mg L^{-1}), that present strong antioxidant activity. Lower values of FRS% were found in STCO (64.04%) and CFCO (65.15%) wine samples. Regarding the antioxidant activity using the β-carotene/linoleic acid method, no statistical differences were observed for the different evaluated red wines. The average values in % of protection were STBE (36.99%), STTC (30,03%), STCO (29.35%), MECO (29.63%), CSCO (32.16%) and CFCO (35.99%).

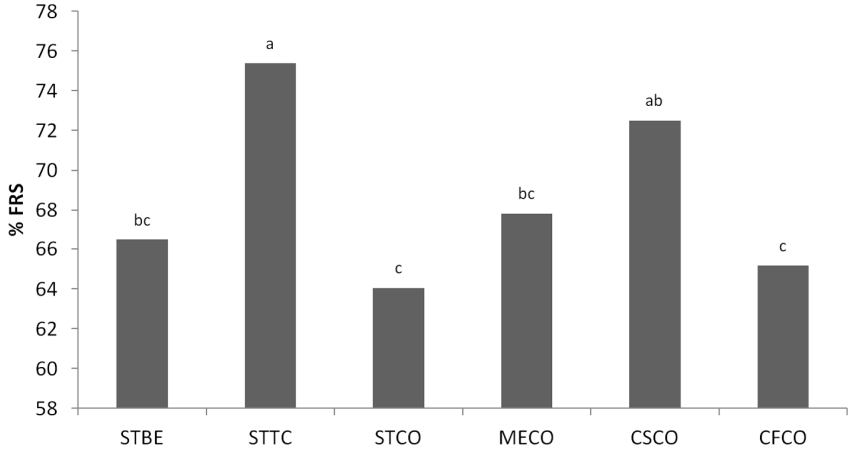

Figure 2. Mean values for antioxidant activity of wines produced in Minas Gerais, Brazil. STBE: Syrah (Boa Esperança); STTC: Syrah (Três Corações); STCO: Syrah (Cordislândia); MECO: Merlot (Cordislândia); CSCO: Cabernet Sauvignon (Cordislândia); CFCO: Cabernet Franc (Cordislândia).

Regarding the antioxidant activity of white wines (Table 2), no statistical differences were observed using both methods of evaluation. Using the DPPH method, the FRS% of the samples were SBBE (5.68), SBCO (5.69) and CHCO (6.30). Using the β-carotene/linoleic acid method, the values observed were SBBE (23.75), SBCO (23.06) and CHCO (30.56) of free radical scavenging (FRS). The rose wine presented 13:48% of FRS and 28.36% of protection against oxidation. Studies comparing the antioxidant activity of wines from emergent tropical regions, associated to the profile

of bioactive phenolic compounds are scarce. The diversification in the phenolic profile of the grapes and wines of different regions can result in products with distinct antioxidant characteristics, which evidences the importance and the demand of studies regarding these chemical characteristics in wine produced regions.

The results suggest that not only the region of grape production play an important role in the development and content of compounds with antioxidant activity, but also the grape variety. Grapes contain a number of health-promoting compounds, like polyphenols, mainly in red varieties. It was expected, therefore, that red wines presented higher antioxidant activities, since red grapes present higher amounts of compounds associated to antioxidant capacity activities.

Antioxidants are compounds that have the ability to scavenge free radicals. Free radicals can cause oxidative damage which might build up over time and lead to degenerative diseases (ZUBIA & DIZON, 2019). Activities above 70% of free scavenging radical has been considered a high anioxidant activity. So it could be concluded that the Cabernet Sauvignon wine produced in Três Corações present this desirable activity, not differentiating, however, from Cabernet Sauvignon wines produced in Cordislândia.

CONCLUSION

Wines from the South of Minas Gerais State, Brazil, presented higher amounts of t-resveratrol when compared to wines produced in traditional regions of the country. The wines studied presented significant contents of total phenolics, antocianins, flavonol, flavanols and phenolic acids, with the necessary bioactive characteristics to act as functional food for consumers and to allow the competition with traditional wine production regions and the consolidation of wines produced in the south of Minas Gerais State.

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RESUMO: Vinhos são conhecidos por seu alto teor de compostos bioativos, os quais podem ser influenciados pela região e clima de cultivo das uvas. Novas regiões de produção são normalmente desenvolvidas utilizando técnicas padrões estabelecidos em regiões produtoras tradicionais, mas é importante a caracterização do perfil do vinho obtido, que é diferente de acordo com o *terroir* e pode ser importante em futuras indicações geográficas. O objetivo do presente estudo foi avaliar a cor, capacidade antioxidante, teor de antocianinas e perfil de compostos fenólicos em vinhos produzidos no estado de Minas Gerais, Brazil. Vinhos foram produzidos em diferentes vinícolas do estafo utilizando as variedades Syrah, Merlot, Cabernet Sauvignon, Cabernet Franc (tintos), Chardonnay e Sauvignon Blanc (brancos) e vinhos Syrah (rose) roses dos municípios de Cordislândia, Boa Esperança e Três Corações, localizados no sul de Minas Gerais. Vinhos produzidos no estado de Minas Gerais apresentaram teores de t-resveraatrol, fenólicos totais, antocianinas, flavonóis, favanois e ácidos fenólicos consistentes com os observados em vinhos de outras regiões produtoras. No entanto, o *terroir* e a variedade de uva podem resultar em uma diferenciação de compostos observados em vinhos. Vinhos Syrah produzidos em Boa Esperança se destacaram com altos teores de antocianinas (24.29 mg L^{-1}), ácidos fenólicos (123.19 mg L^{-1}) and flavanois (35.55 mg L^{-1}), quando comparados com vinhos da mesma variedade de outros municípios e os demais vinhos tintos avalaidos. Vinhos Sauvignon Blanc de Boa Esperança apresentaram altos tores de ácidos fenólicos e flavonoids totais, quando comparados com vinhos da mesma variedade produzidos em Cordislândia. Vinhos Chardonay apresentaram maiores teores de fenólicos totais quando comparados com outros vinhos brancos avaliados. Vinhos Rosé produzidos no Sul de Minas Gerais apresentaram teores de ácidos fenólicos de 36.33 mg L^{-1} e toeres de flavonois totais de 29.7 mg L^{-1}. Maior atividade antioxidante pelo método do DPPH (% de sequestro de radicais livres) foi observada em vinhos Syrah produzidos em Três Corações (75.37%), não se diferenciando de vinhos Cabernet Sauvignon de Cordislândia (72,50%), teores que podem ser correlacionados com o maiores tores de de fenólicos em vinhos, na forma de compostos fenólicos (3009 mg L^{-1}). Não foram observadas diferenças nos teores de atividade antioxidante em vinhos brancos. Os resultados indicam que os vinhos de Minas Gerais paresental características nutricionais e benéficas indicadas no consume, quando comparados com vinhos produzidos em tradicionais e diferentes regiões do Brasil e outros países.

PALAVRAS-CHAVE: *Vitis vinifera*. Compostos bioativos. Resveratrol. Qualidade. Vinhos brasileiros

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