# WINE GRAPE QUALITY OF GRAPEVINES GROWN IN THE CERRADO ECOREGION OF BRAZIL

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## Abstract

**Aims**: Geographical indication plays an important role in the improvement of wine quality. In this context, the search for new grape growing areas has been constant. The São Francisco River Valley in the cerrado of Minas Gerais State (Brazil) has been pointed out in the Geoviticulture Multicriteria Climatic Classification System (MCC System) as a potentially winegrowing region, especially considering the autumn-winter period when night temperatures are favorable to grape ripening. In this work, we studied the maturation curves and fruit composition of four wine grape varieties (Syrah, Merlot, Cabernet-Sauvignon and Cabernet Franc) in two growing seasons in order to validate the state of Minas Gerais as a new winegrowing region in Brazil.

**Methods and results**: Quality parameters (berry weight, pH, titratable acidity and total soluble solids) were measured weekly from véraison to harvest, and sugar, organic acid, anthocyanin and phenolic concentrations were determined in must and berry skins and seeds at harvest. Syrah berries showed the highest weight throughout maturation which contributed to higher yield (8.92 ton $ha^{-1}$), followed closely by Merlot (8.07 ton $ha^{-1}$). Berry sugar concentrations were higher and malic acid levels were lower than the values usually observed in wine grapes harvested during summer in traditional winegrowing regions in Brazil. Cabernet Franc showed lower levels of anthocyanins and skin phenolics per kg berries and the highest values of seed phenolics, which were not affected by growing season.

**Conclusion**: Weather conditions of the cerrado of Minas Gerais State in Brazil during winter allowed complete maturation of Cabernet-Sauvignon, Cabernet Franc, Merlot and Syrah cultivars as revealed by the satisfactory sugar, anthocyanin and skin phenolic accumulation.

**Significance and impact of the study**: This study revealed the potential of the cerrado ecoregion in the northeast of Minas Gerais to become a new winemaking region in Brazil.

**Key words**: *Vitis vinifera*, anthocyanin, phenolic compound, maturation, cerrado

## Résumé

**Objectif**: L'indication géographique joue un rôle important dans l'amélioration de la qualité du vin. Dans ce contexte, de nouvelles régions viticoles sont recherchées en permanence. La Vallée du Rio São Francisco, située dans la région du Cerrado de Minas Gerais (Brésil), a été désignée par le « Geoviticulture Multicriteria Climatic Classification System (MCC System) » comme une région avec un potentiel intéressant pour la production de vin, en raison notamment des températures nocturnes de l'automne et de l'hiver, favorables à la maturation du raisin. Ce travail a porté sur l'étude des courbes de maturation et la composition des baies de quatre cépages de cuve (Syrah, Merlot, Cabernet-Sauvignon et Cabernet Franc) sur deux millésimes, dans le but de classer le Cerrado de Minas Gerais, comme nouvelle région viticole brésilienne.

**Méthodes et résultats**: Les paramètres qualitatifs (poids de baies, pH, acidité et solides solubles) ont été mesurés une fois par semaine entre la fin de la véraison et la vendange. Les acides organiques, sucres, anthocyanes et composés phénoliques ont été évalués dans le moût et la pellicule des raisins. Les baies de Syrah ont eu le poids le plus élevé pendant la période de la maturation, ce qui a entraîné le rendement le plus important (8,92 $ton.ha^{-1}$), suivi de près par le Merlot (8.07 $ton.ha^{-1}$). Pour l'ensemble des cépages et des millésimes analysés, les concentrations en sucres ont été plus élevées et les teneurs en acide malique ont été plus faibles que celles observées pour les raisins de cuves provenant des vignobles traditionnels du Brésil. Le cépage Cabernet Franc a montré les plus faibles teneurs en anthocyanes et en composés phénoliques de la pellicule, et les teneurs les plus élevés en composés phénoliques dans les pépins, et ce indépendamment du millésime.

**Conclusion**: Les conditions climatiques hivernales du Cerrado de Minas Gerais ont permis une bonne maturation des baies des cépages Cabernet-Sauvignon, Cabernet Franc, Merlot et Syrah, pour la concentration en sucres, la teneur en anthocyanes et en composés phénoliques de la pellicule des baies.

**Impact scientifique de cette étude**: Cette étude a permis de montrer que la région du Cerrado, située au Nord de Minas Gerais, présente de bonnes conditions pour devenir une nouvelle région viticole du Brésil.

**Mots-clés**: *Vitis vinifera*, anthocyanes, composés phénoliques, maturité, Cerrado

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## INTRODUCTION

The quality of Brazilian wines has experienced an extraordinary evolution over the last two decades. At an early beginning, Brazilian wines were represented by wines made from American cultivars. Wine industry evolved to European cultivars and varietal wines from vineyards grown basically in the south of Brazil. Nowadays winegrowers lay improvement of quality not only on breeding programs and management practices but also on determination of geographical indication (TONIETTO *et al.,* 2006).

In the most traditional grape growing regions in the South and Southeast of Brazil, classified by TONIETTO and CARBONNEAU (2004) as a humid warm temperate with temperate nights viticultural climate, the vegetative and reproductive phases of the grapevines occur under high air temperature and rainfall, which increase the susceptibility of grapes to berry splitting, botrytis and other fungal diseases (JACKSON and LOMBARD, 1993). Furthermore, the excessive soil moisture slows ripening, increases yield and dilutes sugar and other components by berry enlargement, elevates juice pH and acid content, and reduces anthocyanin accumulation due to shading by continuous and excessive shoot growth (SMART and ROBINSON, 1991). In this context, the search for new grape growing areas has been constant as shown by the recent establishment of new vineyards in São Joaquim (Santa Catarina State), Campanha (Rio Grande do Sul State) and in arid and semi-arid regions of São Francisco River Valley in the Northeast of Brazil (TONIETTO and CARBONNEAU, 1999).

The State of Minas Gerais, in the Southeast region of Brazil, presents a wide range of climatic conditions, where the dry climate of the North region contrasts with the mild temperature and abundant rainfall in the mountains of the Southeast region. Therefore, the quality and typicity of wines produced in these different regions vary according to the agronomical response of cultivars growing under different climatic zones (TONIETTO *et al.,* 2006).

In the Southeast of Minas Gerais State some authors have shown that it is possible to improve the quality of wine grapes when the harvest is moved from January (summer) to July (winter) by double pruning (first pruning in August and second one in January) (AMORIM *et al.,* 2005). At the winter harvest, Syrah grapevines showed higher yield, higher sugar, anthocyanin, and total phenolic levels and lower rot incidence as compared to grapes harvested during the summer (FAVERO *et al.*, 2008). These results indicate that double pruning practice could be considered as an important tool for improving wine grape quality in other regions.

The São Francisco River Valley, in the cerrado of Minas Gerais State, is a traditional table grape growing region, where the high temperature and the cultural practices, such as irrigation and pruning management and growth regulator application, allow grapes to be produced all year round. In Pirapora, the main table grape growing city (around 500 ha) in Minas Gerais State, the monthly values of minimum average air temperature vary from 12.2 to 20.4°C and those of maximum average air temperature vary from 28.2 to 31.7°C (CONCEIÇÃO and TONIETTO, 2005). According to these authors, in spite of high temperatures, this region has a great climatic potential to become a grape growing for wine making region, especially considering the autumn-winter (May to July) period when there are « temperate nights viticultural climate » favorable to grape ripening. In the previous studies conducted in this tropical region, FAVERO *et al.* (2010) showed that it is possible to produce Syrah grapes with optimum maturity indices mainly when the trellis system used was a modified Geneva Double Curtain. However, despite this first evaluation, there is need for more information about the performance of other field-grown grapevines under such climatic conditions. In this context, the objective of this study was to evaluate the maturation and fruit composition of four red wine grape varieties grown in the cerrado ecoregion of Minas Gerais State.

## MATERIALS AND METHODS

### 1. Vineyard description and plant material

This trial was carried out in a commercial vineyard in Pirapora (17° 21' S, 44° 55' W), in the north of the Minas Gerais State, Brazil, at an altitude of 505 m. The regional climate is classified as Aw – wet tropical with dry winter – according to Köppen climate classification. The annual mean rainfall is 1,200 mm, the annual insolation is 2,695 h, the maximum temperature is 30.6°C, the relative humidity is around 70%, and the thermal amplitude range is from 12.7 to 16.1°C during the harvest period (TONIETTO *et al.,* 2006).

The predominant regional soil is sandy latosol with low content of organic matter and low water holding capacity. Therefore, during the driest period (March to September) the vineyard was irrigated once a week by drip emitters.

Four red cultivars (*Vitis vinifera* L.) including Cabernet-Sauvignon, Merlot, Syrah and Cabernet Franc grafted onto 1103 Paulsen rootstock were evaluated during the winter growing season of 2007 and 2008. A randomized complete design was used with a population of 300 plants per cultivar.

The grapevines were planted in 2005 in north-south-oriented rows at 2.8 m x 1.5 m and trained on a bilateral Royat Cordon. The vertical shoots were supported by three trellis wires and spur pruned (two buds per spur) in February, six months after the first pruning realized in September of the previous year. Immediately after pruning, the buds were painted with a 6% hydrogen calciumcyanamide (Dormex®) solution to stimulate budburst. In both growing seasons, standard cultural practices were applied to all cultivars.

All cultivars were harvested on the same day due to the distance of over 1,000 km between the vineyard and the winery, with the exception of Merlot grapes in the 2008 season, which were harvested earlier due to visual symptoms of berry dehydration.

**2. Fruit composition**

Quality parameters such as pH, soluble solids, titratable acidity and berry weight were measured weekly from véraison (two green berries per cluster left) to harvest. Each sample (100 berries per cultivar) was randomly collected from an experimental plot of 300 vines. The berries were weighed and a subsample of 50 berries was used for transversal diameter determination. Each sample was then divided into three subsamples of approximately 34 berries for must analyses. At harvest, three replicates of 70 berries were randomly collected from the vines to evaluate sugars (glucose, fructose and sucrose) and organic acids (malic and tartaric) in must. Total phenolic compounds in grape seeds and skins and anthocyanins in grape skins were evaluated from a sample of 100 berries. Yield components (cluster and berry weight, yield) were also evaluated in the 2008 season.

Soluble solids (ºBrix) were determined using a handheld temperature-compensated refractometer (ATAGO Model Pal-1). The pH of undiluted must of each sample was determined using a pHmeter (Micronal B474). Titratable acidity was determined by titration with 0.1N NaOH to a phenolphthalein end point and results were expressed as g $L^{-1}$ of tartaric acid.

For phenolic compounds determination, approximately 0.5 g of frozen powder skin was mixed with an extraction solution of acidified methanol (HCl 1%, v/v) using an Ultra Turrax mixer (IKA T-18 basic) at 13,000 rpm for 1 min. The samples were kept overnight in the extraction solution in the dark at 4ºC. Then, extracts were separated by centrifugation in a Universal 320 centrifuge (Hettich) for 10 min at 8,000 rpm. The pellet was washed with extraction solution until complete removal of the color. The supernatants were brought together into a 100 mL calibrated flask. Total monomeric anthocyanins were measured using the pH-differential method (GIUSTI and WROLSTAD, 2001), using Â = 28000 and MW = 529 (AMERINE and OUGH, 1980). Total phenolics were determined in the same extract by the Folin-Ciocalteu assay, with absorbance readings at 760 nm, and the total phenolic content was expressed as gallic acid equivalents in milligrams per gram of fresh grape skins (AMERINE and OUGH, 1980). Phenolic compounds in seeds were also quantified by the Folin-Ciocalteu assay after extraction with alcoholic solution (methanol acidified with HCl 1% v/v) according to the methodology described by GONZÁLEZ-NEVES *et al.* (2004).

An anion exchange resin (Bio-Rex 5, Bio-Rad Labs) was used to separate the must into sugar and acid fractions (McCORD *et al.,* 1984). An aliquot of 20 µL was taken from the acid fraction and injected into a HPLC-DAD (Hewlett Packard, model 1100) equipped with SupelcoGel C-610H column (Supelco 7.8 x 300 mm) at 15°C and DAD detector at 245 nm. Water acidified with phosphoric acid solution at 0.5% was used as mobile phase at a flow rate of 0.5 mL $min^{-1}$ in an isocratic condition. Standard solutions of malic and tartaric acid were used to identify and quantify the acids in the chromatogram.

Glucose, fructose and sucrose were quantified from the sugar fraction obtained from the anion exchange resin as described above. An aliquot of 25 µL was injected into a HPLC-PAD (Dionex, Sunnyvale, CA, USA) in a DX-500 chromatograph. This was coupled to a pulsed amperometric detector using a CarboPac PA1 (4.0 x 250 mm) column (Dionex). A solution of 18 mM NaOH was used as mobile phase with an isocratic flow of 1 mL. Standard solutions of glucose, fructose and sucrose were used to identify and quantify the sugars in the chromatogram.

**3. Data analyses**

Statistical data analysis was performed by analysis of variance (ANOVA) using SAEG software. The statistical significant differences were detected by Tukey test at 5% probability.

## RESULTS AND DISCUSSION

Parameters of technological maturity (berry weight, total soluble solids, pH and titratable acidity) were evaluated from véraison to harvest. Their evolution during grape maturation in 2007 and 2008 vintages are summarized in figure 1.

In the 2007 vintage, the maturation period was 15 days shorter than in the 2008 vintage. Despite the young age of the plantation, 2007 was the first year of commercial production of the 2-year-old vineyard, the evolution of quality parameters of the four cultivars followed the same pattern in both vintages. Cabernet Franc vines did not follow the same developmental stage, as véraison occurred

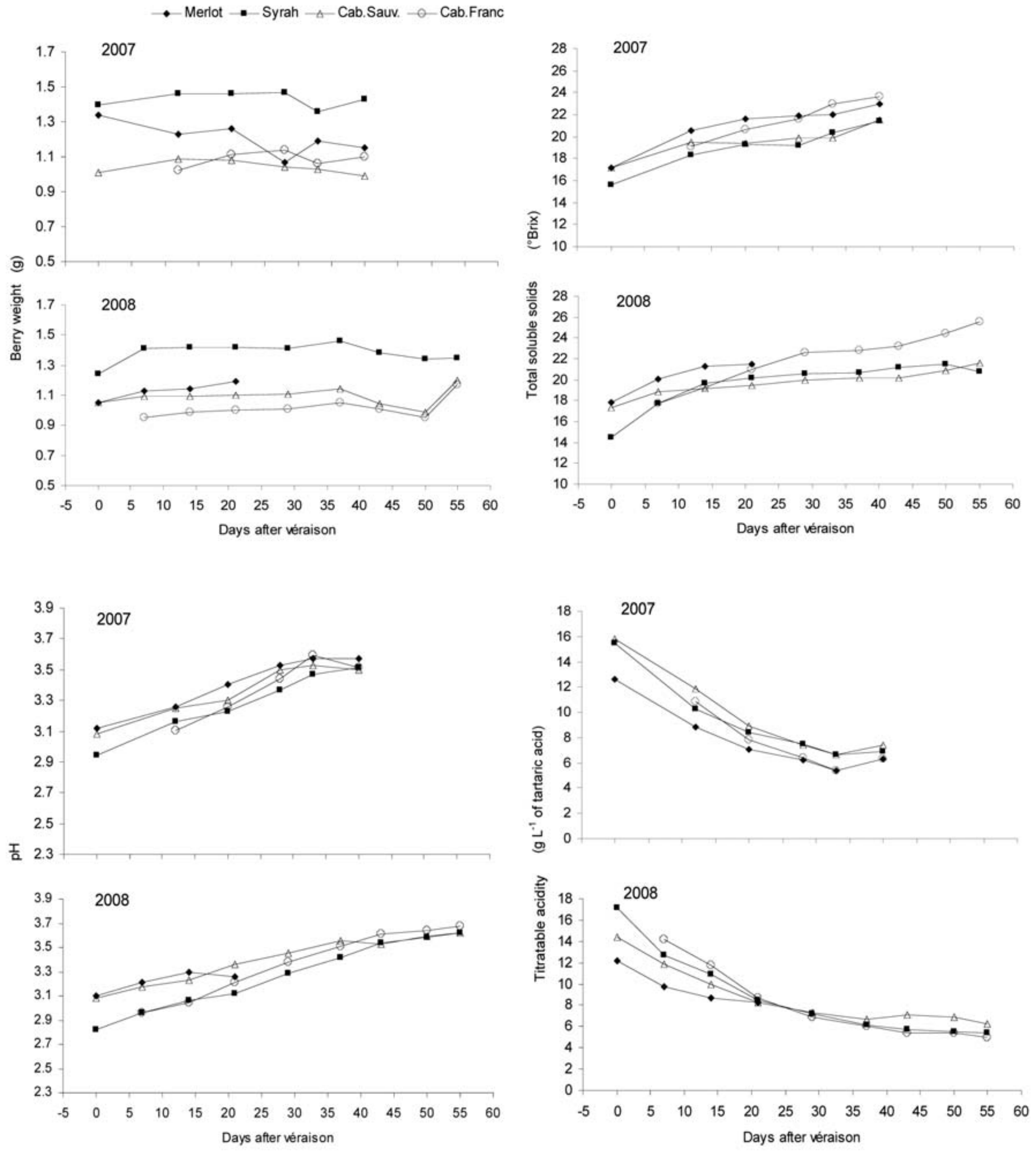


**Figure 1 - Evolution of berry weight, total soluble solids, pH and total acidity from véraison to harvest in 2007 and 2008 winter vintages. Data are means of three replicates.**

**Table 1 – Physical parameters determined in berries at harvest and crop production.**

| Cultivar | Berry diameter (mm) | | | Berry weight (g) | | | Cluster weight (g) | Crop level (g pl$^{-1}$) | Estimated yield (t ha$^{-1}$) |
|---|---|---|---|---|---|---|---|---|---|
| | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) | 2008 | 2008 | 2008 |
| Syrah | 12.36 ± 0.91b | 12.33 ± 0.79b | ns | 1.43 ± 0.01a | 1.35 ± 0.03a | * | 135.7 ± 15.5a | 3570.6 ± 940.5a | 8.92 |
| Cabernet-Sauvignon | 11.76 ± 0.94c | 12.14 ± 0.80b | ns | 0.99 ± 0.00c | 1.20 ± 0.02b | * | 89.9 ± 11.4c | 2124.1 ± 962.0a | 5.30 |
| Merlot | 12.91 ± 0.95a | 12.80 ± 0.73a | ns | 1.12 ± 0.03b | 1.19 ± 0.01b | * | 119.9 ± 13.4b | 3237.0 ± 753.5a | 8.07 |
| Cabernet Franc | 11.65 ± 0.98c | 11.93 ± 0.89b | ns | 1.08 ± 0.02b | 1.18 ± 0.03b | * | 92.4 ± 10.0c | 2401.1 ± 386.3a | 6.00 |

All data are expressed as mean value ± standard deviation (n=3)
Different letters within the same column mean significant differences according to a Tukey test ($p<0.05$).
(1)Non significant (ns) or significantly different (*) between years according to Fischer's least significant difference at the 5% level.

7 to 10 days after the other cultivars under study (figure 1). Such behavior was expected because the period between flowering and véraison of Cabernet Franc is longer than that of Cabernet-Sauvignon, Merlot and Syrah vines (BLOUIN and GUIMBERTEAU, 2004).

Berries showed a slight weight increase during the first 10 days after véraison. This corresponds to the second growth phase of maturation during which free sugars, potassium, amino acids and phenolic compounds accumulate and concentrations of malic acid and ammonium decrease in grapes (RIBÉREAU-GAYON *et al.,* 2006).

Syrah showed the highest berry weight throughout maturation (figure 1), which contributed to its higher yield (table 1). The cluster weight was higher in Syrah (135.7 g) and Merlot (119.9 g), whereas Cabernet-Sauvignon and Cabernet Franc showed the lowest cluster weight (89.9 and 92.4 g, respectively). Although there were no significant differences in yield between cultivars, Merlot and Syrah showed the highest estimated yield (higher than 8 ton $ha^{-1}$). These yields are in the range considered satisfactory for tropical wine grape region (LEÃO *et al.,* 2009).

The mean berry weight over the two vintages (1.19 g) was lower than the range commonly observed (1.40 to 1.78 g) in wine grapes during the summer harvest in Brazilian Southeast Regions (RIZZON and MIELE, 2001, 2002, 2003). The control of berry size is important mainly for red wine grape varieties since there is an increase of skin:pulp ratio, which contributes to improve grape quality. The berry weights observed in this study are in the range usually found in traditional wine making regions such as Bordeaux (VAN LEEUWEN *et al.,* 2004), Napa Valley (BENZ *et al.,* 2006), and Australia (GINESTAR *et al.,* 1998).

The technological maturity indices were quantified in must at harvest and also presented per kilogram berries fresh weight (tables 2 and 3). High total soluble solid content (sugars) and pH and low titratable acidity (TA) and malic acid content in 2008 in comparison with 2007 indicates that higher ripeness was reached in 2008 except for Merlot cultivar, which was harvested earlier due to berry dehydration observed in the field.

The range of berry sugar concentrations (21° to 25°Brix) under the warm and dry climate of the Northeast of Minas Gerais State was higher than the values (under 19°Brix) usually observed in wine grapes harvested during the summer in Brazilian South Region (RIZZON and MIELE, 2001, 2002, 2003, 2004; DETONI *et al.,* 2007; MANDELLI *et al.,* 2008; CHAVARRIA *et al.,* 2008). Furthermore, a similar range of berry sugar concentration was also observed for Merlot (24.9°Brix) in Napa Valley (BENZ *et al.*, 2006) or Syrah (23°Brix) in Australia (GINESTAR *et al.*, 1998).

The alcoholic degree of wine is determined by berry sugar concentration at harvest. In cool weather regions, such as traditional wine regions of Southeast and South of Brazil, the sugar level of the grapes is too low to reach the desired alcoholic concentration of 11°GL and the addition of sugar cane to must before fermentation is necessary. This process is called chaptalization. In this study, the results showed that for wine grape harvested in Pirapora there is no need to adjust the sugar level by chaptalization, which is a qualitative advance for a wine making region.

As expected, the acidity level was lower than that observed for wine varieties grown in the South and Southeast Regions of Brazil (table 2). The values of TA and pH usually found for Cabernet-Sauvignon, Cabernet Franc and Merlot growing under temperate climate conditions vary from 7.8 to 9.0 g $L^{-1}$ and from 3.1 to 3.5, respectively (DETONI *et al.*, 2007; RIZZON and MIELE, 2001, 2002, 2003). In São Paulo State, the values of TA are higher than 8.5 g $L^{-1}$ for berries of Cabernet-Sauvignon and Syrah (ORLANDO *et al.,* 2008). In addition, all cultivars showed lower malic acid concentration (table 3) than that observed in the South Region, which is normally higher than 4 g $L^{-1}$ (RIZZON and MIELE, 2001, 2002).

**Table 2 – Classical parameters of technological maturity determined in grape must and berries at harvest.**

| | Total soluble solids | | | | | | pH | | | Titratable acidity | | | | | | Maturation index (2) | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | (°Brix) | | | (g $kg^{-1}$) | | | | | | (g $L^{-1}$ tartaric acid) | | | (g tart.acid $kg^{-1}$) | | | | |
| Cultivar | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) | 2007 | 2008 |
| Syrah | 21.4b | 20.8b | ns | 175.03b | 187.87b | * | 3.51b | 3.62b | * | 6.90b | 5.40c | * | 5.65a | 4.87c | * | 31.0 | 38.5 |
| Cabernet-Sauvignon | 21.5b | 21.6b | ns | 161.66c | 186.13b | * | 3.50b | 3.62b | * | 7.37a | 6.20b | * | 5.54ab | 5.35b | * | 29.2 | 34.8 |
| Merlot | 23.0a | 21.5b | * | 165.18c | 186.92b | * | 3.57a | 3.26c | * | 6.32c | 8.27a | * | 4.54c | 7.20a | * | 36.4 | 26.0 |
| Cabernet franc | 23.6a | 25.6a | * | 200.01a | 224.49a | * | 3.51b | 3.68a | * | 6.30c | 4.95d | * | 5.33b | 4.35d | * | 37.5 | 51.7 |

All data are expressed as mean value (n=3)
Different letters within the same column mean significant differences according to a Tukey test ($p<0.05$).
(1)Non significant (ns) or significantly different (*) between years according to Fischer's least significant difference at the 5% level.
(2)Maturity indice = total soluble solids/titratable acidity (g 100 $mL^{-1}$).

**Table 3 – Levels of reducing sugars and organic acids in grape must and berries at harvest.**

| Cultivar | Glucose (g L-1) | | | Glucose (g kg-1) | | | Fructose (g L-1) | | | Fructose (g kg-1) | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) |
| Syrah | 119.0a | 108.2a | * | 97.36a | 97.61a | ns | 116.3ab | 106.4b | ns | 95.14b | 95.98b | ns |
| Cabernet-Sauvignon | 105.2b | 105.5a | ns | 79.01b | 91.02a | * | 112.4b | 118.2ab | ns | 84.34b | 102.03b | * |
| Merlot | 111.3ab | 110.6a | ns | 79.90b | 96.30a | * | 116.8ab | 109.7b | ns | 83.86b | 95.53b | * |
| Cabernet franc | 120.0a | 112.9a | ns | 101.54a | 99.18a | ns | 130.1a | 132.1a | ns | 110.13a | 115.98a | ns |
| | **Tartaric acid (g L-1)** | | | **Tartaric acid (g kg-1)** | | | **Malic acid (g L-1)** | | | **Malic acid (g kg-1)** | | |
| | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) |
| Syrah | 10.9a | 6.7a | * | 8.90a | 6.06a | * | 3.9a | 2.4c | * | 3.19a | 2.13b | * |
| Cabernet-Sauvignon | 6.7b | 7.3a | ns | 4.99b | 6.27a | ns | 3.7a | 3.2b | * | 2.77a | 2.79a | ns |
| Merlot | 6.3b | 7.3a | ns | 4.55b | 5.29a | ns | 2.2b | 3.7a | * | 1.38c | 3.24a | * |
| Cabernet franc | 6.7b | 6.6a | ns | 5.71b | 5.82a | ns | 2.6b | 1.9d | * | 2.19b | 1.65c | * |

All data are expressed as mean value (n=3)
Different letters within the same column mean significant differences according to a Tukey test (p<0.05).
(1)Non significant (ns) or significantly different (*) between years according to Fischer's least significant difference at the 5% level.

The high diurnal temperature observed in Pirapora may be responsible for reduced malic acid level (JACKSON and LOMBARD, 1993). In contrast, the level of tartaric acid was higher in Pirapora when compared to values of 5.4 g $L^{-1}$ observed in Brazilian South Region (RIZZON and MIELE, 2001, 2002, 2003, 2004). In this case, reduced water supply may be responsible for the increased tartaric acid concentration in must (BLOUIN and GUIMBERTEAU, 2004).

The tartrate:malate ratio was in the range usually observed in traditional wine making regions such as Bordeaux and California (BLOUIN and GUIMBERTEAU, 2004) and the pH level was in the range 3.1 to 3.6 recommended for a good wine stability (AMERINE and OUGH, 1980).

Some indices such as glucose:fructose ratio and total soluble solids/titratable acidity (maturity indice - MI) are commonly used to evaluate the technological maturity and to predict the harvest date (BLOUIN and GUIMBERTEAU, 2004; FALCÃO *et al.*, 2008). A glucose:fructose ratio close to 2 is reached at véraison dropping to 1 at maturation and to 0.95 in ripe grapes (BLOUIN and GUIMBERTEAU, 2004) while MI levels above 30 indicate optimal ripeness level for wine production (FALCÃO*et al.,* 2008). Maturity indice above 30 were reached in all cultivars except for Cabernet-Sauvignon in 2007 and Merlot in 2008 (table 2). The glucose:fructose ratio was significantly higher in Syrah (1.02), followed by Merlot (0.98), Cabernet-Sauvignon (0.91) and Cabernet Franc (0.89) (table 3). These results suggest that at harvest date Cabernet-Sauvignon and Cabernet Franc grapes were overripe while Syrah and Merlot grapes were mature. The maturity indice, however, is not suitable for comparing different varieties since some are rich both in sugars and in organic acids (RIBÉREAU-GAYON *et al.,* 2006a). Grapes reach enological maturity when various factors are in balance, giving the potential to produce the highest quality wine. Technological, aromatic and phenolic maturity are independent variables that must all be taken into account in assessing enological maturity and deciding when the grapes should be harvested (RIBÉREAU-GAYON *et al.*, 2006b).

The range of phenolics and their concentrations are important determinants of flavor. Anthocyanins are a major component in the color of red wine. The most abundant class of soluble polyphenolics in grape berries are the polymeric flavan-3-ols (tannins) found in the hypodermal layers of the skin and the soft parenchyma of the seed between the cuticle and the hard seed coat. Tannins are an important component of the gustatory impact of wine, with molecules with higher degree of polymerization found in skins contributing to body and mouthfeel and smaller subunits, such as epicatechin gallate, found in seeds contributing to bitterness and astringency. Tannins also contribute to color stability of wine by forming long-lived polymeric complexes with anthocyanins (DOWNEY *et al.,* 2006).

The results of total anthocyanins and phenolics in berry skin and seeds at harvest are presented in table 4. Although total anthocyanin and phenolic concentrations in berry skin were significantly higher in the 2008 season than in the previous season (as also reported by FALCÃO *et al.*, 2008), there was no significant effect of growing season when data were presented in mg per kg fresh berry weight. ORTEGA-REGULES *et al.* (2008) observed climatic influence on anthocyanin and tannin content in three years of observations, however, as in the present study, the authors did not observe climatic influence when considering two consecutive seasons.

On the contrary, seed phenolics were affected by climatic conditions and showed significant lower levels in the 2008 vintage except for Cabernet Franc. Although the maturity indice was much higher in 2008 (51.7) than in 2007 (37.5) for Cabernet Franc cultivar, there was no decrease in seed phenolic content (table 4).

Total anthocyanins and total phenolic compounds were higher than those found by FALCÃO *et al.* (2008) in Cabernet Sauvignon berries grown in São Joaquim (Santa Catarina State, Southern Brazil) but are close to total anthocyanin data obtained by AROZARENA *et al.* (2002) and ORTEGA-REGULES *et al.* (2008) for Cabernet-Sauvignon and Syrah varieties in Spain, respectively.

The adoption of double pruning to change the harvest from January (summer) to July (winter) in a tropical region such as Pirapora allowed maturation and ripening of grapes in dry and high thermal amplitude conditions (above 15°C) which contributed to anthocyanin and skin phenolic accumulation (DOWNEY *et al.*, 2006).

## CONCLUSION

Crop production of the 3-year-old vineyard was in the range considered satisfactory for tropical wine grape region. Syrah and Merlot had an estimated yield above 8 ton $ha^{-1}$ followed by Cabernet Franc (6 ton $ha^{-1}$) and Cabernet-Sauvignon (5.3 ton $ha^{-1}$).

Weather conditions of the cerrado of Minas Gerais State allowed complete maturation of all the four tested wine grape cultivars, revealing satisfactory berry chemical composition for wine making.

These data allowed us to validate under field conditions the potential of the cerrado of Minas Gerais State for fine wine production as initially suggested by CONCEIÇÃO and TONIETTO (2005) based on meteorological data.

**Table 4 – Concentration of total anthocyanins and phenolics at harvest according to variety and year.**

| Cultivar | Total anthocyanins | | | | | |
|---|---|---|---|---|---|---|
| | (mg $g^{-1}$ berry skin) | | | (mg $kg^{-1}$ berry FW) | | |
| | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) |
| Syrah | 9.16a | 19.47a | * | 1128.19ab | 1141.92a | ns |
| Cabernet-Sauvignon | 6.85b | 14.00c | * | 1314.67a | 1199.28a | ns |
| Merlot | 4.56c | 16.26b | * | 1046.92ab | 1326.56a | ns |
| Cabernet franc | 7.95ab | 14.54bc | * | 732.11b | 905.64a | ns |
| | Seeds total phenolics | | | | | |
| | (mg $g^{-1}$ seeds) | | | (mg $kg^{-1}$ berry FW) | | |
| | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) |
| Syrah | 72.42b | 67.04bc | ns | 4268.74b | 2630.90c | * |
| Cabernet-Sauvignon | 86.67ab | 59.35c | * | 4960.90ab | 3037.83bc | * |
| Merlot | 101.09a | 76.04ab | * | 5302.52a | 3741.33b | * |
| Cabernet franc | 89.32a | 85.70a | ns | 5500.45a | 5104.55a | ns |
| | Skin total phenolics | | | | | |
| | (mg $g^{-1}$ berry skin) | | | (mg $kg^{-1}$ berry FW) | | |
| | 2007 | 2008 | sign(1) | 2007 | 2008 | sign(1) |
| Syrah | 26.17a | 71.28a | * | 3266.56ab | 4234.53a | ns |
| Cabernet-Sauvignon | 24.38ab | 43.58bc | * | 4682.25a | 3740.56ab | ns |
| Merlot | 17.76b | 45.81b | * | 4074.08a | 3730.71ab | ns |
| Cabernet franc | 22.80ab | 38.55c | * | 2100.62b | 2408.76b | ns |

All data are expressed as mean value (n=3)
Different letters within the same column mean significant differences according to a Tukey test ($p<0.05$).
(1)Non significant (ns) or significantly different (*) between years according to Fischer's least significant difference at the 5% level

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