



**18.º Simpósio Internacional GiESCO
Proceedings**

INSTITUTO NACIONAL DE INVESTIGAÇÃO AGRÁRIA E VETERINÁRIA, I.P.

INIAV - DOIS PORTOS (EX-ESTACÃO VITIVINÍCULA NACIONAL)

FACULDADE DE CIÊNCIAS DA UNIVERSIDADE DO PORTO

7 a 11 de Julho de 2013

CHARACTERIZATION OF WINES FROM A NEW REGION OF ALTITUDE IN THE NORTHEAST OF BRAZIL

CHARACTERIZATION DE VINS D'UNE NOUVELLE REGION D'ALTITUDE AU NORD-EST DU BRÉSIL

Ana Paula Torres¹; Juliane Barreto de Oliveira¹; Lorraine Berron¹; Jairo Vaz²; Odilésio Gomes³; Tiago Reis Menezes¹; Laurena Rayanne Vieira de Moraes¹; Pollyane Ferreira da Silva¹; Aline Camarão Telles Biasoto⁴; Giuliano Elias P ereira^{5,*}

¹Students, Brazilian Agricultural Research Corporation – Embrapa Tropical Semi-Arid, BR 428, km 152, P.O. Box 23, CEP 56.302-970, Petrolina - PE, Brazil;

²Secretaria da Agricultura, Pecuária, Irrigação, Reforma Agrária, Pesca e Aquicultura-Seagri-BA, Av. Luis Viana Filho, 4ª Avenida, nº 405 - Centro Administrativo da Bahia, CEP: 41.745-002, Salvador - BA, Brazil;

³Associação dos Criadores e Produtores de Morro do Chapéu - BA, Brazil;

⁴Brazilian Agricultural Research Corporation – Embrapa Tropical Semi-Arid, BR 428, km 152, P.O. Box 23, CEP 56.302-970, Petrolina - PE, Brazil;

⁵Brazilian Agricultural Research Corporation – Embrapa Grape & Wine/Tropical Semi-Arid, BR 428, km 152, P.O. Box 23, CEP 56.302-970, Petrolina - PE, Brazil. *Corresponding author : Pereira, +55 87 3866-3600, E-mail : giuliano.pereira@embrapa.br

SUMMARY

Fine wines in Brazil have been produced since the 80's in many regions, like in the South, where the climate conditions are similar to the temperate zones found in the vineyards of the South Hemisphere, and also in the Northeast, in the São Francisco river Valley, located at 350 m of altitude, where the high temperatures, solar radiation and water availability for irrigation allow to produce tropical wines twice a year. In the Chapada Diamantina, located in the Estate of Bahia, vines were planted in January 2011, at 1,150 m of altitude where, despite this new wine region is located in the Northeast of Brazil, the climate conditions can be compared as a temperate zone, once this region doesn't present temperature above the 30-32°C in the summer, with an interesting thermal amplitude between day and night. In the winter, temperatures can reach 6-8°C. In this region, it is possible to have one harvest per year, but two prunings, one for vine formation and another for grape production. The cultivars tested are Sauvignon, Chardonnay, Muscat à Petit Grains, Syrah, Cabernet Sauvignon and Petit Verdot. The vines were formed between September 2011 and March 2012, were pruned in April and first grapes were harvested in September 2012. Wines were elaborated according to classical conditions, and analyzed in January 2013. Wines presented very interesting chemical composition, with balance between alcohol content, organic acids and phenolics, for reds, and a very powerful aromatic profile, with typical notes from each wine of the varieties. Comparing wines from the Chapada Diamantina and São Francisco Valley, mainly for Syrah and Sauvignon, the wines from altitude present very high characteristic flavors, valorizing typicality of these wines. In the present work, wines from six cultivars recently introduced in a new wine region of Brazil are characterized, showing the different oenological potential, and results are discussed.

RÉSUMÉ

Le Brésil élabore des vins fins depuis les années 80 dans plusieurs régions, comme au Sud du pays, où les conditions climatiques sont similaires aux zones tempérées rencontrées dans les vignobles de l'hémisphère sud, mais aussi au Nord-Est, dans la Vallée du São Francisco, située à 350 m d'altitude, où les hautes températures, la forte radiation solaire et disponibilité en eau pour l'irrigation, rendent possible la production de deux récoltes par an. Dans la Chapada Diamantina, dans l'État de Bahia, un vignoble expérimental a été installé en janvier 2011, à 1.150 m d'altitude où, bien que cette région soit située au Nord-Est du Brésil, les conditions climatiques peuvent être comparées à celles des zones tempérées, avec des températures ne dépassant pas 30-32°C en été et une amplitude thermique intéressante entre le jour et la nuit. En hiver, les températures peuvent descendre jusqu'à 6-8°C. Dans ces conditions, il est possible de produire une récolte par an, avec deux tailles, une pour la formation et une autre pour la production. Les variétés testées sont le Sauvignon blanc, le Chardonnay, le Muscat à Petits Grains, la Syrah, le Cabernet Sauvignon et le Petit Verdot. Les vignes ont été formées entre septembre 2011 et mars 2012, taillées en avril et les premiers raisins ont été récoltés en septembre 2012. Les vins ont été élaborés selon les conditions classiques de vinification et analysés en janvier 2013. Les vins présentent des caractéristiques analytiques intéressantes, avec un équilibre entre l'alcool, l'acidité et les composés phénoliques, pour les rouges, et un intéressant potentiel aromatique pour les vins blancs et rouges, chaque cépage faisant preuve d'une typicité intéressante. En comparant les vins de la Chapada Diamantina avec ceux de la Vallée du São Francisco, principalement les vins variétaux de Syrah et de Sauvignon blanc, il ressort que les vins d'altitude, même en première production, présentent une typicité remarquable, avec des notes florales et fruitées, valorisant leur caractéristiques variétales. Dans ce travail, les vins variétaux de six cépages récemment introduits dans une nouvelle région brésilienne sont caractérisés et montrent différents potentiels œnologiques et organoleptiques, enfin les résultats sont discutés.

Key-words: *Vitis vinifera* L.; grapes; wines of altitude; aroma profile; wine typicality.

Mots-clés: *Vitis vinifera* L.; raisins; vins d'altitude; profil aromatique; typicité des vins.

INTRODUCTION

Traditionally grown in temperate climate areas, vines have been cultivated for commercial activities in new regions where geographical conditions are quite diversified. Tropical wines have been produced in some countries like Thailand, India, and Myanmar, in the North Hemisphere as well as in Venezuela, Colombia and Brazil in the South Hemisphere (Tonietto and Pereira, 2012).

In Brazil, the viticulture to produce fine wines is recent, even in the traditional South regions of the country, where the activity started there are 30 years ago. In the same way, the first tropical wines from Northeast of Brazil had been made in the São Francisco river Valley since the 80's, located at 350 m of altitude. In this region, climate conditions are very special and due to the high temperatures (with an annual average of 26°C), sunlight (3,000 hours.year⁻¹) and water availability for irrigation (500 mm of annual average rainfall), one vine plant can produce twice a year, in a tropical semi-arid climate, presenting an intra-annual climatic variability (Tonietto and Teixeira, 2004).

Many regions are starting their commercial activities, introducing new vineyards with the aim to produce fine wines in Brazil, especially in the Southern, South-Eastern and North-Eastern regions. One of them is located in the Bahia State, also in the North-East region, in the city of Morro do Chapéu (11° 33' 11" S e 41° 09' 27" W), Chapada Diamantina, at 1,100 m of altitude, where climatic conditions can be considered as tropical of altitude. The first vines were planted in January 2011, in Observation Units with *Vitis vinifera* L. cultivars, in order to verify the adaptation of different varieties to local soil and climate conditions, and to evaluate the agronomic and oenological potential of grapes and wines.

In this region, climatic characteristics are quite interesting and can be considered better than those found in the São Francisco river Valley. In the Chapada Diamantina, the annual average temperature is 19°C, with interesting thermal amplitudes between day and night throughout the year, which favours slower phenolic compounds maturation and tends to increase the aroma precursors formation (Peynaud, 1997), with annual average rainfall of 600 mm and water availability for irrigation by artesian well.

Thus, the aim of this work was to determine the analytical characteristics of grapes and wines elaborated in a tropical of altitude region in the North-East of Brazil.

MATERIAL AND METHODS

An observation unit was established in January 2011 in Morro do Chapéu-BA, localized in the "Chapada Diamantina", in the northeast of Brazil. In the experimental vineyard were grown six cultivars, among white and red grapes, such as: Muscat à Petits Grains, Sauvignon, Chardonnay, Cabernet Sauvignon, Syrah and Petit Verdot. The vineyard was trained in vertical shoot positioning, double-spur pruned cordon, grafted onto rootstock 1103 Paulsen, and with drip irrigation. The soil is the type sandy, with good depth and with pH around 4.8. The vines were formed between September 2011 and February 2012, and the first production pruning was made in March 2012. The first crop was harvested in September 2012 for Muscat à Petits Grains, Sauvignon, Chardonnay and Syrah grapes, while Cabernet Sauvignon and Petit Verdot were harvested in October 2012. Immediately after harvest, the grapes were transported to the Laboratory of Enology at Embrapa, in Petrolina-PE, Brazil. They were sampled (three replicates of 300 berries) and analyzed to determine pH, total soluble solids content (°Brix), total acidity and berry weight (AOAC, 1998; OIV, 1990). The wines were also tasted by a panel of eight winemakers to describe the sensorial characteristics.

The winemaking was carried out in 20L glass tanks and elaborated using sulphur dioxide as antioxidant with controlled temperatures (Peynaud, 1997). One hundred percent varietal wines were produced from each cultivar in duplicates. The alcoholic fermentation of red wines were conducted at the 25±2°C with six days of maceration, followed by malolactic fermentation realized at 18±2°C for twenty days, and cold stabilization at 0°C for one month. For white wines the alcoholic fermentation was carried out at 18±2°C for 30 days, then it was realized a clarification and cold stabilization (0°C) along 30 days. Additionally, the malolactic fermentation was realized in the Chardonnay wines. All the wines were bottled in December 2012 and analyzed one month later, to determine pH, total and volatile acidity, density, dry extract, alcohol content, total and free sulphur dioxide, total anthocyanins, total polyphenol index, and colour intensity (AOAC, 1998; OIV, 1990).

RESULTS AND DISCUSSION

Especially the plants of Sauvignon, Muscat à Petits Grains, Syrah and Petit Verdot, showed well developing and adaptation to the Chapada Diamantina soil and climatic conditions, presenting a good leaf area / fruit ratio, with twelve shoots per vine and one bunch per shoot (data not shown). For Cabernet Sauvignon and Chardonnay, the development was not enough, with low leaf area, and yield had to be decreased by suppressing six

bunches per vine (data not shown). Table I shows the results of some physical-chemical analyses carried out in the berries at harvest. It is interesting to note that even being young vines, with one year

potential to the production of wines with good stability, by comparing with tropical wines from the São Francisco river Valley, where wines have presented low chemical and sensorial stabilities

TABLE I. Physical-chemical analyses of the grapes from Morro do Chapéu, Chapada Diamantina-BA, Brazil, harvested in September and October 2012.

Analyses physico-chimiques de raisins de Morro do Chapéu, Chapada Diamantina-BA, Brazil, récoltés en Septembre et Octobre 2012.

Grape	TSS (°Brix)	Total acidity (g.L ⁻¹ tartaric acid)	pH	Berry weight (g)
Sauvignon blanc	25.8	9.3	3.3	134.6
Muscat Petit Grain	26.2	9.4	3.2	158.4
Chardonnay	25.9	8.7	3.2	112.3
Syrah	24.6	9.1	3.3	152.1
Petit Verdot	23.3	9.8	3.5	102.0
Cabernet Sauvignon	22.2	8.6	3.6	106.2

and a half after planting, all the varieties presented high sugar concentration, high total acidity and principally low pH value, with different berry weight. Thus, these preliminaries results demonstrated that these varieties possibly have

(Tonietto and Pereira, 2012; Araújo *et al.*, 2011; Lima *et al.*, 2011; Pereira *et al.*, 2011).

Table II shows the results of the physical-chemical analyses of the wines. The wine from Muscat à Petits Grains and Sauvignon grapes showed the

TABLE II. Physical-chemical analyses of the wines from Morro do Chapéu, Chapada Diamantina-BA, Brazil, in 2012.

Analyses physico-chimiques de vins de Morro do Chapéu, Chapada Diamantina-BA, Brazil, année 2012.

Parameters	Wine					
	SB	MPG	CH	SY	PV	CS
pH	3,3	3,2	3,4	3,6	3,5	3,6
Total acidity (g.L ⁻¹)	6,37	8,02	6,05	5,47	6,6	6,15
density	0,9923	0,9924	0,9933	0,9938	0,9941	0,9954
alcoholic strength (v/v%)	15,1	15,3	14,7	13,2	13,2	12,3
Sulfur Dioxide Free (mg.L ⁻¹)	20,5	24,9	23,0	51,2	51,2	38,7
Total Sulfur Dioxide (mg.L ⁻¹) ⁽¹⁾	51,2	43,5	71,7	56,3	61,1	51,2
Volatile Acidity (g.L ⁻¹)	0,42	0,31	0,39	0,25	0,30	0,31
Dry Extract (g.L ⁻¹)	.....	.....	.....	26,9	29,4	30,1
anthocyanins Totals (g.L ⁻¹)	.....	.....	.....	1,18	1,23	1,06
Total Polyphenol Index (I 280nm)	.....	.....	.....	77,0	87,2	83,0
Color Intensity	.....	.....	.....	15,7	19,9	15,8
Color 420nm	.....	.....	.....	5,7	7,0	5,8
Color 520nm	.....	.....	.....	7,9	10,4	8,1
Color 620nm	.....	.....	.....	2,1	2,4	1,9
Tonality	.....	.....	.....	0,72	0,67	0,71

Where: SB is Sauvignon; MPG is Muscat à Petits Grains; CH is Chardonnay; SY is Syrah; PV is Petit Verdot; and CS is Cabernet Sauvignon.

lowest pH (3.2 and 3.3, respectively), while Syrah and Cabernet Sauvignon wines presented the highest value (3.6). The pH of Sauvignon wine was equal to that found by Mota *et al.* (2010), which the grapes were harvested in 2007 from Minas Gerais, in the Southeastern region of Brazil. The pH of the Chardonnay wine is close to the values found by Scopel (2009) in Chardonnay wines from Rio Grande do Sul. The pH is a good indicator of the strength of wines to contamination by bacteria and stability. Generally it is desirable for white wines a pH between 3.1 and 3.4, while for red wines, the optimal pH must be between 3.3 and 3.6. However, with the malolactic fermentation the pH may increase (Jackson, 2000). Thus, the values of pH of all red wines evaluated are within the desired range according to the literature.

The total acidity of overall the wines evaluated is in agreement with the standards of the Brazilian legislation (BRASIL, 2009) and within of the limits recommended by Bertolini (1986), among 4.5 g. L⁻¹ and 6.75 g. L⁻¹, with exception for the Muscat wine, which showed the highest value of total acidity (8.02 g.L⁻¹). Chavarria *et al.* (2008) found also high value of total acidity in Moscato Giallo wines from Rio Grande do Sul, Brazil (7.60 g. L⁻¹). In contrast, Syrah wines showed the lowest total acidity (5.47 g.L⁻¹), similar to those values found by Triches, *et al.* (2008) in Syrah wines elaborated from grapes harvested in July 2008, in the Sub-middle Sao Francisco Valley (5.32 g.L⁻¹).

The alcohol content in the majority of the wines are within of the limits established by Brazilian legislation (BRASIL, 2009), among 8.6 to 14°GL, except for the Muscat (15.3°GL) and Sauvignon wines (15.1°GL). The alcohol content of the wines ranged from 12.3°GL (Cabernet Sauvignon) to 15.3°GL (Muscat à Petits Grains). These differences among the alcoholic content of the samples studied can be explained by the choice of the harvest date, which was defined by °Brix analysis and berry tastes carried out weekly, to evaluate phenolic compounds from skins and seeds for reds, and skins for white grapes. Oliveira *et al.* (2008) found, in Sauvignon wines from the São Francisco Valley, North-East of Brazil, but located at 350 m of altitude, alcohol content of 13.4 °GL, in the first semester of 2007, showing different responses and oenological potential of the grapes according to the soil and climatic conditions (Reynier, 2007). It is interesting to note that even grapes have presented high acidity (Table I), also showed high content of total soluble solids and consequently high alcohol degree in the wines. Some adjustments in the vineyard need to be carried out for the next seasons, trying to reduce sugar content, by increasing the yield, keeping more than one bunch per shoot, or decreasing the vine vigor, changing the harvest date, or controlling

irrigation and nutrition, with a moderate stress (Van Leeuwen *et al.*, 2009 and 2004; Reynier, 2007; Peynaud, 1997).

The concentration of free sulphur dioxide ranged among 20.5 mg.L⁻¹ (Sauvignon) and 51.2 mg.L⁻¹ (Syrah and Petit Verdot). The Brazilian legislation (BRASIL, 2009) not establish limit for free sulphur dioxide in the wines. On the other hand the Brazilian law allows the maximum limit of 350 mg.L⁻¹ of total sulphur dioxide in wines. The total sulphur dioxide in the wines samples evaluated varied from 51.2 mg.L⁻¹ (Sauvignon and Cabernet Sauvignon) to 71.7 mg.L⁻¹ (Chardonnay).

The volatile acidity contents in all the wines analyzed were below of the limit allowed by the Brazilian legislation and by the international legislation (BRASIL, 2009; OIV, 1990), indicating a good sanity of the grapes at harvest and good control of the winemaking process. According to the Brazilian legislation (BRASIL, 2009), the maximum limit allowed to wines of volatile acidity is 1.2 g.L⁻¹.

The total solid amounts include the contents of the fixed acids, minerals and organic salts, polyalcohols, phenol compounds, nitrogen, sugars and polysaccharides (Rizzon, 2010). The red wines evaluated showed values of dry extract of 30.1 g. L⁻¹ in the Cabernet Sauvignon wines, 29.4 g. L⁻¹ for Petit Verdot and 26.9 g. L⁻¹ in the Syrah wines. These values were highest than those found in the research developed by Manfroi *et al.* (2010) to Cabernet Sauvignon from Rio Grande do Sul, South of Brazil, that varied from 22.5 g. L⁻¹ to 25.4 g. L⁻¹.

The total anthocyanins in red wines are also showed in the Table II. The highest values of anthocyanins content were found in the Petit Verdot wines (1.23 g. L⁻¹), followed by Syrah (1.18 g. L⁻¹) and Cabernet Sauvignon wines (1.08 g. L⁻¹). The concentration of anthocyanins in the grape and wine depends on climatic factors, the cultivar, growing conditions, ripeness of the grapes and winemaking method employed (Gonzalez, 2004; Peynaud, 1997). The concentration of anthocyanins in red wines of *Vitis vinifera* L. varieties usually varies between 0.35 g. L⁻¹ and 1.1 g. L⁻¹ according to Leone *et al.* (1984). Values showed by Triches *et al.* (2008), in Syrah wines from the Sub-middle Sao Francisco river Valley, were 0.36 g. L⁻¹ (for grapes harvested in July 2008) and 0.46 g. L⁻¹ (for grapes harvested in December 2008). Thus, is possible that the environmental conditions of the Chapada Diamantina, in an altitude tropical climate, with high thermal amplitudes throughout the year, especially during the ripening period, in July, August and September 2012, provide major anthocyanins content in the red wines by promoting phenol synthesis in the vines (Van Leeuwen *et al.*, 2004; Gonzalez, 2004).

The total polyphenol content depend on the environmental conditions, sanity and maturation stage of the grapes, variety, and winemaking protocols (Brighenti *et al.*, 2010; Peynaud, 1997). In this research the Petit Verdot wines showed the highest values of total polyphenol index (87.2), followed by Cabernet Sauvignon (83.0) and Syrah (77.0). These values were also highest than those reported by Nascimento *et al.* (2010) for Cabernet Sauvignon wines from the Sub-middle São Francisco river Valley.

The colour intensity of wines is defined by Glories (1984a and b) as the sum of the optical densities measured in the 420, 520 and 620 nm. In this study the Petit Verdot wines showed the highest colour intensity (19.9), followed by Cabernet Sauvignon and Syrah wines (15.8 and 15.7, respectively) (Table 2). Syrah wines from Chapada Diamantina showed higher colour intensity than the Syrah wines produced in the South-eastern region of Brazil, located in a wet tropical climate, whose values varied from 5.68 to 14.33, of the wines from the summer and winter periods of 2005 and 2006 vintages, respectively (Mota *et al.* 2009). Petit Verdot wines showed the highest values of optical readings at 420, 520 and 620 nm, followed by Cabernet Sauvignon and Syrah wines (Table 2). Regarding the tonality, the Syrah wines showed the highest values (0.72), followed by Cabernet Sauvignon (0.71) and Petit Verdot (0.67). The values of tonality may be relating with the degree of tannin polymerization and with the combination of tannins with anthocyanins (Glories, 1984). Birth *et al.* (2011) found values of tonality around to 0.67 for Syrah wines elaborated in the Sub-middle São Francisco river Valley.

The sensory evaluation of the wines by the oenologists showed a high potential (data not shown). Among white wines, Sauvignon was described by light yellow colour with greenish reflexes, fresh and presenting typical flavours, with notes of exotic fruits and floral, excellent structure and acidity, with persistence, typical of this variety, as compared with some wines originated from temperate regions. The Muscat wines were described as typical, with high-aromatic potential. Among the reds, Syrah were the best evaluated wine, with excellent colour, fruity, typical floral and spicy with aromatic freshness, bodied and presenting aromatic persistence. In relation to the other, wines were described presenting potential, but they were unbalanced, mainly in relation to the acidity and hard phenolics (reds). The age of the vines and the adjustments to be made in the field and in the winery could improve the quality of the wines.

In this paper, the first wines evaluated in the *terroir* of the Chapada Diamantina, at 1,100 m above sea level, present a promising future as a successful

winegrowing region in Brazil. Producers and investors will be introducing the first commercial vineyard in August 2013, and the region could become a reference in the country.

CONCLUSIONS

The varieties *Vitis vinifera* L. planted in Morro Chapeu, at 1,100 m in the Chapada Diamantina-BA, North-East of Brazil, presented an interesting development, and showed good structure and leaf area / fruit ratio, except for Chardonnay and Cabernet Sauvignon. All varieties recently planted produced grapes with different oenological potential, with high levels of sugars and acidity, with low pH.

The physical-chemical analyses of the wines showed different characteristics. The Sauvignon and Muscat white wines presented high alcohol content, while Petit Verdot wines presented high levels of anthocyanins, total polyphenol and colour intensity.

The sensory analyses described that Sauvignon and Syrah were the better wines, even being the first crop of the vines, presenting high typicality for both, with typical notes of flavours and well balanced.

We can conclude, therefore, that the varieties are adapting to local climate and soil conditions, being necessary other studies and some adjustments in the management of the vines, like to try different number of bunches to decrease sugar content, increasing the yield per vine, the definition of the harvest date, different winemaking protocols, to improve wine quality and typicality. The plants had one and a half year, very young, and wines showed an interesting oenological potential, which allow us to predict this new area like a future winegrowing region producing high quality wines from Brazil.

ACKNOWLEDGEMENTS

The authors thank the Associação dos Criadores e Produtores de Morro do Chapéu-BA, the Secretaria da Agricultura, Pecuária, Irrigação, Reforma Agrária, Pesca e Aquicultura – Seagri-BA, the Brazilian Agricultural Research Corporation – Embrapa, and the Fundação de Amparo à Ciência e Tecnologia de Pernambuco – Facepe, to their financial support and partnership.

REFERENCES

- AOAC - ASSOCIATION OF OFFICIAL AGRICULTURAL CHEMISTS, 1998. *Official Methods of Analysis of AOAC International*. 16^a ed., volume II.
- Araújo, A. J. de B.; Vanderlinde, R.; Lima, L. L. de A.; Pereira, G. E. Characterization of aromatic profiles in Brazilian tropical

- wines determined by gas chromatography and multivariate statistical analysis. In: INTERNATIONAL SYMPOSIUM OF THE GROUP OF INTERNATIONAL EXPERTS OF VITIVINICULTURAL SYSTEMS FOR COOPERATION, 17., 2011, Asti. Proceedings... Asti: *Le Progrès Agricole et Viticole*, 2011. p. 49-51.
- Bertolini, L. et al, 1996. Higher alcohol production by cryotolerant *Saccharomyces* strains. *Am. J. Enol. Vitic.*, 47, 343-345.
- Brasil, 2009. Ministério da Agricultura Pecuária e Abastecimento. Procedimento de análise de fermentados alcoólicos. Available in: <http://www.agricultura.gov.br>.
- Brighenti, A. F.; Rufato, L.; Kretschmar, A. A.; Madeira, F.C, 2010. Despontamento dos ramos da videira e seu efeito na qualidade dos frutos de 'Merlot' sobre porta enxertos 'Paulsen 1103' e 'Couderc 3309'. *Rev. Bras. Frutic.*, 32, 19-26.
- Chavarria, et al., 2008. Caracterização físico-química do mosto e do vinho Moscato Giallo em videiras cultivadas sob cobertura de plástico. Brasília, DF. p. 913.
- Glories, Y. (1984a). La couleur des vins rouges. Mesure, origine et interprétation. Partie I. *Connaiss. Vigne Vin*. 18, 195-217.
- Glories, Y. (1984b). La couleur des vins rouges. Mesure, origine et interprétation. Partie II. *Connaiss. Vigne Vin*. 18, 253-271.
- Gonzalez, N. G. et al, 2004. Phenolic potencial of Tannat, Cabernet-Sauvignon and Merlot grapes and their correspondence with wine composition. *Anal. Chim. Acta*. v. 513, p. 191-196.
- Jackson, R. S, 2000, 647p. *Wine science: Principles, practice and perception*. 2nd Ed. San Diego, CA: Elsevier Academic Press..
- Leone, A.; La Notte, E.; Gambacorta, G. Gli antociani nelle fase di macerazione e di elaborazione Del vino. La influenza della técnica diffusiva sulla loro estrazione. 1984.
- Lima, L. L. A.; Pereira, G. E.; Andrade, S. A. C.; Guerra, N. B. Polyphenolic and chromatic characterization of tropical red wines produced in the São Francisco river Valley (Northeast Brazil). In: INTERNATIONAL SYMPOSIUM OF THE GROUP OF INTERNATIONAL EXPERTS OF VITIVINICULTURAL SYSTEMS FOR COOPERATION, 17., 2011, Asti. Proceedings... Asti: *Le Progrès Agricole et Viticole*, 2011. p. 33-35.
- Manfroi, et al., 2010. Influência de taninos enológicos em diferentes dosagens e épocas distintas de aplicação nas características físico-químicas do vinho Cabernet Sauvignon. *Rev. Ciên. Tecnol. Alim.*, 131.
- Mota, et al., 2009. Caracterização físico-química e amins bioativas em vinhos da cv. Syrah I – Efeito do ciclo de produção. *Rev. Ciên. Tecnol. Alim*, 29, 380-385.
- Nascimento, R. L. et al, 2010. Efeitos de diferentes estratégias de irrigação sobre as características físico-químicas de vinhos tropicais Syrah. Petrolina, PE. Embrapa Semiárido.
- Nascimento, R. L. et al, 2011. Efeitos de diferentes estratégias de irrigação sobre as características físico-químicas de vinhos tropicais Syrah. Petrolina, PE. Embrapa Semiárido.
- Oliveira, et al., 2008. Caracterização Físico-Química de Vinhos Brancos Elaborados na Região do Submédio do Vale do São Francisco, Brasil. Petrolina, PE. Embrapa Semiárido.
- ORGANISATION INTERNATIONALE DE LA VIGNE ET DU VIN – OIV, 1990. 368p. *Recueil des méthodes internationales d'analyse des vins et des moûts*. Paris.
- Pereira, G. E.; Araújo, A. J. B.; Santos, J.; Vanderlinde, R.; LIMA, L. L. A, 2011. Chemical and aromatic characteristics of Brazilian tropical wines. *Acta Hort.*, 910, 135-140.
- Peynaud, E, 1997, 340p. *Connaissance et travail du vin*. Ed. Dunod, Paris.
- Reynier, A, 2007, 532p. *Manuel de viticulture*, 10. éd. Lavoisier, Paris.
- Rizzon, L. A, 2010. *Metodologia para análise de vinho*. Embrapa Informação Tecnológica, 22 p, Brasília, DF.
- Scopel, G, 2009. Características Analíticas de Vinhos Chardonnay e Riesling Itália do Rio Grande do Sul. Bento Gonçalves, RS. 20p.
- Tonietto, J., Teixeira, A. H. C, 2004. Zonage climatique des périodes viticoles de production dans l'année en zone tropicale: application de la méthodologie du Système CCM Géoviticole. In: *Joint International Conference on Viticultural Zoning*, Cape Town, South Africa [S.I.: s.n.], 193-201.
- Tonietto, J.; Pereira, G.E, 2011. A concept for the viticulture of tropical wines. In: Proceedings of the IX International Terroir Congress, France, 34-37.
- Triches, S. W. et al, 2008. Comparação físico-química de vinhos da variedade Syrah (*Vitis vinifera* L.) elaborados em dois ciclos no mesmo ano, em região semiárida tropical. Petrolina, PE. p. 265.
- Van Leeuwen, C.; Trégoat, O.; Choné, X.; Bois, B.; Pernet, D.; Gaudillere, G, 2009.. Vine water status is a key factor In grape ripening and vintage quality for red Bordeaux wine. How can it be assessed for vineyard management purposes? *J. Int. Scien. Vigne Vin*, 43, 121-134.
- Van Leeuwen, C.; Friant, P.; Choné, X.; Trégoat, O.; Koundouras, S.; Dubourdieu, D. , 2004. *Am. J. Enol. Vitic.*, 55, 207-217.