INFLUENCE OF THE STORAGE CONDITION ON PHYSICOCHEMICAL CHARACTERISTICS OF RED WINES FROM SÃO FRANCISCO VALLEY, BRAZIL

L'INFLUENCE DES CONDITIONS DE STOCKAGE SUR LES CHARACTÉRISTIQUES PHYSICOCHIMIQUES DE VINS ROUGES DE LA VALLÉE DU SÃO FRANCISCO, BRÉSIL

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Abstract

In the São Francisco Valley, Northeast of Brazil, tropical wines have been produced thirty years ago. Vines can produce twice a year and wine stability can change according to the harvest date. Normally wines elaborated from grapes harvested between November-December have a fast evolution, while wines from grapes harvested between June-July can have greater stability. Annual average temperature is 26°C, but in the summer (November) the maximum average is 31°C. After bottling, another factor influencing wine stability is the storage condition. In this way, the aim of this study was to evaluate the influence of the conditions of bottle storage on physicochemical characteristics of commercial Syrah tropical wines, from grapes harvested in November 2014. Wine bottles were stored in two conditions, in the cellar at 18 ±2 °C, and in the shelf, in ambient temperature. Wines were analyzed one, four, seven and ten months after bottling, by HPLC, to determine classical analyses, phenolic compounds and antioxidant capacity. As results, anthocyanins, flovonols, flavanols and stilbene reduced their concentrations in both conditions along ten months, while galic and p-coumaric phenolic acids increased concentrations after ten months in both conditions. But wines stored in the cellar presented higher values of malvidin-3-glucoside as compared to wines stored in shelves. Wines presented 120 mg L-1 of malvidin-3-glucoside one month after bottling, and ten months after storage presented significant differences (59.2 mg L-1 in wines from cellar and 17.5 mg L-1 in wines from shelves). We conclude that storage conditions can influence tropical wine stability and may increase shelf life if temperature is controlled and stable along time.

Keywords: *Vitis vinifera* L., Syrah wines, phenolics, stability

Résumé

Dans la Vallée du São Francisco, Nord-Est du Brésil, des vins tropicaux sont produits depuis trente ans. Les vignes peuvent produire deux fois par an et la stabilité de vins peut changer selon la date des vendanges. Normallement, les vins élaborés à partir de raisins récoltés entre novembre-décembre ont une évolution rapide, tandis que les vins élaborés à partir de raisins récoltés entre juin-juillet peuvent avoir une stabilité majeure. La température moyenne annuelle est de 26ºC, mais en été (novembre) les moyennes maximales atteignent 31ºC. Après l'embouteillage, un autre facteur qui influence la stabilité de vins est la condition de stockage. Dans cette ligne, l'objectif de cette étude a été d'évaluer l'influence de différentes conditions de stockage de bouteilles sur les charactéristiques physicochimiques de vins rouges tropicaux commerciaux Syrah, élaborés avec des raisins récoltés en novembre 2014. Les vins en bouteille ont été stockés en deux conditions : en cave à 18±2ºC, et en étagère sans contrôle de température. Les vins ont été analysés un, quatre, sept et dix mois après l'embouteillage, par HPLC, pour déterminer les analyses classiques, les composés phénoliques et la capacité antioxydant. Comme résultats, les anthocyanins, flavonols, flavanols et stilbènes ont réduit leur concentrations dans les deux conditions au cours de dix mois, tandis que les acides gallique et p-coumarique ont augmenté leur concentrations dans les deux conditions. Mais les vins stockés en cave en température contrôllée ont présenté des concentrations plus élevées de malvidine-3-glucoside quand comparés aux vins stockés en étagères. Les vins ont présenté 120 mg L^{-1} de malvidine-3-glucoside un mois après l'embouteillage, tandis que dix mois après le stockage ont présenté des différences significatives (59,2 mg L^{-1} pour les vins en cave et 17,5 mg L^{-1} pour les vins en étagères). Nous pouvons conclure que la condition de stockage a influencé la stabilité de vins et peut augmenter la durée de vie si la température est contrôllée et stable au cours du temps.

Mots-clés: Vitis vinifera L., vins Syrah, phénoliques, HPLC

Introduction

São Franciso Valley, located in the Northeast of Brazil, is a tropical semi-arid climatic condition, producing grapes and wines thirty years ago (Padilha et al., 2016a and b; Pereira et al., 2011). The grape and wine production in the region is particular because vines can produce twice a year, due to the high annual average temperature (26.5°C), high solar radiation and water availability for irrigation (Pereira et al., 2016). Wineries try to schedule harvests of the plots in the winery, according to different factors (wine demand, market, climate, physical structure-tanks). Grape and wine typicality depends and changes with harvest date, presenting different characteristics, according to the month in the year when grapes are harvested.

Some practical observations of commercial wines about shelf life gave us knowledge to describe wine stabilization according to the harvest date. Wines elaborated with grapes harvested between May and August have presented higher shelf life than wines elaborated with grapes harvested between October and January. These characteristics can be explained by temperatures during grape maturation. Between May and August the average temperature is about six degrees less than average temperature between October and January. These climatic conditions can explain different response of the wines to the stabilization (Pereira et al., 2016).

Another factor influencing wine stability is the storage condition. Some authors have showed that wines presented loss of phenolic compounds if submitted to different conditions (Kallithraka, et al., 2010; Recamales et al., 2006). Linton and Bordelon (2010) showed that wines stored in temperatures above 24ºC and positioned vertically presented lost of quality, fast evolution and risk of contamination. But few studies are available to evaluate storage conditions of wine stability. In this way, this study aimed to evaluate effects of two storage conditions on Syrah commercial red wines from Northeast of Brazil.

Material and methods

Climatic data

Climatic data between April and December, corresponding to the harvest periods in São Francisco Valley are shown (Figure 1). Data were collected from weather station located in Lagoa Grande city, Pernambuco State, where winery is located (08º48' S of latitude and 40º21' W of longitude). It is interesting to note that temperatures between May and August are lower than those from October and December. The present study evaluated wines elaborated from grapes harvested in November 2014, period presenting major problems of wine stability, due to the high temperatures during grape maturation (Pereira et al., 2016).

Chemicals

Ethanol was purchased from Merck (Darmstadt, Germany). Methanol, acetonitrile and phosphoric acid were obtained from Vetec Química Fina Ltda. (Rio de Janeiro, Brazil), J. T. Baker (Phillipsburg, NJ, USA) and Fluka (Switzerland), respectively. Malvidin-3-glucoside, cyanidin-3-glucoside, peonidin-3-glucoside, delphinidin-3-glucoside and pelargonidin-3-glucoside, kaempferol-3-glucoside, myricetin-3-glucoside, quercitin-3-glucoside, isorhamnetin-3-glucoside, (-)-epicatequin gallate, (-)-

epigallocatequin, syringic acid, and t-resveratrol were purchased from Extrasynthese (Genay, France). Galic, cynamic and caffeic acids were obtained from Chem Service (West Chester, USA). P-cumaric and chlorogenic acids were purchased from Sigma-Aldrich (St. Louis, MO, USA). Ultra-pure water was obtained from Milli-Q ® (Millipore, Bedford, MA, USA).

Wine sample and storage conditions

A commercial Syrah wine elaborated with grapes harvested in November 2014 and bottled in March 2015 in the winery was used in this study. Wines were sent to Brazilian Agricultural Research Corporation - Embrapa, located 30 km from the winery, and placed in two storage conditions. Twelve bottles were placed vertically in shelves, at room no controlled temperature (ambient), and other 12 bottles placed in the cellar, with controlled temperature (18±2ºC) and horizontally positioned.

Analyses carried out in the wines

Classical analyses

Density, pH, alcohol degree, total titratable and volatile acidity, total and free sulphur dioxide, dry extract, total phenolics and antioxidant capacity were carried out in the wines one and ten months after bottling, according to traditional literature (Peynaud, 1997; Ribereau-Gayon et al., 2004; Rizzon, 2010; Padilha et al., 2016a and b).

High performance liquid chromatography-HPLC of the phenolic compounds

Phenolic compounds were determined by high performance liquid chromatography-HPLC using a Waters equipment (model Aliance e2695) equipped with DAD, according to methodology developed by our group (Padilha et al., 2016a and b). All analyses were carried out in triplicate and results were expressed as means and standard deviation.

Statistical analysis

The statistical analysis was performed using variance analysis (ANOVA), by SPSS Inc. 17.0 software (Chicago, IL, USA).

Results and Discussion

Classical analyses carried out in the wines placed in shelves and in cellar are shown in the Table 1.

No significant differences were found in all classical analyses carried out in the wines between one and ten months after bottling. All results of the wines are according to Brazilian legislation (Brasil, 2004). Similar results were found in previous work (Roussis et al. 2008).

Wines analyzed by HPLC presented significant differences according to storage conditions and aging in bottles along ten months (Table 2). All anthocyanins reduced between one and ten months, in both storage conditions. But wines stored in cellar presented higher anthocyanin concentrations than wines stored in shelves. Malvidin 3-O-glucoside, the major anthocyanin found, reduced from 113.9 mg L-1 one month after bottling in wines stored in shelves to 17.5 mg L-1 ten months after bottling, while wines in cellar reduced from 125.5 mg L-1 one month after bottling to 59.2 mg L-1 ten months after. The sum of all phenolics also present the same result, wines from cellar showed the highest concentrations as compared to wines from shelves (Table 2). These results highlight importance of controlled temperatures to increase shelf life of tropical wines. The reduction of the anthocyanin concentrations can be explained by reactions with other polyphenols, polymerization and also oxidation (Sanza and Dominguez, 2006; Monagas et al., 2006). Reduction of anthocyanins stored in shelves after ten months was around 85%, while wines in cellar reduced around 50% only.

According to the other phenolics, few differences were found between wines stores in shelves and in cellar. All flavonol concentrations presented reduction along ten months independently of the storage conditions. For flavanols responses were different, (-)-epicatechin gallate increased from one to four months and then reduced until ten months after bottling. (-)-Epigallocatechin presented similar evolution to anthocyanins, reducing between one and ten months. Phenolic acids had different response, but in general they were approximately stable along ten months after bottling, the same for tresveratrol. Caffeic and chlorogenic acids presented higher concentrations in wines from cellar than those from shelves, ten months after bottling. In contrast, wines from shelves presented higher concentrations of gallic and p-coumaric acids than wines from cellar after ten months, while one month after bottling teir concentrations were similar in both storage conditions.

Kallithraka, et al. (2010) found significant differences between wine storage in Hellenic varietal white wines, linked to many phenolics. Recamales et al. (2006) showed that white wines had decreasing of phenolics over twelve months mainly due to the variable temperature.

Conclusion

In this study wine composition was determined according to different storage condition and along ten months after bottling. For classical analyses, no differences were found for all parameters. Phenolic compounds determined by HPLC allowed to show significant differences if wines were stored in cellar or in shelves. Anthocyanins in both conditions decreased along ten months, but wines in cellar presented the highest concentrations of all anthocyanins. The other phenolics presented different responses. It is important to highlight that controlled temperatures can improve shelf life of Syrah tropical red wines from Northeast of Brazil.

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Table 1. Physicochemical analyses of a Syrah commercial red wine according to two storage conditions in the Northeast of Brazil, 2014 vintage.

Parameter	**Wine**			
	1 Month		**10 Months**	
	Shelf	**Cellar**	**Shelf**	**Cellar**
DEN	0.9949±0.01	0.9950±0.01	0.9951±0.01	0.9954±0.01
pH	3.84±0.04	3.82±0.01	3.93±0.02	3.92±0.02
TA	6.90±1.33	6.90±1.33	6.77±2.34	7.03±1.51
AD	13.42±0.08	13.43±0.12	13.70±0.14	13.83±0.03
VA	0.64±0.02	0.59±0.10	0.66±0.07	0.67±0.03
DE	32.17±0.29	32.28±0.41	33.38±0.73	34.47±0.14
FSD	63.80±0.43	63.54±0.98	28.33±0.42	42.07±1.19
TSD	86.43±0.40	86.58±0.38	51.29±0.50	70.83±1.32
AOX	19.78±0.96	21.33±0.50	23.09±0.55	23.61±0.84
TP	3974.17± 4.57	4015.98±10.68	3924.62±11.19	3980.36±5.80

*Where: DEN = Density; TA = Total acidity (g L-1); AD = Alcohol degree (ºGL); VA = Volatile Acidity (g L-1); DE = Dry Extract (g L-1); FSD = Free Sulphur Dioxide (mg L -1); TSD = Total Sulphur Dioxide (mg L -1); AOX = Antioxidant activity (mM Trolox L-1); TP = Total Phenolics (mg L-1).

Table 2. Phenolic compounds determined in Syrah commercial red wines placed in two storage conditions in the Northeast of Brazil, 2014 vintage.

Phenolic compound	**Wines**							
	1 Month		**4 Months**		**7 Months**		**10 Months**	
	Shelf	**Cellar**	**Shelf**	**Cellar**	**Shelf**	**Cellar**	**Shelf**	**Cellar**
Anthocyanins								
Malvidin 3-O-glucoside	113.9±2.9bA	125.5±1.5aA	77.7±2.9bB	105.1±0.6aB	30.1±0.5bC	71.4±2.4aC	17.5±2.2bD	59.2±4.2aD
Cyanidin 3-O-glucoside	2.3±0.1aA	2.3±0.1aA	2.1 ±0.1aA	2.2±0.2aA	1.7±0.1bB	2.4±0.2aA	1.4±0.1bB	2.0± 0.1aA
Delphinidin 3-O-glucoside	14.5± 0.4aA	15.4±0.3aA	10.7±0.4bB	13.6±0.4aB	5.2± 0.1bD	10.3±0.4aB	3.3±0.3bE	8.7±0.8aC
Peonidin 3-O-glucoside	20.9 ±0.5bB	22.9±0.2aA	14.4±0.5bC	19.3±0.2aB	5.9±0.1bE	13.9±0.4aC	3.4±0.3bF	11.6±0.8aD
Pelargonidin 3-O-glucoside	20.8±0.6aA	22.9±0.4aA	14.9±0.7bB	19.9±0.2aA	5.8±0.1bD	14.1±0.8aB	3.3±0.4bE	11.6 ±1.2aC
Flavonols								
kaempferol-3-O-glucoside	2.9±0.2aA	3.1±0.4aA	2.4±0.5aA	3.0±0.1aA	0.4±0.1aB	0.4±0.0aB	0.4±0.0aB	0.4±0.1aB
Isorhamnetin-3-O-gluco	9.9±0.6aA	9.3±0.5aA	6.2±0.5aB	6.2±0.2aB	1.9±0.0aC	1.9±0.2aC	1.8±0.2aC	1.7±0.1aC
Myricetin-3-O-glucoside	2.8±0.3aA	2.4±0.1aA	2.3±0.3aB	2.4±0.2aB	1.8±0.2aB	1.9±0.2aB	2.1±0.3aB	1.9±0.4aB
Quercetin-3-O-glucoside	7.7±0.2aA	7.5±0.4aA	7.4±0.3aA	6.6±0.7aA	5.5±0.1aA	6.0±0.3aA	5.1±0.4aA	5.4±0.5aA
Quercetin	1.2±0.1aA	0.9±0.1aA	1.1±0.2aA	1.0±0.2aA	0.7±0.1aA	0.7±0.1aA	0.8±0.1aA	0.7±0.2aA
Rutin-3-O-glucoside	1.2±0.2aA	1.3±0.2aA	1.2±0.3aA	1.2±0.1aA	0.1±0.0aB	0.2±0.0aB	0.1±0.1aB	0.2±0.1aB
Flavanols								
(-)-Epicatechin gallate	1.3±0.5aC	2.7±0.5aC	7.7±0.4aA	7.6±0.3aA	5.3±0.2aB	5.8±0.1aB	5.1±0.5aB	5.1±0.4aB
(-)-Epigallocatechin	10.9±0.6aA	10.9±0.7aA	5.3±0.9aB	6.0±0.5aB	3.1±0.1aC	3.0±0.1aC	3.0±0.1aC	3.0±0.1aC
Phenolic acids								
Caffeic acid	29.3±0.2aA	29.4±0.2aA	28.7±1.6aA	30.5±0.3aA	29.0±0.3bA	33.0±0.7aA	26.9±0.1bA	31.1±1.0aA
Cinnamic acid	0.9±0.0aA	0.8±0.1aA	0.9±0.1aA	0.8±0.1aA	0.7±0.0aA	0.7±0.0aA	0.6±0.0aA	0.7±0.0aA
Gallic acid	64.1±0.4aB	60.9±1.6aC	67.8±1.3aB	65.3±0.4aB	71.9±1.0aA	67.0±1.5bB	72.0±0.3aA	66.2±1.0bB
Chlorogenic acid	3.1±0.1aC	3.1±0.3aC	2.7±0.2aC	2.9±0.1aC	10.7±0.6aA	12.5±1.5aA	6.0±0.2bB	11.0±2.2aA

p-Coumaric acid	11.0±0.1aC	10.7±0.2aC	12.5±0.8aB	12.1±0.1aB	14.5±0.1aA	12.8±0.4bB	15.0±0.1aA	12.5±0.2bB
Stilbenes								
Trans-resveratrol	0.7±0.0aA	0.8±0.1aA	0.7±0.0aA	0.8±0.0aA	0.7±0.0aA	0.7±0.1aA	0.6±0.0aA	0.7±0.1aA
Sum of all phenolics	**19.5**	**332.8**	**266.7**	**309.5**	**195.0**	**258.7**	**168.4**	**233.7**

*Lowercase letters refer to storage type, in each period (month), while capital letters are related to stability along times (1 to 10 months).

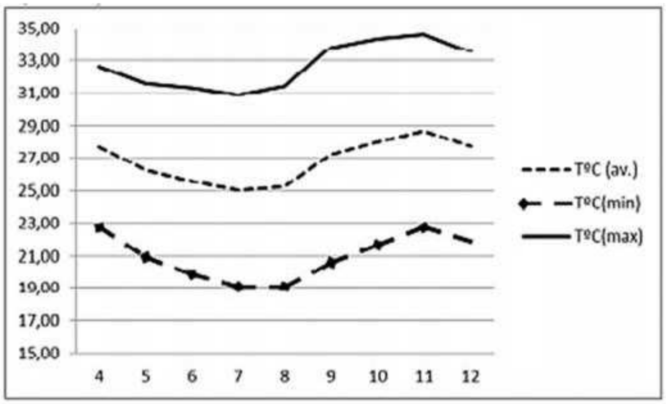

Figure 1. Mensal average of minimum, medium and maximum temperatures between April and December 2014, in Lagoa Grande, Pernambuco State, Northeast of Brazil. Numbers in abscissa corresponding to months in the year (4-April, 12-December).