THE EFFECT OF VITICULTURAL CLIMATE ON RED AND WHITE WINE TYPICITY

Characterization in Ibero-American grape-growing regions

J. TONIETTO[1*], V. SOTES RUIZ[2], M. CELSO ZANUS[1], C. MONTES[3], E.M. ULIARTE[4], L.A. BRUNO[5], P. CLIMACO[6], A. PENA[7], C. CRIVELLARO GUERRA[1], C.D. CATANIA[4], E.J. KOHLBERG[8], G.E. PEREIRA[1], J.-M. RICARDO-DA-SILVA[9], J.V. RAGOUT[10], L.V. NAVARRO[10], O. LAUREANO[9], R. de CASTRO[9], R.F. DEL MONTE[4], S.A. de DEL MONTE[4], V. GOMEZ-MIGUEL[2] and A. CARBONNEAU[11]

1 : EMBRAPA Uva e Vinho, Rua Livramento, 515 - 95700-000 - Bento Gonçalves, Brazil
2 : UPM - Universidad Politécnica, Madrid, Spain
3 : CEAZA - Centro de Estudios Avanzados en Zonas Áridas, La Serena, Chile
4 : INTA – EEA, Mendoza, Argentina
5 : PFCUVS-FAUTAPO, Tarija, Bolivia
6 : INIA/INRB, Estação Vitivinícola Nacional, Dois Portos, Portugal
7 : Faculdad de Ciencias Agronomicas, Universidad de Chile, Santiago, Chile
8 : Kohlberg Estate, Tarija, Bolivia
9 : ISA-UTL - Instituto Superior de Agronomia, Lisboa, Portugal
10 : Enology expert, Spain
11 : Supagro, Montpellier, France

Abstract

Aim : This study is part of a CYTED (Ibero-American Program for Science, Technology and Development) project on vitivinicultural zoning. The objective was to characterize the effect of viticultural climate on red and white wine typicity in the macro Ibero-American viticultural region.

Methods and results : The climate of 46 grape-growing regions in 6 Ibero-American countries (Argentina, Bolivia, Brazil, Chile, Spain and Portugal) was characterized using the three viticultural climate index of the Geoviticulture MCC System : the Heliothermal index HI, the Cool Night index CI and the Dryness index DI. The main sensory characteristics frequently observed in representative red and white wines of each of these regions were described by enology experts in the respective countries : intensity of colour, aroma, aroma-ripe fruit, body-palate concentration, alcohol, tannins (for red wines) and acidity as well as persistence on the palate. The data were submitted to a correlation analysis of the variables and Principal Component Analysis (PCA).

Conclusion : The typicity of red and white wines was correlated with the HI, CI and DI viticultural climate indexes from the MCC System. The main wine sensory variables affected by viticultural climate were identified.

Significance and impact of the study : The results can be used to project the potential impacts of climate change on wine sensory characteristics.

Key words : Ibero-American grape-growing areas, viticultural climate indexes, wine typicity, sensory variables, climate change

Résumé

Objectif : Cette étude fait partie d'un projet CYTED (Programme Ibéro-Américain de Science et Technologie pour le Développement) sur le zonage vitivinicole. L'objectif a été de caractériser l'effet du climat viticole sur la typicité des vins rouges et blancs dans la macro région viticole Ibéro-Américaine.

Méthodes et résultats : Le climat de 46 régions viticoles situées dans 6 pays Ibéro-Américains (Argentine, Bolivie, Brésil, Chili, Espagne et Portugal) a été caractérisé par les trois indices climatiques viticoles du Système CCM Géoviticole : l'indice Héliothermique IH, l'indice de Fraîcheur des Nuits IF et l'indice de Sécheresse IS. Les caractéristiques sensorielles les plus fréquemment observées dans les vins rouges et blancs représentatifs de chacune des régions ont été évaluées par des œnologues experts de chaque pays : l'intensité de la couleur, de l'arôme, de l'arôme de fruit mûr, de la concentration, de l'alcool, des tanins (pour les vins rouges) et de l'acidité de même que la persistance.

Conclusion : Une corrélation entre la typicité des vins rouges et blancs et les indices climatiques viticoles IH, IF et IS du Système CCM a été mise en évidence. Les principales caractéristiques sensorielles du vin affectées par le climat viticole ont été identifiées.

Signification et importance de l'étude : Les résultats peuvent être utilisés pour tenter de donner une idée de l'impact du changement climatique sur les caractéristiques sensorielles des vins.

Mots clés : régions viticoles Ibéro-Américaines, indices climatiques viticoles, typicité des vins, variables sensorielles, changement climatique.

*Corresponding author : Jorge.tonietto@embrapa.br

Spécial Laccave, *J. Int. Sci. Vigne Vin,* 2014, 19 - 23

INTRODUCTION

The effect of climate on grape composition and wine characteristics and typicity has been characterized in many specific viticultural regions and climates worldwide. However, few studies have characterized this effect at global scale considering different climates.

This study is part of a CYTED (Ibero-American Program for Science, Technology and Development) project on vitivinicultural zoning (CYTED, 2003 ; Sotés & Tonietto, 2004). The objective was to characterize the effect of viticultural climate on the typicity of red and white wines in the macro Ibero-American viticultural region, as perceived by expert enologists.

MATERIAL AND METHODS

1. Methodology

The methodology was applied to 46 main grape-growing regions across 6 Ibero-American countries : Argentina (Catania et al., 2007), Bolivia, Brazil, Chile, Spain and Portugal. The viticultural climate of each region was characterized using the three viticultural indexes of the Geoviticulture MCC System (Tonietto, 1999 ; Tonietto & Carbonneau, 2004) : HI (Huglin's Heliothermal Index), CI (Cool Night Index) and DI (Dryness Index). The indices were calculated based on the inter-annual climate averages collected from a representative weather station in each region.

2. Sensory evaluation

The main sensory variables frequently observed in dry red and white wines (up to 12 months after alcoholic fermentation) produced from representative grape(s) of each of the 46 grape-growing regions were described (based on empirical knowledge) by experienced enologists in the respective countries using the methodology of Zanus & Tonietto (2007). The sensory evaluation concerned the intensity of wine descriptors most affected by viticultural climate : Colour (Cou), Aroma - Intensity (Ar), Aroma - Ripe Fruit (Ar-Fm), Concentration (Con), Alcohol (Al), Tannins (Tan ; only for red wines), and Acidity (Ac). Persistence (Per) on the palate was also evaluated. The experts used a sensory evaluation form consisting of a 5-point intensity scale where 1 = low intensity and 5 = high intensity (Table 1).

3. Data analysis

The variable set was submitted to a correlation analysis and Principal Component Analysis (PCA).

RESULTS AND DISCUSSION

1. Red wines

The average and standard deviation of viticultural climate indices and wine sensory variables across the 46 grape-growing regions are shown in Table 2. The average HI value was 2.411, with a minimum of 1.710 and a maximum of 3.572 ; the average CI value was 13.3 °C, with a minimum of 8.1 °C and a maximum of 21.7 °C ; and the average DI value was -68 mm, with a minimum of -276 mm and a maximum of 200 mm. This is a good representation of the variability observed at global scale, except in very cool and cool climates. The averages for all sensory variables ranged from 3.0 (Ac) to 3.7 (Al, Ar-Fm, and Cou) and standard deviations from 0.66 (Al) to 0.83 (Cou).

Table 3 shows the correlation coefficients between MCC System climate indices and sensory variables for all 46 grape-growing regions. The following significant correlations were found : HI - positive correlation with Al and negative correlation with Ac ; CI - negative correlation with Cou, Ar, Con, Tan and Per ; and DI - positive correlation with Ac and negative correlation with Al.

The correlations between climate indices and red wine sensory variables were analyzed using PCA analysis

Table 1. Sensory evaluation form of red and white wines from different grape-growing regions.

Sensory Descriptor	Low	Intensity Trend →			High
Colour - Intensity					
Aroma - Intensity					
Aroma – Ripe fruit - intensity					
Concentration - intensity					
Alcohol - intensity					
Tannins – intensity (red wines)					
Acidity - intensity					
Persistence					

(Figure 1, left plot). The first two principal components (PC1 and PC2) accounted for 63.21 % of the variability.

This analysis strengthen the correlation results reported in Table 3 and confirms the effect of temperature (HI) on the increased perception of Alcohol and the decreased perception of Acidity in red wines. With respect to soil water supply, the highest DI values contributed to the increased perception of Acidity and the decreased perception of Alcohol. The analysis also highlights the effect of night temperature at ripening time on wine sensory characteristics : cool nights (lowest CI values) contributed to the increased perception of Colour, Tannins, Aroma, Concentration and Persistence.

2. White wines

The average and standard deviation of viticultural climate indices and wine sensory variables across the 46 grape-growing regions are shown in Table 2. The average HI value was 2.411, with a minimum of 1.710 and a maximum of 3.572 ; the average CI value was 13.5 °C, with a minimum of 8.1 °C and a maximum of 21.7 °C ; and the average DI value was -53 mm, with a minimum of -276 mm and a maximum of 200 mm. Again, this is a good representation of the variability observed at global scale, except in very cool and cool climates. The averages for all sensory variables ranged from 2.4 (Cou) to 3.6 (Al) and standard deviations from 0.65 (Cou and Al) to 0.99 (Ar-Fm).

Table 3 shows the correlation coefficients between MCC System climate indices and sensory variables for all 46 grape-growing regions. The following significant correlations were found : HI - positive correlation with Al and negative correlation with Ac ; CI - positive correlation with Cou and negative correlation with Ar, Ar-Fm, Ac and Per ; and DI - positive correlation with Ac and Cou.

The PCA analysis of the correlations between climate indices and white wine sensory variables is depicted in Figure 1 (right plot). The first two principal components (PC1 and PC2) accounted for 60.45 % of the variability. The third principal component (not shown) accounted for 17.45 % of the variability and highlighted the « DI x Cou » clustering.

This analysis strengthen the correlation results reported in Table 3. With respect to temperature, the results for white wines follow the same trend as that for red wines, that is, an effect of HI on the increased perception of Alcohol and the decreased perception of Acidity. The analysis also highlights the effect of night temperature at ripening time on wine sensory characteristics : cool nights (lowest CI values) contributed to the increased perception of Aroma (Ar

Table 2. Average and standard deviation in MCC System climate indices and wine sensory variables for all 46 grape-growing regions under study

Wines		HI	CI	DI	Cou	Ar	Ar-Fm	Con	Al	Tan	Ac	Per
Red	Average	2411	13.3	-68	3.7	3.6	3.7	3.6	3.7	3.4	3.0	3.6
	Standard deviation	399. 03	2.99	120.47	0.83	0.71	0.71	0.75	0.66	0.72	0.80	0.71
White	Average	2411.4	13.5	-53	2.4	3.5	3.2	2.9	3.6	-	2.8	3.3
	Standard deviation	400.41	3.01	128.24	0.65	0.96	0.99	0.95	0.65	-	0.79	0.86

Table 3. Correlation coefficients between climate indices of the MCC System and wine sensory variables for all 46 grape-growing regions under study : red wines (in red) and white wines (in green)

Variable	HI	CI	DI	Cou	Ar	Ar-Fm	Con	Al	Tan	Ac	Per
HI	1.00	**0.59****	**-0.39****	0.11	-0.15	-0.13	0.16	**0.34***	-	**-0.63****	-0.28
CI	**0.60****	1.00	0.03	**0.36***	**-0.31***	**-0.37***	-0.12	0.25	-	**-0.39****	**-0.42****
DI	**-0.35***	0.06	1.00	**0.42****	-0.01	-0.09	0.08	-0.15	-	**0.58****	0.05
Cou	-0.25	**-0.45****	0.05	1.00	-0.01	-0.13	0.22	**0.54****	-	-0.05	0.00
Ar	0.08	**-0.33***	-0.15	**0.41****	1.00	**0.86****	**0.62****	0.05	-	**0.31***	**0.73****
Ar-Fm	0.10	-0.20	-0.25	**0.40****	**0.65****	1.00	**0.68****	-0.03	-	**0.30***	**0.78****
Con	-0.13	**-0.34***	-0.04	**0.72****	**0.51****	**0.55****	1.00	**0.45****	-	0.15	**0.58****
Al	**0.36***	0.09	**-0.49****	0.12	0.21	**0.39****	**0.31***	1.00	-	-0.38**	0.02
Tan	-0.21	**-0.35***	0.12	**0.76****	0.24	0.25	**0.67****	-0.01	1.00	-	-
Ac	**-0.55****	-0.25	**0.53****	**0.37***	-0.22	-0.06	**0.31***	**-0.45****	**0.49****	1.00	**0.42****
Per	-0.14	**-0.41****	-0.21	**0.56****	**0.74****	**0.65****	**0.59****	**0.31***	**0.37***	-0.02	1.00

In bold are significant correlations at the 0.05 (*) and 0.01 (**) probability level

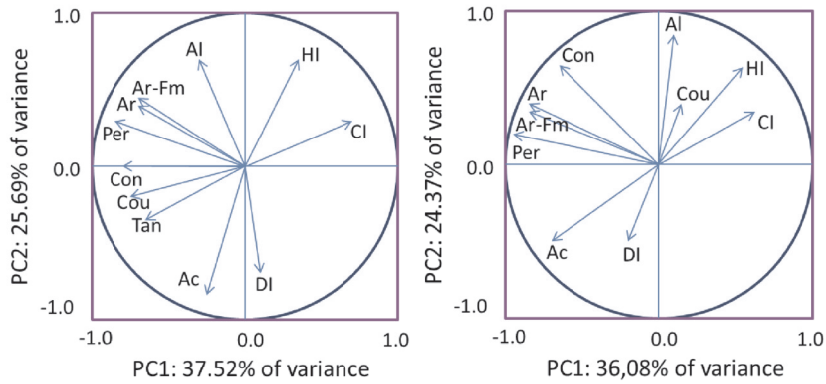

Figure 1. Principal Component Analysis (PCA) of MCC System climate indices (HI, CI and DI) and sensory characteristics (Cou, Ar, Ar-Fm, Al, Con, Tan, Ac and Per) of red (left plot) and white wines (right plot) for all 46 grape-growing regions under study.

and Ar-Fm), Acidity and Persistence and the decreased intensity of Colour. Finally, the highest DI values contributed to the increased perception of Acidity and Colour. The correlation between high colour intensity and high DI (wetter areas) observed in white wines may be attributed to a faster evolution of colour, given that these wines usually have lower alcohol levels.

3. Climate change and wine typicity: relationship between wine sensory patterns and MCC climate indices

This study across Ibero-American grape-growing regions can provide insights into the impact of climate change (and hence changes in MCC climate indices) on wine sensory patterns.

Considering that climate change will lead to warmer temperatures, HI is likely to increase. The same is true for minimum temperatures, which means that CI is also likely to increase in the future. Climate change may also lead to greater variability in rainfall across viticultural areas, which may result in lower DI in certain areas (if considering the atmospheric demand in response to increasing temperature). Figure 2 shows the main trends in sensory perception for red and white wines according to future climate change scenarios and associated changes in MCC System climate indices (based on the significant correlations presented in Table 3, considering an increase in HI and CI and a decrease in DI).

CONCLUSIONS AND CONSIDERATIONS

This study shows that wine typicity is determined in part by the regional viticultural climate and that the MCC System viticulture indices are significantly related to wine sensory characteristics.

The response of wine sensory characteristics to both viticultural climate and climate change is, of course,

Sensory descriptor	MCC Climate index		
	HI ↗	CI ↗	DI ↘
Colour - intensity		↗↘	↘
Aroma - intensity		↘↘	
Aroma - Ripe fruit - intensity		↘	
Concentration - intensity		↘	
Alcohol - intensity	↗↗		↗
Tannins - intensity (red wines)		↘	
Acidity - intensity	↘↘	↘	↘↘
Persistence		↘↘	

Figure 2. Potential trends in sensory perception for red (in red) and white wines (in green) in response to climate change, considering an increase in HI and CI and a decrease in DI (and vice versa for < HI, < CI and > DI).

not linear. It is also influenced by numerous factors, such as grape variety and its interactions with the environment and the cultural and enological practices of each region.

Nevertheless, the results obtained in this study, and future studies using the same methodology, could be used in wine typicity projections for potential grape-growing regions and in the qualitative assessment of wine typicity in response to climate change for current grape-growing regions.

Acknowledgements : This article was first published in French in "Clima, Zonificacion y Tipicidad del vino in regiones viti-vinicoles iberoamericanas, 2012. Eds J. Tonietto, V. Sotez-Ruiz, V.D. Gomez-Miguel. CYTED, Madrid, 411 pp."

REFERENCES

Catania C.D., Avagnina de Del Monte S., Uliarte E.M., Del Monte R.F., Tonietto J., 2007. El clima vitícola de las regiones productoras de uvas para vinos de Argentina. In : *Caracterização Climática de Regiões Vitivinícolas Ibero-Americanas*. Tonietto J., Sotés V. (Eds.), Bento Gonçalves : Embrapa Uva e Vinho, pp. 9-55, www.cnpuv.embrapa.br/tecnologias/ccm.

CYTED (Ciencia y Tecnología para el Desarrollo), 2003. *Metodologías de Zonificación y su Aplicación a las Regiones Vitivinícolas Iberoamericanas.* Sotés Ruiz V. (coordinator), Proyecto de Investigación Cooperativa, UPM, España.

Sotés V., Tonietto J., 2004. Climatic zoning of the Ibero-American viticultural regions. In : *Proceedings of the Joint International Conference on Viticultural Zoning 2004, Cape Town, South Africa*. South African Society for Enology and Viticulture (SASEV) – OIV – Gesco, p. 202. CD-ROM (Viticultural Terroir Zoning, 2004).

Tonietto J., 1999. Les macroclimats viticoles mondiaux et l'influence du mésoclimat sur la typicité de la Syrah et du Muscat de Hambourg dans le sud de la France : méthodologie de caractérisation. *Thèse de Doctorat*, École Nationale Supérieure Agronomique de Montpellier- Ensa-M (France).

Tonietto J., Carbonneau A., 2004. A multicriteria climatic classification system for grape-growing regions worldwide. *Agric. Forest Meteorol.*, **124**, 81-97.

Zanus M.C., Tonietto J., 2007. Elementos metodológicos para a caracterização sensorial de vinhos de regiões climáticas vitivinícolas. In : *Caracterização Climática de Regiões Vitivinícolas Ibero-Americanas*. Tonietto J., Sotés V. (Eds.), Bento Gonçalves : Embrapa Uva e Vinho, pp. 57-64, www.cnpuv.embrapa.br/tecnologias/ccm.