CHEMICAL AND SENSORY CHARACTERIZATION OF COMMERCIAL XAREL.LO WHITE WINES FROM THE PENEDES REGION

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RESUMEN

Con el fin de caracterizar los vinos producidos a partir de la variedad de uva blanca Xarel.lo, la más cultivada en la región del Penedés (Cataluña, España), se realizó un estudio global sobre veinticinco vinos blancos monovarietales (*var*. Xarel.lo) y comerciales procedentes de diferentes añadas y de las bodegas más representativas de la región del Penedés, basado en la aplicación del análisis sensorial descriptivo y químico. El análisis sensorial mostró dos grupos principales o estilos de vinos, los vinos jóvenes, que caracterizados por un sabor fresco y un marcado aroma a fruta y floral y los vinos envejecidos que fueron sometidos a crianza, caracterizados por atributos sensoriales más complejos y que presentaban notas de tostado, picante y compota. Las diferencias en las características sensoriales parecieron estar relacionadas con un alto contenido de acetatos de alcoholes superiores, etil y metil ésteres de ácidos grasos en los vinos pertenecientes al primer grupo mientras que los del segundo grupo mostraron baja concentración de ésteres pero alta de compuestos como el furfural, furaldehído y vitispirano.

ABSTRACT

In order to characterize wines produced from the white grape variety Xarel.lo, the most cultivated in the Penedés (Catalonia, Spain), a comprehensive study based on the application of descriptive sensory and chemical analyses of twenty-five commercial monovarietal white wines (*var. Xarel.lo*) from different vintages and from representative wine cellars along the Penedés region has been performed. The sensory analysis showed two main groups of wines, younger wines characterised by a marked fruity and floral aroma and fresh taste and older wines that underwent *crianza*, characterised by more complex odour attributes such as *toasted*, *spicy* and *compote*. The differences in sensory characteristics were related to a higher content of higher alcohol acetates and ethyl and methyl esters of fatty acids in wines from the first group, while the second group was characterized by a lower concentration of esters, but higher of compounds such as furfural, furaldehyde and vitispiranes.

INTRODUCTION

Currently, Xarel.lo is the white grape variety most cultivated in the Penedés (Catalonia, Spain) and it is allowed in the production of wines commercialized under the Origen Denomination (O.D) Penedés. Traditionally, this variety has been used, generally in mixtures, for the production of Cava wines (Spanish sparkling wines). Therefore, most of the scientific studies have been focused on knowing its technological aptitude for the production of this type of wines. However, in recent years the number of monovarietal Xarelo.lo wines produced by using different winemaking technologies has highly increased. This fact shows the necessity of studies focused on the chemical and sensory characterisation of these wines.

Although some previous works have been done on the free and bound volatile composition of Xarel.lo musts, in the case of wines, only De la Presa and Noble (1995) and De la Presa et al., (1995) performed, respectively, the sensory and chemical characterization of wines from this variety. In the latter works, the authors showed sensory and chemical differences in wines from this variety compared to white wines from other typical grapes from Penedés such as Macabeo and Parellada also used for Cava wines production. However, the rather small number of samples employed in these previous studies (two wines of each variety) may not be enough to represent the sensory and chemical characteristics of the Xarel.lo wines from different winemaking technologies currently in the market.

The aim of the present study is therefore, to characterize representative monovarietal Xarel.lo wines that are being commercialised under the O.D. Penedés using both descriptive sensory and chemical analysis. The final goal will be to find relationships between the chemical and sensory characteristics, which may helps in the development of winemaking and viticultural practices that lead characteristic sensory profiles.

MATERIALS AND METHODS

Wine samples. Twenty-five commercial monovarietal white wines (*var. Xarel.lo*) from representative wine cellars from the Penedés region (Catalonia, Spain) and vintages were analyzed. These wines were selected by the Instituto Catalan de la Viña y el Vino (INCAVI) and represent the majority of the Xarel.lo wines from the Penedés region available in the market. The global composition of the wines fit in the requirements of the Spanish O.D. Penedés.

Analysis of non-volatile compounds. Free amino acids and the sum of free amino acids plus peptides were determined by colorimetric methods (Doi et al. 1981). Peptides were quantified by the difference between both determinations. The concentration of high molecular weigh nitrogen compounds (HMWN) was determined following the Bradford method (Bradford, 1976). Total phenolic compounds concentration was determined using the Folin-Ciocalteu reagent.

Analysis of major volatile compounds. Major volatile compounds were determined by direct injection of 1 µL of wine spiked with the internal standard (0.06 g L^{-1} of 3-pentanol in ethanol 10 % v:v) on an Agilent 5890 gas chromatograph. For quantification purposes calibration curves of each standard compound in synthetic wines were made and analysed in the same conditions than the samples.

Analysis of minor volatile compounds. Minor volatile compounds were analysed by HS-SPME-GCMS. The extraction was performed with the exposure of a 85 μm CAR-PDMS fibre to the headspace of the wine for 20 minutes at 40ºC and constantly stirring (500 rpm). The fibre was desorbed in the GC injector port in splitless mode for 10 minutes. A mass spectrometer Agilent 5973N was used for qualitative purposes. Quantitative data were obtained by calculating the relative peak area in relation to that of the internal standard (methyl-nonanoate). For quantification, calibration curves of each standard compound in synthetic wines were made and analysed in the same conditions than the samples. A semi-quantitative analysis assuming that component response factors were the same as the response factor of the internal standard was performed for those compounds for which none reference compound was available.

Sensory descriptive analysis (DA). The sensory panel was composed of 12 trained judges with extensive experience in sensory analysis. Specific training sessions were previously carried out with the aim to look for the most adequate descriptive terms to be used with the wines. From these preliminary tests 16 terms related to the odour (*white flower, white fruit, stone fruit, citric, tropical, fresh grass, dry grass, compote, spicy, toasting* and *lactic*), taste (*fresh* taste, texture, persistence) and color (intensity and tonality) were selected. Wine samples were evaluated in triplicated in three formal sessions that were held in different days.

Data Analysis. The statistical methods used for the data analysis were: one-way ANOVA and Scheffe test for means comparisons; principal component analysis (PCA) (from correlation matrix) was used to examine the relationship among the variables and between samples; cluster analysis (Ward's method, from standardized data) was used to discover natural groupings of the samples; and partial least square regression (PLS) was applied to predict the sensory attributes of the wines based on the chemical composition.

RESULTS AND DISCUSSION

Sensory Characterization

Principal Component Analysis was applied to the intensity data obtained from the sensory evaluation of the wines. From this analysis, two principal components, which explained 74% of the total variation on the data were obtained. The first principal component (PC1, 41.6% of the total variance) was positively correlated with the descriptors white flower, white fruit, stone fruit and fresh taste (loadings > 0.8) and negatively with compote, toasted, spicy, lactic and dry grass (loadings < -0.8). The second principal component (PC2, 32.7% of the total variance) was negatively correlated with citric and tropical aroma, persistence, colour and tonality. In **Figure 1** the scores of the wines in the four groups, and the loadings of the sensory descriptors, are plotted on the plane defined by the two first principal components. As can be seen, four groups of wines which were already noticed by cluster analysis (data not shown) can be distinguished. Wines from group 1, were better characterized by descriptors associated to the PC1, on the contrary, wines included in groups 2 and 3 were very little associated to them. The PCA also revealed a fourth group of wines (group 4) that were negatively related with PC1 (on the contrary to that happened with wines from group 1).

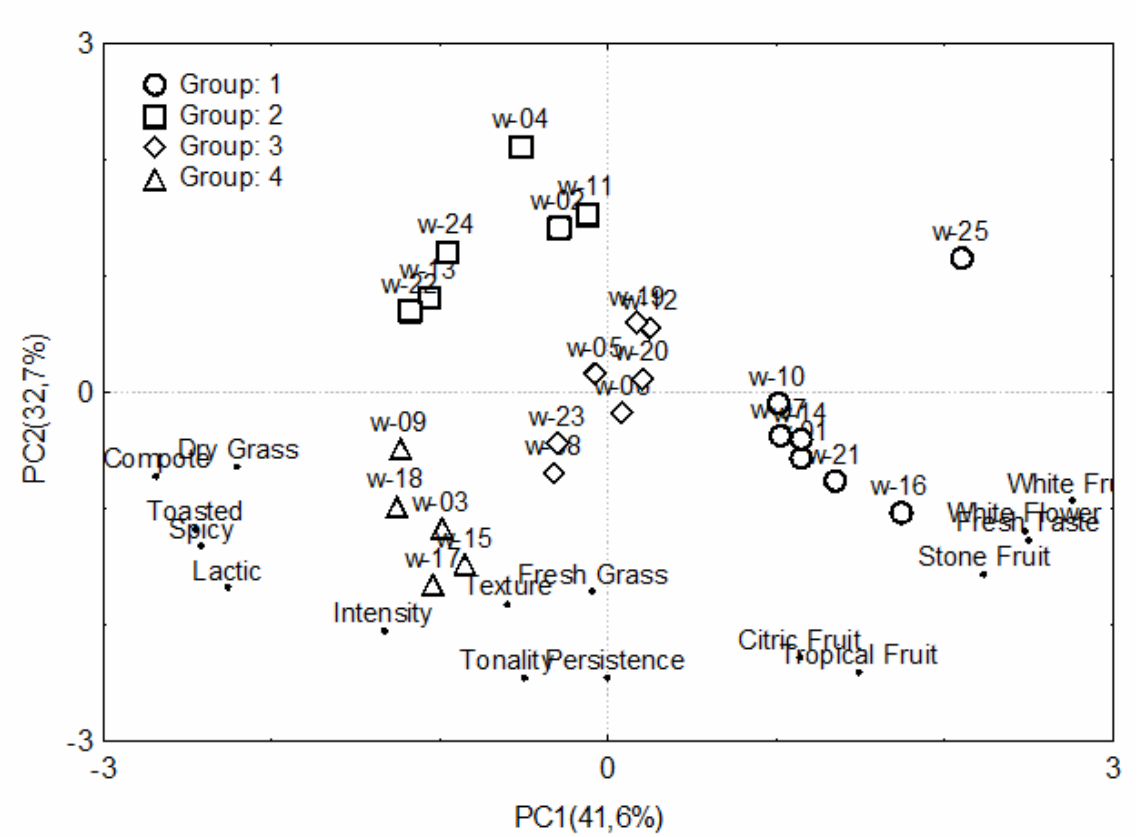

Figure 1. Plot of the wines in the four groups and the loadings of the intensity of sensory attributes on the plane defined by the first two principal components obtained from the PCA.

Chemical Characterization

The sensory differences found between wines can be related to differences in their chemical composition. Therefore, the chemical characterization of the non-volatile and volatile composition of the wines was carried out. The concentration of free amino acids, peptides and polysaccharides was in agreement with previous studies performed in Cava base wines produced from Xarel.lo grapes (Martínez-Rodríguez and Polo, 2003). The total polyphenol concentration showed a higher dispersion due to the *crianza* process that underwent some of them.

Regarding the volatile composition, 59 volatile compounds were identified. All the major volatile compounds (acetaldehyde, ethyl acetate, methanol, 1-propanol, isobutanol, isoamylic alcohols and ethyl lactate), were present in all the samples. Other minor volatile compounds also detected in most of the wines were mainly esters and specifically higher alcohols acetates and ethyl esters of fatty acids. Most of these compounds are important contributors to the fruity and flowery aroma of wines. The three medium chain volatile fatty acids hexanoic, octanoic and decanoic acids and the two alcohols 1-hexanol and 2-phenylethanol also were detected in all the wines. Limonene, linalool and α-terpineol were the only terpenic compounds detected in the wines, and in general, they appeared at very low concentration. In general, it has been indicated that their occurrence in wines can be considered as a quality factor, since they seem to supply pleasant scents to the wines such as tobacco, fruit and tea. Among them, β-damascenone was identified only in 20% of the wines at concentration above 9 μg L^{-1}

and because of the very low perception threshold of β-damascenone (45 ng L^{-1}) (Camara et al., 2007), this compound might have a great importance for wine aroma. Other important norisoprenoids that were identified in the wines, were the two vitispirane isomers and the 1,1,6-trimethylnaphthalene (TDN). The three of them were identified in more than 80 % of the wines. Other compounds identified in the wines were some furfuryl compounds such as furfural, 5-methyl-furfural, ethyl-2-furancarboxylate and acetyl-furan, which are carbohydrate degradation products that can increase with aging bottle (Rapp and Mandery, 1986).

Correlation between sensory characteristics and chemical composition of the wines

Partial least squares regression (PLS) was applied to predict the sensory attributes of the wines based on the instrumental variables (global composition, volatile and non volatile compounds). The size and sign of the values of the regression coefficients in the model for standardized predictor variables can be used to know the variables that most contribute (positively or negatively) to the prediction of the sensory attributes. The PLS results, regression coefficients for the variables that most contribute in the prediction of specific sensory attributes, number of selected components and the determination coefficient (R^2), are shown in **Table 1.** In addition, the table is showing (in brackets), the values of the correlation coefficients, significantly different from zero ($p<0,05$), between the instrumental variables and the sensory attributes. In general, the selected variables that were positively related to *white fruit* and *white flower* were higher alcohols acetates (3-hexen-1-ol acetate, phenyl ethyl acetate, hexyl acetate) and ethyl and methyl esters of fatty acids (methyl octanoate, methyl decanoate and ethy decanoate). This is in agreement with the high involvement of these compounds in the characteristic fruity and flowery aroma of some young white wines. In addition, *white flower* and *white fruit* attributes showed a relative high correlation (0.77 and 0.78) (**Table 1)** with hexyl acetate. On the other hand, and as it is shown in **table 1**, compounds such as diethyl succinate, vitispirane and TDN, were negatively associated to all the fruity attributes. These compounds have been shown to increase during wine aging (Pozo-Bayon et al., 2003). In addition, it is interesting to underline that the attribute *fresh taste* followed a similar trend (**Table 1)** than that observed by the *fruity* and *floral* characteristics and it was also associated to the higher alcohols esters and higher alcohols acetates. In general, esters did not show a contribution to the *spicy* and *toasted* sensory characteristics and even some of them such as 3-hexen-1-ol-acetate and isoamyl acetate were negatively correlated to both sensory attributes (**Table 1).** Interestingly, the only volatile compounds that seemed to contribute the most to both sensory characteristics were furfural to the *toasted* and furaldehyde to both of them (**Table 1**). These compounds are carbohydrates degradation products and it has been shown they can increase with aging bottle (Rapp and Mandery, 1986). In addition, they may have been released into the wines that underwent *crianza* process, since both volatiles may be produced by degradation of polysaccharides during oak wood toasting. It was also interesting the positive contribution showed by other non volatile variables, such as color intensity (CI), polyphenols and alcoholic degree to the *toasty* or *spicy* attributes. This positive association seems to be linked to older wines or to wines that underwent *crianza*, as accounted for all the wines from group 4, in which both sensory attributes were rated the highest as compared to the wines from the three others groups.

Table 1. Regression coefficients from PLS model, for the variables that most contribute in the prediction of specific sensory attributes, and (the correlation coefficient, significantly different from zero).

	Sensory Atributes						
Instrumental variables	**White Flower**	**White fruit**	**Stone fruit**	**Tropical fruit**	**Spicy**	**Toasted**	**Fresh taste**
CI (color intensity)	-0.045 (-0.66)	-0.047 (-0.71)			0.14 (0.69)	0.13 (0.54)	-0.048 (-0.65)
Diethyl succinate	-0.045 (-0.66)	-0.049 (-0.74)	-0.044 (-0.65)	-0.035 (-0.5)			-0.042 (-0.62)
Ethyl 2 methyl butanoate	-0.040 (-0.58)	-0.046 (-0.68)	-0.044 (-0.66)	-0.034 (-0.5)			-0.042 (-0.62)
Ethyl 3 methyl butanoate	-0.039 (-0.57)	-0.041 (-0.61)	-0.036 (-0.54)				
Vitispirane 1	-0.042 (-0.61)	-0.046 (-0.69)	-0.036 (-0.54)	-0.035 (-0.49)			-0.042 (0.59)
Vitispirane 2	-0.041 (-0.61)	-0.046 (-0.69)	-0.035 (-0.53)	-0.035(-0.50)			-0.040 (-0.61)
TDN		-0.040	-0.035	-0.323			
Ethyl acetate						0.11 (0.6)	
Polyphenols					0.113 (0.53)		
Isoamyl alcohols			-0.038 (-0.57)	-0.034 (-0.49)			
2-Phenyl Ethanol				-0.039 (-0.55)			
3-Hexen-1-ol acetate	0.040 (0.59)	0.051 (0.77)	0.043 (0.65)	0.047 (0.50)	-0.066 (-0-49)	-0.075 (-0.58)	0.041 (0.60)
Methyl octanoate	0.036 (0.53)						0.037 (0.54)
Isoamyl acetate		0.042 (0.63)			-0.060 (-0.44)		0.036 (0.54)
Hexyl acetate	0.053 (0.77)	0.052 (0.78)	0.038 (0.6)	0.377 (0.53)		-0.06 (-0.54)	0.044
Phenyl ethyl acetate	0.042 (0.54)	0.042 (0.62)					
Methyl decanoate	0.044 (0.64)			0.037 (0.52)			
Isoamyl decanoate			0.034 (0.52)		-0.060		
Isopentyl hexanoate			0.037 (0.55)	0.065 (0.51)			
peptides			0.036 (0.53)	0.038 (0.54)			
Ethyl decanoate	0.044 (0.65)	0.044 (0.66)	0.044 (0.66)	0.053 (0.75)			0.043 (0.64)
Decanoic acid				0.035 (0.49)			
Furfural						0.12 (0.62)	
5-Methyl furfural					0.117 (0.44)	0.11 (0.52)	
Linalool						-0.069 (-0.42)	
R^2	**0.63**	**0.70**	**0.62**	**0.57**	**0.77**	**0.74**	**0.60**
Number of components	**1**	**1**	**1**	**1**	**2**	**2**	**1**

CONCLUSIONS

Four different styles of monovarietal Xarel.lo wines were found based on their sensory characteristics. Among them, two styles were perfectly distinguishable: young wines, characterized by a marked fruity and floral odour and fresh taste and older wines that underwent *crianza*, characterized by more complex sensory attributes such as *toasted*, *spicy* and *compote* odours. The differences in the two styles were related to a higher content of higher alcohol acetates and ethyl and methyl esters of fatty acids in the case of young wines, while the second style was characterized by lower concentration of esters, but higher concentration of compounds related with wine aging, such as furfural, furaldehyde and vitispiranes. These results may contribute to the promotion of the use of autochthonous grapes varieties to produce high quality wines with distinctive sensory characteristics helping to diversify the current wine market.

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