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Carignan phenolic composition in wines from ten sites of the Maule Valley (Chile): Location and rootstock implications

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ABSTRACT

In recent years, Carignan grapevines in the Maule Valley have been rediscovered by viticulturist and wine-makers, producing very interesting wines and well recognized worldwide. Phenolic compounds are responsible for the sensory attributes of wines, such as colour, bitterness and flavour. Their composition depends of several factors such as variety, soil attributes, climate conditions, viticultural practices, oenological procedures, among others. The aim was to study wine phenolic composition from Carignan grapevines ungrafted and grafted with País, growing in ten sites of the Maule Valley (Chile). Phenolic compounds were analysed by HPLC-DAD. The results showed that water holding capacity and soil depth affected weight of 100 berries and consequently wine phenolic composition. Besides, climatic conditions affected alcoholic degree more than phenolic compounds in wines. Rootstock barely affected phenolic content. These findings are of importance for the Chilean wine industry in relation to the viticultural management and the characterization of the phenolic composition of wines made from the variety, regarding location and rootstock, within the Maule Valley.

1. Introduction

During the recent years, the study of minority grapevine varieties has become interesting due to the oenological potential that have characterized the elaborated wines from these varieties (Gómez-Alonso et al., 2007; Gómez García-Carpintero et al., 2011). Currently, within the Chilean wine scenario,Carignan variety (*Vitis vinifera*. L) from the Maule Valley has had a great resurgence. The surface of the region permits a range of distinct mesoclimates suitable to give a diversity style of Carignan wines (Ubeda et al., 2017). The wines from Carignan are mainly associated with a collective brand called “VIGNO”, which have attracted the attention of critics and specialists of the wine world scenario. On the other hand, the oldest grapevine variety of the Chilean wine industry is País (*Vitis vinifera*. L), which has not had this resurgence. The grapes produced from this variety are sold at a price well below the national average. However, both grapevine varieties are part of the Chilean heritage viticulture, being managed by small wine-growers in a traditional way in Maule Valley. These grapevine varieties have been cultivated mostly, in Maule Valley, one of the largest wine producing area of Chile, with non-irrigated vines trained to a traditional bush system. Maule Valley holds approximately 700 ha of a total of 843 ha of Carignan noir (83%), and around 4995 ha of a total of 12,520 ha of País (38%) planted in the country (SAG, 2014). País is a very rustic variety that tolerates nematodes and other soilborne pests and that under rainfed conditions performs better than most of the *Vitis vinifera* L. varieties. For the aforementioned reasons, and due to the low price of País grapes, it has been used as a rootstock for other varieties, manly in Carignan when retrofitting a vineyard (Moreno and Vallarino, 2011).

Several factors influence grape and wine composition, however the majority of works focus on studying the effect of independent variables on the final composition of the grape and wine (Texeira et al., 2013; Garde-Cerdán et al., 2017; Gutiérrez-Gamboa et al., 2017a). Respect to the influence of “terroir”, Sabon et al. (2002) studied nineteen Grenache wines obtained from representative soils of the Rhone Valley according to their geographical site, climatic conditions, hydrological regulation and soil profile, indicating that the concentration of varietal compounds were correlated with grape maturity due to the ecosystem and particularly the soil. Van Leeuwen et al. (2004) studied three components of terroir as well as soil characteristics, climate conditions

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and variety, reporting that the impacts of climate and soil were greater than the variety. These authors suggested that the effects of climate and soil on fruit quality are mediated through their influence on vine water status. Ubeda et al. (2017) studied the aromatic profile of commercial monovarietal Carignan wines from different zones of Chile, reporting that geographical origin affected the volatile composition of the studied wines and production areas closer to the Andes Mountains showed significant lower contents of esters and acids than the ones closer to the ocean. Recently, Gutiérrez-Gamboa et al. (2017b) and Gutiérrez-Gamboa et al. (2018) studied the effects of locations and rootstock on Carignan grape amino acids and wine volatile composition from different sites of the Maule Valley, reporting that the grapes from the coolest sites presented higher concentration of several amino acids than the grapes collected from warmer sites of this valley, and their resulting wines obtained higher volatile compounds.

The study of phenolic compounds in beverages has become very important since they are responsible for the typical sensory attributes of wines, particularly color, bitterness and astringency (Heras-Roger et al., 2017). Moreover, the occurrence of flavonoids is directly associated with human daily dietary intake of antioxidants in humans, what gives important health benefits (Yao et al., 2004) The main factors that influence grape and subsequently wine phenolic composition are the variety, degree of grape maturation at harvest, climatic conditions, soil characteristics and viticultural and oenological practices (Downey et al., 2006).

Due to the aforementioned, the aim of this research was to study the influence of climatic conditions and soil characteristics on Carignan wines phenolic composition from ungrafted and grafted grapevines with País growing in ten different sites of the Maule Valley.

2. Materials and methods

2.1. Study sites and plant material

In the 2015 vintage, an experimental field was conducted along the Maule Valley, Región del Maule (Chile). Ten different sites from the Maule Valley were selected for the study (Fig. 1), based on geological and geomorphological information provided by CIREN (1997), as shown in Table 1. In four of the sites, Carignan vineyards were planted with grapevines grafted with País (*Vitis vinifera* L.) rootstock: Valdivia (Val), Loncomilla (Lon), Melozal (Mel), and Huerta de Maule (Hdm). In the rest of the sites, Carignan vineyards were planted with ungrafted grapevines: El Peumal (Peu), Sauzal (Sau), Santa Sofía (Sso), Truquilemu (Tru), Curtiduría (Cur), and Ciénaga de Name (Cdn). In each of the sites, was chosen a representative vineyard, where three replicates were arranged randomly within the vineyard, accounting around 18–22 grapevines per replication. The selection of the vineyards was made based on the following characteristics; Carignan grapevines with more than 50 years old, located in rainfed conditions, trained to a bush system, growing in good phytosanitary conditions and with an active leaf surface. Surface, number of plants by hectare, yield, vineyard age, nutritional management, and viticultural practices information is shown in Table 2.

2.2. Soil and climate characteristics

In each of the selected site, a test pit was made with the aim of study the chemical and physical characteristics of the soil. Surface and deep texture, soil depth, water holding capacity, organic matter, and soil total nitrogen analysis were made according to methodology developed by Soil and Crop Technological Center (CTSyC, 2017). The rest of soil descriptive information for each selected site was collected from to the described by CIREN (1997). Information about climatic variables was recorded “in situ”, from temperature and relative humidity sensors (HOBO Pro V2, Onset, Bourne, USA) located in each of the selected sites in the beginning of the most representative row at 1.5 m above the soil. Information about temperature and relative humidity was recorded every 5 min. From the climatic information obtained, bioclimatic indices, such as Huglin’s heliothermal index (HI), biologically effective degree days (BEDD), cool night index (CI), average mean temperature of the warmest month (MTWM) and maximum average temperature of warmest month (MATWM) were calculated according to the exposed by Martínez-Gil et al. (2018) and Gutiérrez-Gamboa et al. (2018). Location, soil properties, and bioclimatic indices information is shown in Table 1.

2.3. Harvest and winemaking procedure

Due to the different climatic conditions along to the different sites from the Maule Valley, 70 kilograms of grape berries within the experimental sites were harvested when reaching the following parameters: content of soluble solids of approximately 22–26 °Brix, titratable acidity between 5 to 8 g L^{-1} and pH level between 3.25 and 3.75. Subsequently, the grapes were stored in a cold chamber at 6 °C during one day before processing. The grapes were destemmed and crushed to obtain the must, which was protected by adding 50 mg kg^{-1} of SO_2. The crashed grapes obtained from each repetition was introduced into tanks of 50 L, so 30 tanks were filled (3 for each replicate). Tanks were stored at 6 °C for pre-fermentative maceration during two days. All the fermentations were performed in the experimental winery of the Vine and Wine Technological Center, (Talca, Chile). Then, crashed grapes was inoculated with a commercial yeast *Saccharomyces cerevisiae* strain BO 213 (Laffort, Bordeaux Cedex, France) to carry out the alcoholic fermentation, which took place at a temperature of 22 ± 1 °C. Alcoholic fermentation was considered finished when the must reached around 2.5 g L^{-1} residual sugar. After 16 days of maceration–fermentation, skins and seeds were removed manually, then the tanks were carried to cold at 6 °C to eliminate the lees. Wines were inoculated with 4 g hL^{-1} of *Oenococcus oeni* strain, B28 PreAc (Laffort). Malolactic fermentation was carried out in tanks of 20 litters. Measurements, of malic acid were performed weekly to determine the end of malolactic fermentation when the wine reached 100 mg L^{-1} of malic acid. Then, oenological parameters were measured in the obtained wine and samples were frozen at −20 °C to the subsequently phenolic analysis.

2.4. Analysis of wine oenological parameters

Grape and wine oenological parameters, such as ºBrix, alcoholic degree, pH, total acidity (g L^{-1} of tartaric acid) and volatile acidity (g L^{-1} of acetic acid), total and free sulphur dioxide and reducing sugars, were determined according the methodology established by OIV (2003). Yeast assimilable nitrogen (YAN) in must was analysed with the method proposed by Sörensen (1907). Malic acid in wines was analysed by means of an automated enzymatic test (Biowine 300, Biolan, Bilbao, Spain). Three replicates were obtained from each site, so the results were the average of three analyses (n = 3).

2.5. Extraction of non-anthocyanin compounds in wines

Isolation of non-anthocyanin compounds from the samples was carried out according to the methodology exposed by Castillo-Muñoz et al. (2007). Extraction was performed on PCX SPE cartridges (500 mg, 6 mL Bond Elut Plexa, Agilent, Palo Alto, CA, USA). The eluate containing the anthocyanin-free fraction was dried in a centrifugal evaporator (miVac, Genevac Ltd., Suffolk, UK) at 35 °C and re-solved in 1.5 mL of 20% (v/v) methanol aqueous solution. The anthocyanin free fraction was used to analyse non-anthocyanin flavonoid compounds (flavonols, flavanols, hydroxycinnamic acids and *trans*-piceid).