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Effect of different aging techniques on the polysaccharide and phenolic composition and sensory characteristics of Syrah red wines fermented using different yeast strains

Rubén del Barrio-Galán *, Marcela Medel-Marabolí, Álvaro Peña-Neira

Department of Agro-Industry and Enology, Faculty of Agronomical Sciences, University of Chile, Post Office Box 1004, Santiago, Chile

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ABSTRACT

The effect of high levels of the polysaccharide *Saccharomyces cerevisiae* yeast strain (HPS) and another conventional yeast strain (FERM) on the polysaccharide and phenolic composition of Syrah red wines during alcoholic fermentation and subsequent aging on lees, with or without oak wood chips, and on inactive dry yeast was investigated. The HPS yeast released higher amounts of polysaccharides during alcoholic fermentation than FERM yeast (485 g L^{-1} and 403 g L^{-1}, respectively) and after the aging period (516 g L^{-1} and 500 g L^{-1}, respectively). The different aging techniques increased the polysaccharide concentration; the concentration was dependent on the aging technique applied. The interaction of the polysaccharides with the phenolic compounds depended on the yeast strain, aging technique, aging period and compound analysed. The HPS wines exhibited better sensory characteristics than the FERM wines after alcoholic fermentation; however, during the aging period, it was difficult to determine which technique produced the best wine due to the interactions of aging technique, aging period and sensory attribute evaluated.

1. Introduction

Yeast mannoproteins have been of interest to winemakers and researchers due to the significant improvements yielded in the final quality of wine (Doco, Vuchot, Cheynier, & Moutounet, 2003). Mannoproteins are parietal polysaccharides with a high level glycosylation that are mainly composed of mannose (>90%), glucose (Guadalupe, Martínez, & Ayestarán, 2010) and proteins (<10%) (Vidal, Williams, Doco, Moutounet, & Pellerin, 2003). The quantity released depends on the yeast strain and the fermentation conditions (Giovani, Canuti, & Rosi, 2010). Mannoproteins improve certain negative sensory attributes such as astringency and bitterness, enhancing the balance, persistence and mouthfeel of red wines (Del Barrio-Galán, Pérez-Magariño, Ortega-Heras, Guadalupe, & Ayestarán, 2012; Del-Barrio-Galán, Pérez-Magariño, & Ortega-Heras, 2011) and improving the colour stability by acting as protective colloids (Del Barrio-Galán, Ortega-Heras, Sánchez-Iglesias, & Pérez-Magariño, 2012; Escot, Feuillat, Dulau, & Charpentier, 2001; Francois, Alexandre, Granes, & Feuillat, 2007).

The technique of aging red wines on lees has been used for many years with the aim of achieving a higher release of mannoproteins during the autolysis of the dead yeast in an attempt to improve their physico-chemical and sensory characteristics. Previous studies have demonstrated that complex polysaccharides can disrupt the interaction between salivary proteins and tannins *via* different mechanisms, inhibiting their interaction and minimising perceptions of astringency (Escot et al., 2001; Carvalho, Mateus, Plet, Pianet, Dufourc et al., 2006) or the precipitation of protein–tannin complexes (Mateus, Carvalho, Luis, & de Freitas, 2004). A recent study confirmed the smoothing capacity of different polysaccharide families on red wines, with special importance being given to mannoproteins (Quijada-Morín, Williams, Rivas-Gonzalo, Doco, & Escribano-Bailón, 2014). In addition, this technique can be complemented with stirring of wine, namely batonnage, which permits the homogenisation of the total wine volume and facilitates the liberation of macromolecules into the wine, such as parietal polysaccharides, mainly mannoproteins (Doco et al., 2003). This technique can be combined with aging in an oak wood barrel to permit a better integration of all of the compounds that form the matrix of the wine. In addition, the aging of the wines in barrels permits the release of other polysaccharides, which can contribute to improving the quality of red wines, even though these polysaccharides are not the same as those released from the yeast cell walls (Del-Barrio-Galán et al., 2011; Nonier, Vivas, Vivas-de-Gaulejac, Absalon, Vitry et al., 2005). However, due to

* Corresponding author. Tel.: +56 2 29785730; fax: +56 2 29785796.
E-mail address: rdelbarriogalan@gmail.com (R. del Barrio-Galán).

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the higher production costs, including those associated with the storage of the wines in oak wood barrels, and given the actual global wine market, it is necessary to search for other aging techniques that permit a reduction in production costs and that favour greater flexibility and manageability. Therefore, the addition of oak wood chips into wines aged on lees could be a good alternative to produce wines with similar quality as those aged in oak wood barrels. However, the liberation of hydrolysed tannins from oak wood can produce a higher astringency in the wines. Thus, the combination of oak wood chips with aging on lees can modulate this negative sensation in the mouth because the parietal polysaccharides from yeast lees can combine with the tannins, preventing their autoaggregation, polymerisation and precipitation, thereby reducing their reactivity with salivary proteins (Guadalupe, Palacios, & Ayestarán, 2007; Poncet-Legrand, Doco, Williams, & Vernhet, 2007; Riou, Vernhet, Doco, & Moutounet, 2002).

Despite the positive effects referred to above, the aging of wines on lees can also involve many disadvantages, such as greater demands on winery resources, namely more staff to perform the 'batonnage' and longer wine storage times, which increase the price of the final product, as well as the appearance of reduction notes (Chatonnet, 2000). In addition, the aging of wines on lees may involve some microbiological alterations due to the development of spoilage microorganisms, such as *Brettanomyces* (Chatonnet, 2000; Zamora, 2002). Hence, a large variety of commercial products rich in parietal yeast polysaccharides are supplied by manufacturers, which can yield similar characteristics to those of wines aged on lees but without their disadvantages. These products are mainly classified as inactive yeasts, yeast autolysates, yeast walls and yeast extracts (Pozo-Bayón, Andújar-Ortiz, & Moreno-Arribas, 2009) depending on their composition and purification degree. Their effect on the quality of wines can be very heterogeneous depending on the product used (Del Barrio-Galán, Pérez-Magariño, Ortega-Heras, Guadalupe et al., 2012). The price of these products is variable and depends on their purification degree, and their use can increase the final price of the wine, which is a clear disadvantage. The interest in the selection and use of high polysaccharide liberation yeast strains during fermentation has recently increased. This interest is mainly due to the higher liberation of mannoproteins that can benefit the sensory and physicochemical characteristics mentioned above. Their use can permit the release of greater amounts of these polysaccharides (mannoproteins) more rapidly into the wine, reducing production costs as well as the technological and microbiological disadvantages involved with the techniques mentioned above, reducing the aging periods and bringing the final wine to the market in a shorter period.

Therefore, the aim of this work was to study the effect of the aging of wines on lees, with or without oak wood chips, and with commercial inactive dry yeast previously fermented with different *Saccharomyces cerevisiae* yeast strains, which exhibit different capabilities for polysaccharide liberation, on the quality of Syrah Chilean red wines.

2. Materials and methods

2.1. Winemaking process and treatments

The study was carried out using Syrah red grapes supplied for Caliterra winery (Errazuriz group) located in the Colchagua valley (34.63° South latitude, 71.37° West longitude). The grapes selected for this study (about 65,000 kg) were harvested according to their technological maturity, based on the optimum sugar content (≈24.8° Brix) and total acidity (≈5.5 g L^{-1} of H_2SO_4), and transported to the winery. Once there, the traditionally winemaking process in red wines was followed. Briefly, after de-stemming, crushing and subsequent sulfiting, the must was transferred to two different 25,000-L stainless steel tanks for the alcoholic fermentation. One of these tanks, was inoculated with a commercial *S. cerevisiae* (*ex bayanus*) yeast (30 g hL^{-1} of Fermicru LS2 supplied by Oenobrands, Montpellier, France) (FERM) which is the conventional yeast used by Caliterra winery. The other tank was inoculated with another commercial *S. cerevisiae* yeast strain (30 g hL^{-1} of Uvaferm HPS supplied by Lallemand-South America, Santiago, Chile) (HPS) which produces high levels of polysaccharides during alcoholic fermentation (20–30% higher than other specific yeasts), according to the manufacturer's specifications.

The wine fermentation process strictly followed the manufacturing specifications of red wine made from Syrah at the Caliterra Winery. Alcoholic fermentation was performed at a controlled temperature of 21–25 °C, and once completed, the wines were racked off and stored in the tanks for 5 days to permit the sedimentation of gross lees and then were racked off again. Then, 600 L of each type of fermented wine were transported to the pilot plant of the Department of Agro-industry and Enology of Agronomical Sciences Faculty of Chile University. Once there, the wines were stored in tanks until malolactic fermentation (MLF) was complete because MLF began spontaneously in the winery. Then, the sulphur dioxide content was adjusted to reach 35 ppm of free SO_2, and both type of wines were distributed in different 25-L food-grade plastic tanks and stored for 5 days to favour the sedimentation of fine lees, which were collected for use in the treatments performed with lees, as described by Del Barrio-Galán et al. (2011). Different treatments were performed in triplicate and lasted 4 months: control wines (the wines obtained after alcoholic and malolactic fermentation without any treatment) (C); wines aged on lees (fine lees collected (3% *v*/*v*)) (L), wines aged on lees (fine lees collected (3% *v*/*v*) and French (*Quercus petraea*) oak wood chips (3 g L^{-1} medium toasted degree of Noble Sweet, l'oenologie du bois (Laffort, France)) (L + CH), where the lengths of the chips were between 7 and 20 mm and produced a sweetness sensation according to the supplier specifications; and wines with commercial inactive dry yeast added (30 g hL^{-1} of OPTILEES (Lallemand-South America)) (CIDY) that can release high amounts of low-molecular-weight polysaccharides, mainly mannoproteins (according to the supplier specifications) and supplied by Lallemand-South America. All wines were resuspended and homogenised with the lees, chips and commercial inactive dry yeast through two batonnages per week during the first two months. Then, only one batonnage per week during the last two months was performed with the objective of preventing wine oxidation and microbiological alteration.

2.2. Chemical reagents

Methylcellulose (1500 cP viscosity at 20 g L^{-1}), acetaldehyde and standards of gallic, protocatechuic, caffeic, syringic, *p*-coumaric, ferulic, ellagic and caftaric acids, tyrosol, tryptophol, quercetin, myricetin, astilbin, (+)-catechin and (−)-epicatechin, malvidin-3-glucoside, dextrans and pectins were purchased from Sigma–Aldrich Chemical Co. (St. Louis, MO). Polyethylene membranes of 0.45 and 0.22 μm pore sizes were acquired from EMD Millipore (Billerica, MA). Sodium sulphate (anhydrous), potassium metabisulfite, vanillin (99%), ethyl acetate, diethyl ether, sodium hydroxide, acetic acid, formic acid, sulphuric acid, ethanol, hydrochloric acid and HPLC-grade acetonitrile, methanol and ammonium formate were purchased from Merck (Darmstadt, Germany). All the reagents were of analytical grade or higher.

2.3. Analyses of enological parameters

The total (TA) and volatile (VA) acidity, pH (Mettler Toledo Sevencompac pH/ion S220, Santiago, Chile), SO_2F (sulphur dioxide