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Biological aging of sherry wines under periodic and controlled microaerations with *Saccharomyces cerevisiae* var. *capensis*: Effect on odorant series

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Abstract

Wine aged for 2 years in cellar conditions and a batch of non aged wine were subjected to biological aging with *S. cerevisiae* var. *capensis* under controlled microaeration. Another batch of the non aged wine and 4 year aged wine in cellar conditions were used as control and named initial and final control wines, respectively. Thirty-five aroma compounds were quantified by GC–MS, and grouped in nine odorants series to compare the microaerated wines with the control wines. Fruity, balsamic, floral, herbaceous, fatty and roasty series increases their values, while solvent and phenolic diminishes by the effect of yeast metabolism. Roasty and spicy series show the higher values in wines previously aged in cellar conditions for 2 and 4 years probably due to the contact of the wine with the wood. The roasty series is dependent of compounds such as 2,3-butanedione, 2,3-pentanodione, 4-ethylguaiacol and some lactones, whereas the spicy series is only dependent on 4-ethylguaiacol. The similarity obtained for some odorant series in wines aged under controlled conditions and wines aged for 4 years in cellar, suggest that the biological aging time can be shortened using a first step for wine aging in stainless-steel under controlled and periodic microaerations and a second step in an oak cask under cellar conditions.

Keywords: Aroma compounds; Odorant series; Biological aging; Microaeration; Sherry wine; *Saccharomyces cerevisiae* (*capensis*)

1. Introduction

Sherry wines are traditionally obtained in winegrowing areas of southern Spain, although the production of different sherry type wines have been extended to other countries with similar climatic characteristics, such as California, in USA, Italy, South Africa, and Australia. The original and distinctive stage in the winemaking of these wines, in relation to other white wines, is the biological aging process, conducted during several years in vast maturation cellars. Industrial biological aging is carried out in 600 l American oak casks, which are replenished partially to 5/6 of their capacity, and staked some on other forming scales, each one containing wine with a different degree of aging. The process involves the development and maintenance of a "flor" yeast biofilm on the wine surface, at least during 4 years, as a previous step to obtain a high quality wine.

The metabolism of some wine components such as glycerol, ethanol, and amino acids by flor yeast, the concentration in dissolved oxygen of wine, and the relative abundance of some flor yeast species, affect the biofilm development (Berlanga, Atanasio, Mauricio, & Ortega, 2001; Bravo, 1995; Martínez, Pérez, & Benítez, 1997; Mauricio, Moreno, & Ortega, 1997). The partial depletion of nutrients due to yeast metabolism should be corrected by means of blending operations (rocios) carried out by mixing the wines of different degrees of aging, and it is the principle of scales, so called "criaderas" and "soleras" system, which ensure the homogeneity of the final wine (solera), decreasing the influence of annual vintages on wine composition (Berlanga, Peinado, Millán, Mauricio, & Ortega, 2004).

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The immobilization of wines over long times, and the analyses and operations for the maintenance and development of yeast biofilms increase the estimated cost for the elaboration of sherry wines substantially. For these reasons, several authors have assayed different systems to shorten the biological aging time. Thus, Saavedra and Garrido (1961) increased the surface-to-volume ratio of wines by using $1.5 \times 0.75 \times 0.3$ m stainless steel trays; this procedure, however, entails individual processing of each tray and produces large amounts of biomass, detracting from wine quality. Rankine (1955) suggested the use of packed yeasts in oak chips; Ough and Amerine (1972) use a stainless steel tank provided with stirrers for aeration of wine in submerged culture of yeasts. The system proposed by Rankine (1997) and Ough (1992) is based on the aeration of wine dropping it on the interior surface of the tank, using a pump. Another system for shortening the biological aging was developed in our laboratory (Cortés, Moreno, Zea, Moyano, & Medina, 1999), consisting basically of periodic and short microaerations carried out after the film formation on the wine-surface using an aeration chamber which allows maintenance of the flor velum contrary to other aeration systems.

The aroma of wine is the result of the contribution of some hundreds of volatile compounds and it is an important factor to consider in their sensorial quality. The odor of one volatile compound is described in terms of one or several descriptors agreed upon by experts (Etievant, 1991; Ferreira, Aznar, López, & Cacho, 2001; Guth, 1997; López, Ferreira, Hernández, & Cacho, 1999). In addition, several authors have used odorant series to describe the aroma of wine (Torres, 1987; Brugirard, Fanet, Seguin, & Torres, 1991). Grouping the volatile compounds with a similar descriptor in odorant series, an odorant profile can be established for each wine and the contribution of each compound to each series could be determined. This procedure allows to relate the quantitative information obtained by chemical analysis with the sensorial perceptions, with a view to obtaining an odorant profile for the wine, which is simpler and based on more objective criteria than existing alternatives (Peinado, Moreno, Bueno, Moreno, & Mauricio, 2004; Peinado, Mauricio, & Moreno, 2006).

The aim of the present work is to study the effect of controlled and periodic microaeration in wine aged for 2 years in cellar conditions and a batch of the young wine (non aged) inoculated with *Saccharomyces cerevisiae* var. *capensis*. Resulting wines have been compared by means of the odorant series with 4 year aged wine in cellar conditions and another batch of the young wine used as controls to study a possible reduction of the biological aging time.

2. Materials and methods

2.1. Yeast strain and inocula

Pure culture of *Saccharomyces cerevisiae* var. *capensis* G1 (ATCC MYA-2451), a flor yeast, was used in this study. Cells were cultured on YM medium (0.3% yeast extract, 0.3% malt extract and 0.5% peptone, pH 6.5) containing 1% glucose as carbon source, and incubated at 27 ± 2 °C under shaking for 48 h. Yeast cells were collected by centrifugation at 3500*g*. The pellet was resuspended in a small volume of each sterilized wine type and used to inoculate the wines with a population of 10^6 living cells ml^{-1}.

2.2. Wines

Wines from Pedro Ximénez grape variety grown in the Montilla–Moriles region (Córdoba, southern Spain) with different aging time were used. One was young wine (unaged); the other two were wines previously aged for about 2 and 4 years, respectively, using a ''criaderas and solera'' system. The wine aged for 4 years was collected from the barrel row called the ''solera'', which contained the oldest wine (viz. commercial sherry wine to be bottled shortly). Wines aged for less than 4 years cannot be bottled for this wine type; for this reason it was used as reference. The wine aged for 2 years was obtained from the row called the ''second criadera'' in an system consisting of 4 rows (3 criaderas and 1 solera). Wines were sterilized by passage through Supra EK filters (Seitz, Germany).

2.3. Culture and experimental conditions

All tests were conducted in 10 l stainless steel vessels containing 8.7 l of sterilized wine (the surface-to-volume ratio was thus 39.3 $cm^2 l^{-1}$) that were thermostated at 20 ± 1 °C. A batch of young wine and 4 years aged wine were used as initial and final control, respectively. The 2 years aged wine and another batch of young wine were subjected to biological aging under controlled microaeration. Samples were collected from the initial wine (prior to inoculation), once the whole surface was covered with a flor velum, and also after 14, 28, 42, 56 and 70 days. After each sample was collected, the wine was subjected to a short microaeration in a 1 l sterilized aeration chamber into which air was introduced through a sterilized filter of 0.45 μm pore size. The wine was transferred from the bottom of the vessel to the aeration chamber on top through Teflon tubing with the aid of a peristaltic pump. The wine was recirculated through the aeration chamber until a 4 mg l^{-1} concentration of dissolved oxygen was reached. Under these conditions, the flor velum remained intact because the wine was returned to the bottom of the vessel via a submerged tube. All tests were performed in triplicate.

2.4. Wine sample selection

Expert tasters of the collaborative cellar were asked to choose one sample of each wine among the wine samples collected during the experiments of controlled biological aging, according to the quality standard of the cellar. Only the wine samples selected were subjected to aroma compounds analysis by GC–MS.