METHODS FOR PRODUCING LOW-ALCOHOL WINE I. VITICULTURAL AND PRE-FERMENTATION STRATEGIES

METODE DE PRODUCERE A VINURILOR CU GRAD ALCOOLIC SCĂZUT. I. STRATEGII VITICOLE ŞI PRE-FERMENTATIVE

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Abstract. *Wine is defined as a food product obtained exclusively by fermentation of grapes or grape must, with an alcoholic strength of minimum 8.5% (v/v). Climate change, advanced viticultural practices, improved plant material and modern vinification techniques lead to elevated sugar levels in grapes and furthermore to an increase in alcohol content of wine. Although wine showed notable health benefits, due to higher ethanol content obtained in recent years wine consumption is more often restricted. In this context, the aim of this work was to present the currently known technological possibilities for the production of low-alcohol wines, with an emphasis on viticultural and pre-fermentation strategies to reduce sugar concentrations in grapes and must.*

Key words: alcohol content, glucose oxidase, grape sugars, reverse osmosis, technological maturity.

Rezumat. *Vinul este definit ca produsul alimentar obținut prin fermentarea strugurilor sau a mustului de struguri, cu o concentrație alcoolică dobândită de minim 8,5% (v/v). Modificările climatice, utilizarea de material biologic ameliorat, alături de dezvoltarea tehnologiilor viti-vinicole, au condus treptat la o creştere semnificativă a nivelului de zahăr în struguri şi, implicit, la creşterea concentrației alcoolice a vinurilor obținute. Deşi vinul prezintă beneficii importante pentru sănătate, datorită conținutului ridicat de etanol, consumul acestuia este deseori restricționat. In acest context, scopul prezentei lucrări a fost expunerea posibilităților tehnologice actuale de producere a vinurilor cu grad alcoolic scăzut, respectiv a unor strategii viticole şi practici pre-fermentative de reducere a concentrațiilor de zaharuri din struguri şi must.*

Cuvinte cheie: concentrație alcoolică, glucozoxidaza, maturitate tehnologică, osmoză inversă, zaharuri din struguri.

INTRODUCTION

Although current legislation defines wine as a food product obtained exclusively by the alcoholic fermentation of fresh grapes or grape must, with a

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minimum ethanol content of 8.5% (v/v), actually, the alcoholic concentration of the worldwide wines is always much higher. Throughout time the alcoholic concentration of wines has increased progressively, a trend that was initially attributed to climate changes (a gradual increase in average air and soil temperatures) and afterwards to new developed viticultural practices, improved plant material and modern vinification techniques, that lead to obtaining elevated sugar levels in grapes and furthermore to an increase in alcohol content of wine.

Besides its negative psychological and physiological effects on human health, ethanol is indispensable for the aging, stability and organoleptic properties of wine (Ozturk and Anli, 2014). Considering all these aspects, the production of wines with low or reduced ethanol concentration has become a great challenge for wine producers, that has gained considerable attention over the past 10 years. Consumer demand is apparent for wines with lower ethanol levels, perceived as healthier. Wines with a reduced alcohol content can be classified as dealcoholised or no-alcohol (< 0.5% v/v), low-alcohol (0.5 - 1.2 % v/v) or reduced-alcohol (1.2 to 6.5 % v/v), but this classification system may vary between countries.

Viticultural strategies for limiting sugar accumulation in grape berries include “short term” changes (reducing leaf area and leaf removal, summer pruning, defoliation, aplication of growth regulators, managing harvest dates or modification of irrigation regime) and “long term” changes in vineyard (selection of root stock, grape varieties and vineyard site, soil composition). Pre-fermentation practices refer to dilution and blending of grape must with elevated sugar concentration with must from early harvests (low-sugar grapes) or the treatment of grape must to remove sugars (membrane processes and enzyme addition). These aspects will be briefly presented in this paper, focusing on the details that are of interest to technologists, oenologists and field researchers.

MATERIAL AND METHOD

In order to present relevant and recent data regarding production of low-alcohol wine (LAW), these approaches summarizes international literature data on viticultural strategies and pre-fermentation practices for producing LAW, to a better understanding of the concept and its easier implementation by winemakers.

RESULTS AND DISCUSSIONS

a. Viticultural strategies

1. Leaf area reduction

Leaf area to fruit mass ratio is a viticultural index for producing high-quality grapes and wine. According to Stoll *et al.* (2010) the rate of sugar accumulation in grapes is largely influenced by this ratio. A value between 0.8 and 1.2 m^2/kg allows grapes to achieve good ripeness. Leaf area reduction can be achieved through severe trimming or leaf removal treatments, performed at different stages of berry growth, thereby influencing the sugar content in must. Martinez de Toda *et al*. (2013) conducted a severe shoot trimming over a threeyear period. Véraison was delayed by about 20 days, while soluble solids were reduced by 12 to 15% (alcohol reduction of 2% v/v). Also, the pH, anthocyanin content and grape size and yield were reduced by about 10%. Until a leaf area to fruit ratio index below 0.50 m^2/kg was no negative impact on grapevine development in the next year. Increasing leaf removal up to 50% in Sangiovese cultivar grapes resulted in a soluble solids reduction, but with negative effect on yield in the following season (Palliotti *et al*., 2013).

2. Application of growth regulators

Application of exogenous growth regulators (e.g. 1-naphthaleneacetic acid) may be a useful tool for delaying sugar accumulation in grapes (Varela *et al*., 2013). Post veraison anti-transpirant treatments, with conifer resins like pinolene, induced a significant reduction of sugar concentration, regardless of the cultivar and the vine productivity (Palliotti *et al*., 2010). Also, application of inhibitors of natural ripening hormones were reported to delay grape ripening.

3. Optimization of harvest date

Harvest date largely determines grape must composition and therefore influences wine sensory profile. Winemakers tend to delay harvest in the search of flavour or phenolic maturity. Cabernet Sauvignon wines showed both vegetative and fruity characters, whereas vegetative attributes where dominant in wines made from earlier harvested (Bindon *et al.* 2013). Sensory quality of wines changes with different harvest dates and it is necessary that grapes to reach a certain level of maturity. Obtaining LAW from early harvest is still limited due to associated quality losses (flavour and phenolic compounds). Pickering *et al*. (2000) concluded that harvesting grapes at an early stage of development and subsequent vinification resulted in LAW with “unripe” aromas and unacceptably high acidity.

4. Water management

Modification of irrigation regime is a short-term viticultural practice that consists in increasing irrigation during the last few weeks before harvest that may cause a significant delay in grape ripening, with a small reduction in final wine alcohol content. Also, plant irrigation before harvest has been claimed to cause a significant delay in grape ripening with concomitant reduction in wine quality (Varela *et al*., 2015). However, the results were not confirmed in different years. On the other hand, different irrigation volumes showed no significant effect on wine perception and composition (Mendez-Costabel, 2007).

5. Long-term vineyard strategies

These preventive strategies are employed to regulate sugar concentration and raise grape yield based on grapevine breeding and selection of clones and require a careful consideration of climate favorability (Schmitt and Christmann, 2019). Low to moderate vigorous rootstocks may be chosen to lower the alcohol content in wines. Also, soil composition influenced grape ripening in terms of acidity and mineral content. Magnesium deficiency and an excess of nitrogen resulted in delayed ripening and lower sugar accumulation (Ozturk and Anli, 2014).

b. Pre-fermentation practices

1. Dilution and blending

Pre-fermentation practices like blending of high sugar grape must with must from early harvest (low sugar content) or dilution are often used. Wines obtained by "double harvest" (blending wines from green and mature grapes) showed significant differences on alcohol level (Martinez de Toda and Balda, 2011).

However, dilution with exogenous water is probably the oldest form of wine fraud and was formerly used for volume increase. The addition of water to reduce the sugar in must in order to reduce the alcohol content in wine is not legal in most wine-producing countries, including Romania. Anyway, beyond reducing sugar concentration, water addition may have as opposite effects lowering must acidity and negatively affecting appearance and taste of the future wine (colour, tannins, flavour compounds) (Schmitt and Christmann, 2019).

2. Enzyme addition

One of the most promising techniques for lowering sugar in the must is the oxidation of glucose by the enzyme glucose oxidase (GOX) (EC 1.1.3.4). The enzyme obtained from the fungus *Aspergillus niger* converts glucose into gluconic acid and hydrogen peroxide (Varela *et al.* 2015). Grape must contains approximately equal amounts of glucose and fructose, therefore, the theoretical maximal reduction on alcohol production can be 50%. In practice, alcohol reductions range from 4 to 40% (Petkova *et al.*, 2016). Pickering *et al.* (1999) reported that the alcoholic fermentation of GOX-treated grape musts proceeded normally and was obtained a 36 to 40% reduction in alcohol. Large amounts of gluconic acid are formed during treatment with GOX and that are present in the finished wine since it cannot be metabolized by yeasts. At bottling the pH of GOX wines are very similar to those of control wines, although titratable acidity remains significantly higher (Pickering *et al.*, 1999). The effectiveness of GOX largely depends on whether it is used as a sole or in combination with catalase (conversion of 1.32% of glucose and 49.25% respectively) (Petkova *et al.*, 2016). Also, GOX can be inhibited by SO_2 in wine (Pickering *et al.*, 1999).

3. Membrane processes

Membrane technologies applied before fermentation have as purpose the reduction of grape must sugar. *Nanofiltration*, described as a technique between *ultrafiltration* and *reverse osmosis* have been used to concentrate and remove sugar from grape must after 1980. Nanofiltration usually retains molecules such as sugars and organic acids (pore size 1–10 nm, pressure up to 40 bar) (Schmitt and Christmann, 2019). To reduce the sugar content in the must the permeate of an ultrafiltration process containing water, acid and sugars is separated and concentrated by nanofiltration. This aqueous solution is finally blended back to the retentate of the ultrafiltration.

In principle, *reverse osmosis* is a filtration method that removes water from unfermented grape must (semi-permeable polymer membrane; pore size 0.1 - 1 nm), used since 1970. Water molecules are the smallest components of the grape must and can pass from the high concentration solution across the membrane to the lower concentration solution. A transmembranar pressure of up to 90 atm removes water from the must through the membrane pores (permeate), while the aroma, sugar and tannin molecules are not filtered (retentate). Low alcohol beverages result from the blending in different proportions of the two phases resulting from the osmosis process and subsequent fermentation. Usually, the analyzed variables are: transmembrane pressure (40 - 60 bar), temperature of the process (20 - 40°C), changes in the must pH, soluble solids, acidity, minerals, phenolic compounds and anthocyanins, colour index and colour density. None of the experiments reported a significant changes in the must characteristics. Gurak *et al.* (2010) indicated that the best process conditions was 60 bar pressure and 40°C, resulting in high permeate flux values. These procedures can be followed by *osmotic* membrane *distillation*, that is a low-temperature method used for grape must concentration by water evaporation, using a porous hydrophobic membrane. Compared to other treatments for alcohol reduction, the sugar reduction involve relatively high volume losses. The reduction of 17 g/L sugars, which corresponds to approximately 1% (v/v) less alcohol, means a volume loss of 7% from the initial volume (Schmitt and Christmann, 2019).

4. Other approaches

Lang and Casimir (1986) developed a method which involves separation of juice into a high-sugar and a low-sugar fraction by freezing, to form a slush. The slush is then filtered using an extractor. Volatile components from the juice of the high-sugar fraction are taken over using a spinning cone fractional distillation column and added to the low-sugar fraction, which is subsequently fermented.

CONCLUSIONS

1. Viticultural strategies are preventative interventions for moderating the concentration of fermentable carbohydrates in wine grapes, imbalancing carbohydrate accumulation and maintaining the development of sensorially grape constituents, resulting in wines with less alcohol concentration. These strategies may allow a good must composition, but they can cause excessively delayed ripening or excessive grape exposure, obtaining beverages of inferior quality.

2. Pre-fermentation practices can be successfully applied by small wineries, the sensory perception of the obtained wine varying widely depending on the process involved. Treatments of grape must to remove sugars (reverse osmosis or the addition of glucose oxidase) are efficient technologies that allow grapes to reach full maturity, with higher chances to obtain quality low alcohol wines. Further studies are still necessary in order to compare or combine these practices.

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