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Assessment of alternative sweetening methods for dealcoholized wine

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Résumé. In recent years, there has been a growing demand for non-alcoholic wines with an ethanol content of less than 0.5% by volume, leading to the active use of various dealcoholization technologies. These technologies include membrane processes and distillation, which affect the sensory characteristics of wine, such as aroma, taste, acidity, and sweetness. Complete removal of ethanol alters the balance of the wine by increasing acidity and reducing the perception of sweetness. To compensate for these changes, alternative sweeteners, particularly cryoconcentrates, are used to enhance the organoleptic properties of the wine. Experimental data confirm that the addition of cryoconcentrates improves the balance and flavor characteristics of dealcoholized wines while preserving their fruity and floral aromatic components. Studies show that vacuum distillation provides better final product quality compared to osmotic distillation. The use of cryoconcentrates demonstrates potential for improving the sensory properties of non-alcoholic wines, contributing to their harmonization and fullness of taste.

1. Introduction

In recent years, there has been a growing demand for non-alcoholic wines with an ethanol content of less than 0.5% ABV. Considering that alcohol reduction through physical methods is legal in many countries worldwide, and various technologies have practical applications in this field, the dealcoholization process can be carried out through several physical processes, based either on membrane technology or distillation processes [1]. These processes significantly differ in their impact on the quality of the final product, particularly on its sensory characteristics and nutritional value.

Complete or near-complete removal of ethanol substantially alters the sensory characteristics of wine, as ethanol affects the perception of sweetness, body, and aroma intensity. Its removal often leads to increased acidity and decreased sweetness perception, impacting the overall balance of the wine. Various approaches, such as the addition of cryoconcentrates or other sweeteners, have been explored to compensate for these changes.

With the growing interest in wines with higher sugar content, research has focused on finding alternative methods of sweetening non-alcoholic wines. Sensory experiments demonstrate the varying effects of different sweeteners on the aroma and taste of dealcoholized wines. One of the latest methods involves the use of cryoconcentrates, which are concentrated grape juices obtained through freezing and water removal by sublimation. Cryoconcentrates can regulate acidity and improve the nutritional value of wines [2]. They offer a natural source of sweetness and beneficial compounds such as antioxidants and vitamins, which can enhance both the sensory properties and the health benefits of non-alcoholic wines.

2. Materials and Methods

For the study, 50 liters of processed table varietal dry white wine made from the Citronny Magaracha white grape variety (a Ukrainian breed grown in the Zaporizhzhia region, Ukraine) were used, along with a cryoconcentrate for sweetening.

To dealcoholize 18 liters of wine, a vacuum distillation unit Hei-VAP Industrial Rotary Evaporators (Heidolph Instruments GmbH & Co. KG; Walpersdorfer STR.12, D-91126, Schwabach, Germany) was used. The unit was equipped with a Hei-Vac Valve Industrial vacuum pump, a touchscreen control panel displaying all process parameters, programmable modes, a lift condenser, a Hei-Chill 3000 cooling system, a 20-liter evaporating flask, and two 10-liter receiving flasks. The wine was divided into three batches for distillation. The flask rotation speed was set to 60 rpm, the water bath temperature to 40°C, the vacuum pressure to 50 mbar, and the condensation temperature was maintained at 1.8°C throughout all dealcoholization experiments. Each dealcoholization process was completed two hours after reaching the set temperature and pressure. This process resulted in the production of 12 liters of dealcoholized wine with 0.18% alcohol by volume and 5.5 liters of alcohol with 43.49% alcohol by volume. The alcohol was then redistilled under the same conditions as the previous distillations, but with a water bath temperature of 50°C. This yielded 1 liter of water with 0.20% alcohol by volume and 4 liters of alcohol with 59.75% alcohol by volume. These were mixed with the dealcoholized wine, resulting in 13 liters of dealcoholized wine.

Osmotic distillation was carried out using a WineBrane Lab Gas/Alc unit (Inoxpa Deutschland, C/Telers 60, 17820, Banyoles, Spain) equipped with a Liqui-Cel® 2.5x8 membrane contactor (3M Deutschland GmbH, Ohder STR.28, 42289, Wuppertal, Germany). The membrane was always stored and cleaned according to the manufacturer's instructions. The feed solution, the wine, was pumped by a a peristaltic pump (Verder Deutschland GmbH & Co. KG, Retsch-Allee 1-5, 42781, Haan, Germany) with a capacity of 300 l/h, while the strip solution, distilled water, was supplied by Flojet membrane pump (Flojet Corporation, Icon 20, 92610, Foothill Ranch, USA) with a capacity of 83 l/h. The temperature of both liquids during the experiments was 20°C. The experiment required 23 liters of wine and two batches of 100 liters of distilled water each. Due to the long processing time (2 days), a turbidity issue caused by microbiological contamination arose. To avoid possible machine blockage, it was decided to complete the final 2.21% alcohol by volume removal using vacuum distillation (as described above). 19 liters of wine were divided into four batches, resulting in 4.3 liters of dealcoholized wine (0.12% alcohol by volume) per batch. Distillation was repeated to further concentrate the alcohol, yielding 0.6 liters of water with 0.15% alcohol by volume and 1.2 liters of alcohol with 33.20% alcohol by volume from 1.8 liters of alcohol. These products were mixed with the dealcoholized wine, resulting in 17.8 liters of dealcoholized wine.

Both types of dealcoholized products were supplemented with a liquid form of SO2 to achieve a free SO2 concentration of 30 mg/l. To stabilize the dealcoholized wines, they were bottled using a Getrankedurchlauferhitzer 03-0318 liquid instant heater (Schankanlagen Koch GmbH, Dagstuhler STR.62, 66687, Wadern-Morscholz, Germany), raising the temperature to 62°C. The wine was bottled in 750 ml brown glass bottles, sealed with a screw cap, and stored in a warehouse at a temperature of 12-15°C for further analysis.

Tastings were conducted in a specially equipped room with individual booths and air conditioning at 20°C. The tasting was carried out by two independent tasting panels.

For the wine tasting, a standard tasting glass made of thin, clean, transparent glass with a capacity of 210-220 cm³ was used, allowing for 60-70 cm³ of wine to be evaluated comprehensively for all elements of quality.

Wine with alcohol and dealcoholized wine were evaluated according to the Standards of the International Organisation of Vine and Wine (Resolution OIV/Competition ECO 332A/200). The maximum tasting score for the experimental samples was 100 points, determined as the sum of the points for each indicator: appearance (clarity, color) – 14; aroma (authenticity, intensity, aroma quality) – 30; taste (authenticity, intensity, harmonious persistence, taste quality) – 44; harmony (overall impression) – 11.

To create aromatic profiles of the experimental samples, a descriptive method using a 10-point scale was applied for the following descriptors: citrus, fruity, muscat, floral, sweetness, acidity, bitterness, body/fullness, intensity, astringency.

Graphical representations of the experimental data were performed using Microsoft Excel 2010.

Comparing the profiles of the experimental samples allowed for identifying their differences and drawing conclusions about changes in wine quality during dealcoholization.

3. Results and discussion

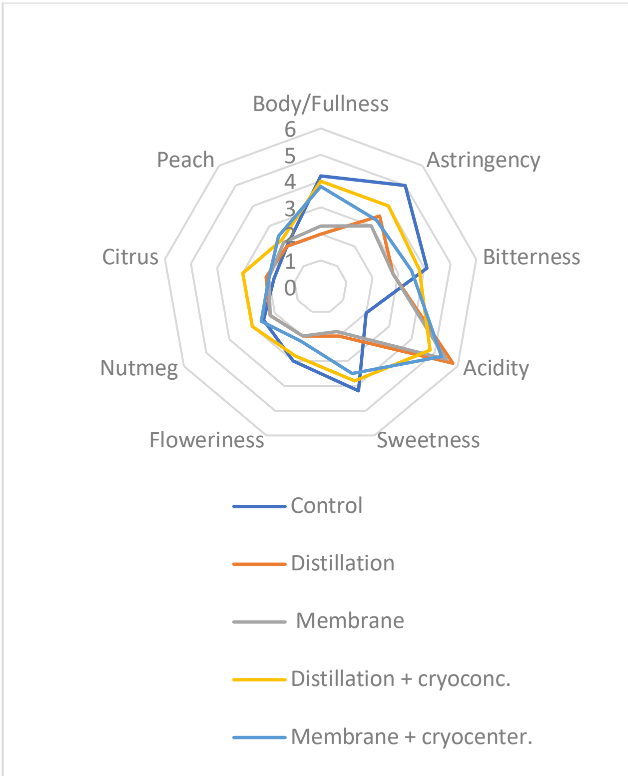

Figure 1. Profilogram comparing alcohol-free wine with the addition of cryoconcentrate.

The results of the sensory analysis of the experimental samples revealed interesting observations regarding the impact of dealcoholization on the sensory characteristics of the wine. Despite the use of two different dealcoholization methods, the perception of peach aroma in the wines remained virtually unchanged (Fig. 1). This may be due to the simultaneous effects of the loss of volatile aromatic compounds and the enhanced perception of other aromas due to the reduction in ethanol levels [3].

The citrus tone was more pronounced in the sample treated with vacuum distillation and the addition of cryoconcentrate, which may indicate a certain influence of this sweetener on the aromatic characteristics of the wine. The nutmeg tone was rated almost equally in both dealcoholized wines, although the control, untreated wine still received higher scores.

The perception of floral aromas was most pronounced in the control sample; however, the version treated with vacuum distillation and cryoconcentrate also demonstrated similar characteristics with light honey notes.

It is important to note that dealcoholization significantly affected the perception of sweetness. The addition of cryoconcentrate proved effective in improving this attribute, explaining the popularity of semi-dry and semi-sweet dealcoholized wines [4]. At the same time, the increased perception of acidity in dealcoholized wines was expected due to the impact of reduced ethanol levels [5], but the addition of cryoconcentrate helped balance this effect while improving the taste characteristics. It can be concluded that the sugar scale should be revised from the point of view of de-alcoholized wine. Since 100 g/l of alcohol has a sweetness level of about 20 g/l, perhaps the addition of sweetener should be on a smaller scale, as in the sparkling wine industry. Sparkling wine is labeled dry up to 32 g/l. This can help consumers better judge the perceived sweetness of a product by reading the label.

Bitterness and astringency also underwent changes. The initial wine had a significantly higher level of bitterness, consistent with the impact of ethanol on this parameter [6]. Astringency, while most pronounced in the control sample, was also higher in the treated wines, with the greatest astringency observed in the wine treated with the vacuum distillation method. This could be connected with the concentration of the wine due to alcohol removal.

The body and fullness of the wine are also closely related to alcohol content, and therefore were significantly lower in the dealcoholized samples. However, the addition of cryoconcentrate helped partially compensate for this deficiency. The same applies to the aftertaste, which was more pronounced in the control sample but improved with the use of cryoconcentrate.

Overall, the study results confirm that dealcoholization significantly affects the sensory characteristics of wine, particularly its taste parameters. Although the differences between the two treatment methods were minor, the use of cryoconcentrate demonstrated its potential to enhance the sensory properties of dealcoholized wines, as shown in the results in Figure 1.

4. Conclusions

The results of the comparative analysis show that vacuum distillation yields better outcomes in preserving the sensory properties of wine compared to osmotic distillation. The sweetening effect of cryoconcentrate is particularly notable, as it positively influences the wine's balance, aroma, and taste qualities. Further research should focus on optimizing the use of various technologies to improve the quality of non-alcoholic wines, particularly in combination with cryoconcentrates to achieve an optimal sensory profile.

5. References

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