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A technological approach for producing liqueur red wine

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Abstract

Liqueur wine or fortified wine is defined as a special wine with a total alcoholic strength of not less than 15% alcohol by volume (ABV) or more than 22% ABV. and a residual sugar content between 50 and 120 g/L. These wines are produced in a wide range of styles with varying sugar content, from extra dry to sweet. This study presents practical aspects for obtaining a liqueur red wine from Merlot grapes by stopping the alcoholic fermentation due to the addition of food ethanol. Thus, Merlot red wine, partially fermented, with an alcoholic degree of 13.5% ABV, total acidity 2.5 g/L H_2SO_4 and residual sugar 27 g/L was stopped alcoholic fermentation by the addition of ethanol. Next, sugar was added and a liqueur wine was obtained with 22% ABV, total dry extract of 81 g/L, reducing sugar content of 55 g/L and total acidity of 3.0 g/L H_2SO_4. The wine fortification by food-grade ethanol addition, was performed under careful monitoring of residual sugar to assess the amount of sugar that needs to be added to supplement the existing one. This process significantly changes the quality profile of the wine, ensuring stability and longevity by preventing oxidation. The fortification allows the expansion of the styles of liqueur wines obtained from local basic wines in order to adapt to the demands of the contemporary consumer.

Key words: liqueur wine, fortified sweet wine, stopping fermentation by adding alcohol

1. Introduction

Fortified wines are currently produced all over the world, being considered specialty products in the wine industry. These wines stand out for their exceptional quality, as a result of specific production processes having a significant economic impact in the wine sector [1, 2]. Given their popularity, the main types of fortified wines known are Madeira, Sherry, Port and Marsala [3, 4].

Although fortified wines have traditionally originated in Europe, their preparation is currently expanding worldwide [1]. Under EU Regulation 479/2008 [5], these types of wine can be manufactured using both partially fermented or fully fermented grape must as well as unfermented grape must. These wines have in common a high alcohol content, in the range of 15 - 22% alcohol by volume (ABV) due to the addition of distilled spirits, usually neutral alcohol of vitivinicultural origin during the winemaking process, after they have been fermented or partially fermented, making it possible to produce a wide range of styles [5-8]. Thus, fortified wines contain additional wine-derived alcohol that has been added to the base wine during alcoholic fermentation, when a part of the initial sugar content of the must has been metabolized by the yeasts into alcohol [9, 10].

Fortified wines are obtained from a base wine with at least 12% alcohol [11]. There are typically two methods of making liqueur wines, as follows: either by adding alcohol to the must before the alcoholic fermentation process begins, or by stopping fermentation

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process as a result of the addition of alcohol, resulting in a mutated [9, 12]. By adding alcohol, the yeast becomes inactive, the fermentation process is interrupted, so the drink is left with more sugar. In this way the sugar content of fortified wines can be controlled. To create a more dry fortified wine, alcohol should be added as close as possible to the end of the fermentation process [10]. The factor that determines whether fortified wine is sweet or dry is the timing when the alcohol is added during fermentation [1, 10]. To obtain a sweeter fortified wine, alcohol is added at the beginning of fermentation, so that the yeast no longer converts the sugar into alcohol and it remains in the wine as residual sugar. On the contrary, to get a dry fortified wine, the whole fermentation process has to be completed, so the sugar is consumed and then the alcohol is added to the wine [1, 10].

Fortified red wines were distinguished by their remarkable antioxidant activity and high levels of bioactive compounds, in particular belonging to the class of phenolic compounds [13, 14]. In addition, fortified wines have a wide range of volatile compounds, depending on the specific wine and the techniques used in the winemaking process, which significantly contribute to their overall profile [15, 16].

The design of fortified wines, with a specific profile, represents a continuous concern in accordance with the preferences of modern consumers. In this context, the purpose of this study is an attempt to obtain a liqueur red wine from Merlot base wine and to evaluate its main quality indices.

2. Material and methods

2.1 Liqueur wine preparation

Obtaining the liqueur wine involved the folowing steps: the preparation of the base wine from Merlot grape variety; stopping the alcoholic fermentation by adding food grade ethanol, resulting in a mutated wine; addition of sugar to obtain the a specific sugar content. Fortification with ethanol before completion of fermentation was carried out under careful residual sugar monitoring to assess the amount of sugar to be added to top up the existing sugar.

In the preparation of liqueur red wine the calculation of the required materials was carried out, taking into account the manufacturing recipe, on the basis of the equations of total material balance and partial material balance in the main components: alcohol and sugar. Thus, the technological mixture for the production of liqueur wine consisted of Merlot red wine (Minis-Maderat vineyard, Arad County, vintage 2023), food grade ethanol 96% ABV and sugar. Finally the acidity of the obtained wine was corrected by adding citric acid.

2.2 Wine analysis

The main quality indices of both base wine and liqueur wine, such as alcoholic strength, total acidity, reducing sugars, total dry extract and non-reducing dry extract were determined according to the International Methods of Wine and Must Analysis [17].

Preliminary analysis of the wine was carried out to assess the behavior of fortified wine to air, heat and cold according to the method described by the OIV [18].

3. Results and Discussion

Merlot wine used as a base to obtain liqueur wine has the main quality indices shown in Table 1.

Table 1. The main characteristics of Merlot base wine

Quality indices of base wine	Values
Total acidity (g/L H_2SO_4)	2.5± 0.03
Alcoholic strength (%, ABV)	13.5 ± 0.02
Sugar (g/L)	27 ± 0.05
Total dry extract (g/L)	52.90 ± 0.08
Non-reducing dry extract (g/L)	25.29 ± 0.04

The production of liqueur wines involves the operation of stopping the alcoholic fermentation by adding food grade ethanol, resulting in a mutated wine. This step is considered one of the basic links in the chain of operations for the production of sweet fortified wines.

When the alcohol is added to wine before the fermentation process is finished, the yeasts are killed, leaving behind a residual amount of sugar. The result is a wine that is both sweet and higher in alcohol.

The calculation of the materials needed to obtain 10 L of liqueur wine starting from the Merlot base wine, on the basis of the equations of total material balance and partial material balance in alcohol and sugar, assumed the following reasoning:

The total material balance expression is shown in equation (1):

$$V + A + VS = 10 \quad (1)$$

where:
- V is the volume of Merlot base wine, L;
- A represents the volume of ethyl alcohol required to stop the alcoholic fermentation, L;
- VS represents the volume taken up by sugar, L.

Knowing that the density of sugar is 1.61 kg/L, equation (1) becomes:

$$V + A + \frac{S}{1.61} = 10 \quad (2)$$

where: S represents the mass of sugar, kg.

The expression of the partial material balance equation in sugar is described by equation (3). In this expression, it has been taken into account that the basic wine has a sugar content of 27 g/L, while for the liqueur wine a sugar content of 55 g/L is desired.

$$0.027 \times V + S = 0.055 \times 10 \quad (3)$$

The expression of the partial material balance equation in alcohol is described by equation (4).
In this expression, it was taken into account that the base wine has an alcoholic strength of 13.5% ABV, the alcohol used for fortification has a concentration of 96% ABV, and for the liqueur wine it was planned to reach an alcoholic strength of 22% ABV.

$$13.5 \times V + 96 \times A = 22 \times 10 \quad (4)$$

Solving the system formed by equations (2), (3) and (4), the base wine volume (V), alcohol volume (A) and sugar amount (S) were determined, as follows:

V = 8.744 L
A = 1.062 L
Z = 0.314 kg

Amount of citric acid required to correct the total acidity of the liqueur wine was calculated on the basis of equation (5):

$$8.744 \times 2.5 = a \times 10 \quad (5)$$

a = 2.186 g/L H_2SO_4

where:
- the total acidity of the base wine is 2.5 g/L H_2SO_4;
- the final acidity of the prepared liqueur wine is 3.0 g/L H_2SO_4;.
- a - the total acidity of the liqueur wine, before correction.

To increase the acidity of Merlot liqueur wine from 2.186 g/L H_2SO_4 to 3.0 g/L H_2SO_4, the amount of citric acid (M citric acid, g) was calculated on the basis of equation (6):

$$M\ citric\ acid = 10 \times (3.0 - 2.186) \times \frac{70}{49} \quad (6)$$

where:
- 70 g/mol is the equivalent weight of citric acid;
- 49 g/mol represents the equivalent weight of H_2SO_4;
- the volume of liqueur wine is 10 L.

M citric acid = 11.63 g

The materials necessary for the preparation of 10 L of liqueur wine from Merlot base wine were shown in Table 2.

Table 2. The materials required for 10 L of liqueur red wine

Materials	Values
Base wine Merlot (mL)	8744
Ethanol 96% ABV (mL)	1062
Sugar (g)	314
Citric acid (g)	11.63

The liqueur wine was investigated for both preliminary and chemical properties.
Preliminary analysis constisted of carefully examination the resistance of the wine to air, the behavior of the wine to cold and the behavior of the wine to warm were evaluated and the observations were noted in Table 3.
These observations allows us to form a preliminary image of its quality, the data obtained in this analysis being supplemented by those obtained through the analysis of the representative chemical indices.

Table 3. Evaluation of wine behavior to air, heat and cold

Wine sample	Air behaviour of wine	Thermal behaviour of wine	Cold behavior of wine
Liqueur wine	Air-resistant wine without opalescence. Clear with metallic sheen, bright, without distortion of odor and bouquet.	No sediment deposits on the vessel walls, no predisposition to precipitation or other undesirable physico-chemical changes. The color is maintained when the wine has been heated at temperatures between 40-60°C; no deposits or turbidity have been observed, the wine retains its clarity and crystalline appearance.	There were no deposits, turbidity or other visible defects, it retains its organoleptic qualities unalterably. After returning to room temperature no deposits are observed.

The liqueur wine obtained have the main chemical indices presented in Table 4.

Table 4. The main chemical characteristics of Merlot liqueur wine

Chemical indices	Values
Total acidity (g/L H_2SO_4)	3.0 ± 0.04
Alcoholic strength (%, ABV)	22 ± 0.03
Sugar (g/L)	55 ± 0.06
Total dry extract (g/L)	80.36 ± 0.04
Non-reducing dry extract (g/L)	25.36 ± 0.03

The alcoholic strength lies at the upper limit of the range specific to these types of wines, ensuring stability and longevity by preventing oxidation processes. In fortified wines, the high level of alcohol works as a stabilizer. The added alcohols allow the fortified wine created to resist longer in storage [2, 10]. A high level of sugar also has a preservative action. As such, a sweeter wine is expected to last much longer than one with a lower sugar content. Fortified Port and Sherry wines are among the wines with a remarkable longevity [19].

4. Conclusion

Merlot liqueur wine has been obtained by a specific fortification method, which was involved the stopping alcoholic fermentation process by food-grade alcohol addition, so that the wine kept a certain residual sugar content. Based on the technological calculations, the amount of alcohol and sugar needed to obtain an assortment of liqueur wine with predetermined quality characteristics was determined. This technological approach not only increases the alcohol content but also significantly changes the sensorial profile of the wine, and also contributes to the stability and longevity of the wine by preventing oxidation. Rigorous research is also needed in order to expand the range of liqueur wines with different sugar content, by stopping the alcoholic fermentation process at different moments of the development, with careful monitoring of the quality profile of the wine. Also, considering the popularity and economic relevance of fortified wines, it is necessary to continue research in order to improve the attributes of liqueur wine through aging.

Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human or animal subjects (if exist) respect the specific regulation and standards.

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