THE MATHEMATICAL MODELLING AND INTERDEPENDENCE OF TARTARIC STABILIZATION FACTORS IN NATURAL WINES

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Abstract: Wine quality depends on the vinification process and the geographical origin of the grapes but also highly relies on the varietal composition of the grape must. For this reason, the present work was undertaken to study the effect of the industrial stabilization process on the potassium bitartrate stability and composition of natural wines. Under laboratory conditions of production and refrigeration were tested and monitored two samples wines at each technological stage. According to achieved results was observed a decrease of color intensity, the content of tartaric acid within the limits of 23 ÷ 40 % of the initial values. Also, the complex stability of studied wines was conditioned by a number of factors: the mass concentration of potassium ions with a weight of 21.3 ÷ 24.5 %, the pH value with 12 %.

Key words: crystalline stabilization, mathematical modeling, winemaking

Introduction

Wine is an alcoholic beverage produced by the fermentation of the juice of fruits, usually grapes, although other fruits such as plum, banana, elderberry or blackcurrant may also be fermented and used to obtain products named "wine". The word "wine" is probably the most ancient fermented beverage and was mentioned in the Bible and in other documents from Asiatic peoples [1].

Wine quality is given by three production phases (grape production, winemaking and bottle conservation) but the factors that determine quality are numerous and a high quality wine is the optimum result of a large number of these factors [2].

In order to establish the interdependence of factors those determine quality was constitute the Pareto chart, a type of chart that contains both bars and where individual values are represented in descending order by bars. The aim of the Pareto chart is to highlight the most important among a (typically large) set of factors [3]. Also, the Pareto chart is one of the seven basic tools of quality control in Food Industry [4].

The present study was conducted in order to study the stabilization of white and red samples wines and to establish the interdependence of tartaric stabilization factors by the Pareto chart. This study allowed us to obtain data necessary for explaining physico-chemical phenomena, which influence stability or instability during wine stabilization treatments, related to the precipitation of tartaric salts.

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Materials and Methods

Investigations have been conducted on two young wines of *Chardonnay* and *Pinot Noir* variety and carried out at the Oenology Research Centre of Technical University of Moldova and the National Audit Centre of Alcoholic Products, Chisinau.

The wine samples submitted for studio were obtained by classic technological schemes and the physico-chemical parameters were carried out on the: alcohol content, the total acidity, the pH value, the content of tartaric acid, potassium and others (Table 1), using the presented in national [5] and international standards methods [6]. The content of cations in wines before and after the tartaric stabilization were determined by the recommended International Organization of Vine and Wine (IOVV) method, using atomic absorption spectrometry [7] and the content of organic acids by capillary electrophoresis [8]. Data obtained of physico-chemical parameters were used for the mathematical modelling and Pareto diagram creation.

After the fermentation process wine samples have been fined with bentonite in order to ensure the protein stability (adsorption of wine proteins), then tartaric stabilized by two methods: conventional cold stabilization (scheme I) and contact seeding with 5 g/l KHT (svheme II) at the temperature of minus 5°C. The conventional process for tartaric stabilization of young wines consists of cooling the wines at a temperature near the freezing point for several days to induce KHT precipitation before bottling [9]. At the end of period, the samples are visual inspected and conclude on the presence or the absence of KHT crystals. The test results, therefore, indicate the final stability of wine and it presents a risk of tartrate precipitation. The sample of wine was considered to be stable, if the tartaric crystals are missing, if not the wine is unstable and will be cold retreated.

After the stabilization by two procedures, the wine samples were filtrated at the seeding temperature to avoid resolubilization of potassium bitartrate crystals back into wine [10]. Evaluation of studied wine quality was performed by sensory analysis because, generally, chemical data are not sufficient to define this parameter. All measurements were carried out in triplicate and the results were statistically analyzed using the Statistica 6.0 program to determine the average value and standard error.

Results and discussion

The data concerning the main wine composition characteristics before and after the stabilization are presented in table 1 and figure 1. According to these data, the wine samples during the stabilization diminished the color intensity, the content of tartaric acid and total polyphenol index within the limits of 23 ÷ 40 % of the initial values. Also, the content of tartaric acid and potassium in samples has decreased in the following order: 9,87 % and 23,8 % (for whitesample) and subsequently 22,42 % and 26,4 % (for red one).

From the comparative analysis of the two procedures is revealed that the decrease of all parameters is more significant in the case of contact seeding procedure in comparison with conventional cold stabilization. The conductivity has diminished in average with 15,9 % and the total polyphenol index with 40 %.

Table 1. *Physico-chemical characteristics of the wine samples.*

№	Parameters	Wine sample					
		White wine			Red wine		
		Initially	Stabilized by chillproofing	Stabilized by contact seeding	Initially	Stabilized by chill-proofing	Stabilized by contact seeding
1.	**Alcoholic degree, % v/v**	12,62	12,48		10,25	10,18	
2.	**pH**	3,13	3,08	3,06	3,30	3,20	3,22
3.	**Total acidity, g/L $C_4H_6O_6$**	7,82	6,80	6,72	8,43	7,52	7,6
4.	**Volatile acidity, g/L CH_3COOH**	0,42	0,48		0,52	0,54	
5.	**Content of tartaric acid, g/L**	2,62	1,62	1,58	2,07	1,48	1,46
6.	**Content of potassium, mg/L**	920	713	682	1070	894	821
7.	**Color intensity, $A_{420\ nm}$**	0,092	0,048	0,042	1,483	1,345	1,121
8.	**Total polyphenol index, mg/L**	148,76	86,31	82,54	1498,11	1076,47	1002,63
9.	**Conductivity at 20°C, µS/cm**	1988	1670	1620	2066	1702	1684
10.	**Sensory analysis, points**	7,7	7,8		7,9	8,0	8,0

In terms of organoleptic analysis, the treatment of young wines enhances the aroma expression, the flavor persistence and specific color for this type of wine.

The technique of refrigeration microbiologically purifies the new wines, stabilizing the color and the flavor, particularly red wines bottled young.

In order to validate the interdependence of tartaric stabilization factors in wine samples the Pareto diagram was constructed. That establishes the major influence of the concentration of potassium ions and tartaric acid, the pH on the resulting parameter - the tartaric stabilization as described in Figure 2.

The percentage share of the selected factors was different in wine samples, so the content of potassium ions was maximally controlled by 24.36 % and a minimum of 3.65 % for the alcoholic degree in white one. In red wine the influence of temperature increased by 2.34% and decreased by 3.0% for content of potassium compared to the white sample.

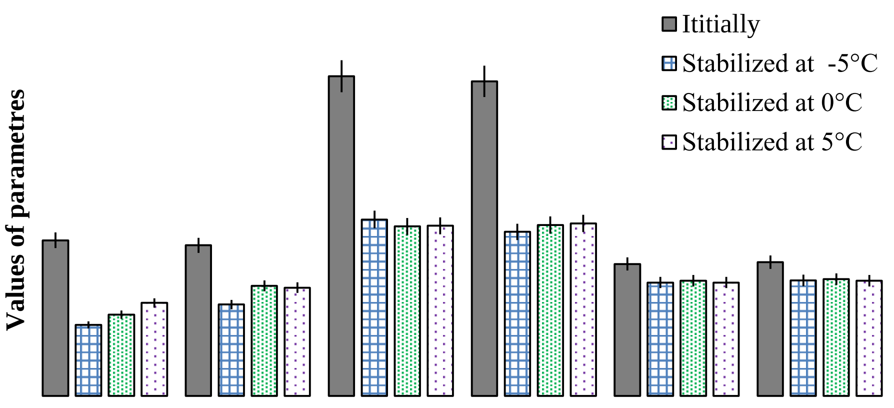
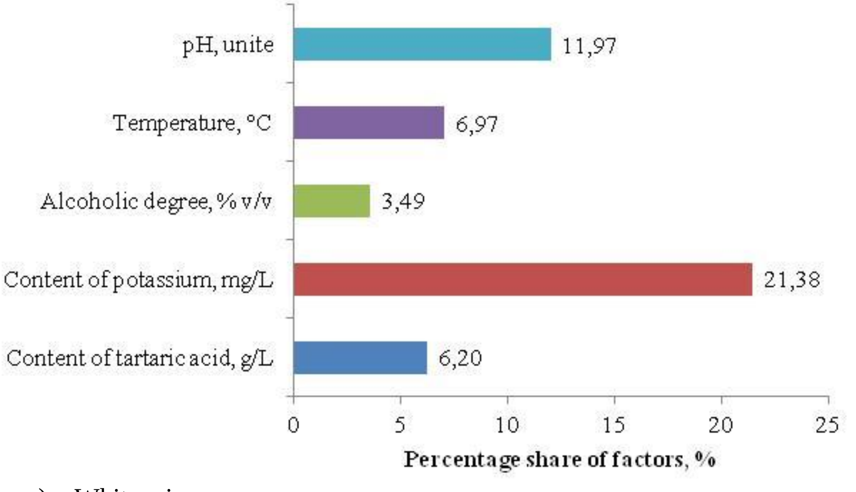
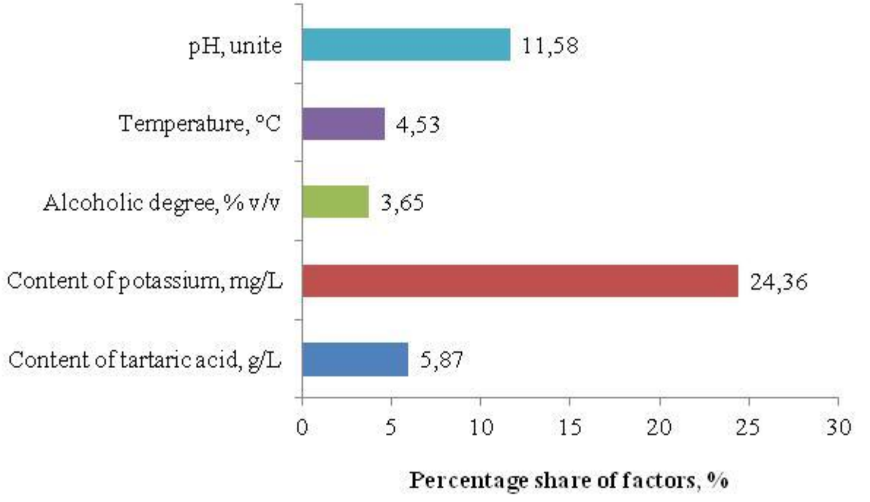


Fig. 1. *The evolution of physico-chemical parameters at different treatment temperature of wine samples.*



a) White wine



b) Red wine

Fig. 2. *The Pareto diagram of wine samples.*

The complex stability of studied wines is conditioned by a number of factors: entirely of the protein content; the mass concentration of potassium ions with a weight of 21.3 ÷ 24.5 %; the pH value of the wines with 12 % of and in the range of 4.5 ÷ 7 % of the treatment temperature.

Increasing temperature influence of the resultant parameter in red wine can be explained by the thermal instability of the phenolic complex that involves the colloidal balance changing in the system and serves as a support in the THK micro crystals creating process.

This study of mathematical modelling allowed us to obtain data necessary for the optimal regime of wines stabilization treatments related to the precipitation of excess tartaric salts.

Conclusion

In winemaking it is usually necessary to reduce the concentration of potassium bitartrate (KHT) in wine to avoid its precipitation in the bottle, which otherwise could reduce perceived wine quality. During cold stabilization the total acidity value had increased in middle with 21%, the color intensity values were halved into white sample and 25 % for red one. Also, the decrease of conductivity values at 20°C is range in limits 318-382 µS/cm.

According to the achieved results, cold stabilization reduces the values of content of tartaric acid of samples in the limits of 30 ÷ 40 % of initial values. Also, the contact seeding is the most efficient procedure of wine tartaric stabilization, due to the present of KHT micro-crystals in wine volume.

Relying on comparative analysis of the two procedures, we recommend the contact seeding procedure for stabilization of the young white wines for economic and technological reasons.

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Further research is required to assess the effectiveness in different types of wine, especially tannic red wines and sweet one which have particularly complex colloidal structures.

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