Factors forming the quality of brandy distillates

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Abstract. The formation of brandy quality affects all stages of its production. Biological and technological properties of grapes determine the composition of aroma-producing components of brandy base wines and distillates, which participate in composing of finished product typical properties. The purpose of the study included the factors forming the quality of brandy distillates, and technological methods for their regulating. Physicochemical, biochemical and technological analyses of grape varieties were carried out. The composition features of grapes were identified depending on their origin, climatic conditions and geographical zone. A system of grape indicators in the production of brandy distillates was substantiated, on the basis of which the parameters for optimizing production processes to improve the quality of finished product were developed.

1 Introduction

The priority direction of scientific and technological development in wine industry is to improve the base of raw materials and products, increase the volume of production, quality and competitiveness to ensure national food security.

Brandy production is a cost-demanding and multi-stage process, which includes grape processing, distillation of base wines and long-term aging of brandy distillate in oak barrels, determining the importance of using a high quality level of raw and other materials, as well as processes at all technological stages [1, 2].

Grape variety is of primary importance in the formation of characteristic properties of a strong drink [3]. Traditionally, brandy production uses European grape varieties of the species *Vitis vinifera* L., which are also in demand in the production of wines, followed by the increase in the problem of shortage of raw materials.

In this regard, it is advisable to use autochthonous grape varieties with properties, valuable for brandy production, as well as interspecific grape varieties, characterized by high fruitfulness and resistance to stress factors [4]. Thanks to the decrease in the use of chemical protection agents, the cultivation of interspecific varieties allows to develop organic viticulture and winemaking, as well as to use unoccupied lands in the zone of "risky viticulture".

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However, grape varieties of different origin and geographical growing area may differ in the oxidase activity, content of carbohydrates, acids and polyphenols. It has a significant impact on the complex of aroma-producing substances of brandy base wines and distillates [5, 6]. The unbalanced component ratio in the bouquet of locally produced brandy with a predominance of fusel tones, the intensity of which is almost two times higher than the level of fruit and floral descriptors, reduces its quality [2, 3].

A problematic issue in winemaking is the low content of organic acids in grapes, which can be caused both by varietal specifics, and by changes in climatic conditions [7]. Considering that sulfur dioxide is not used in brandy production, low-acid base wines with absent antioxidant and antibacterial protection are largely susceptible to oxidation and microbiological spoilage during storage. However, quality control of raw materials is carried out mostly basing on the mass concentration of sugars, which reduces the objectivity of assessment [6].

Technological approaches used in winemaking allow solving a number of problems, but they are not adapted to special properties of a variety, which does not give its biological potential to be fully unlocked [8–13].

Thus, the development of technologically flexible approaches for processing grapes of different varieties and origin, taking into account their physicochemical and biochemical composition, is a current direction of research.

2 Materials and Methods

The purpose of study included the factors forming the quality of brandy distillates depending on the physicochemical and biochemical composition of grapes, and technological methods for their regulating.

The research materials used are must, brandy base wines and distillates from white grape varieties of different origin: European species *Vitis vinifera* L., interspecific varieties of the Institute Magarach selection, autochthonous grape varieties growing in the Republic of Crimea, all harvested in 2015–2022; pure culture yeasts strains of the species *Saccharomyces cerevisiae*, *Lachancea thermotolerans* and *Kluyveromyces marxianus* from the Collection of Winemaking Microorganisms of the FSBSI Institute Magarach of the RAS [14]. In our work, 18 grape varieties were studied, 300 samples of brandy base wines and 320 of young distillates were produced under the conditions of micro-winemaking.

Physicochemical indicators of grapes, must, brandy base wines and distillates were determined in accordance with methodological recommendations “Technological assessment of grape varieties for brandy production” (RD 01580301.005-2020). The must analysis included the mass concentrations of sugars, titratable acids, polysaccharides, phenolic substances, amine nitrogen, pH and oxidase activity. The Agilent Technology 6890 gas chromatograph with a flame ionization detector (quartz capillary column HP-FFAP, active phase - polyethylene glycol / nitroterephthalic acid, carrier gas: hydrogen, temperature control conditions – from 70 to 180^0C) was used to determine the components of aroma-producing complex (content of higher alcohols, medium esters, volatile acids, aldehydes).

The quality of brandy base wines and distillates was assessed in accordance with the regulatory documentation. Data processing was carried out by mathematical statistics methods using the Statistica and MSO Excel software.

3 Results and Discussion

Product quality is influenced by many factors, first of all, by the quality of raw materials and efficiency of technological processes.

The studies of biochemical properties and physicochemical composition of grape varieties, depending on their origin, show a wide range of variations in indicators and differences between them in the mass concentration of polysaccharides, titratable acids, phenolic substances and oxidase activity in must, which are significant for quality formation of brandy products.

Grape polysaccharides are of great practical importance; their high content reduces the yield of must and the level of its clarification. Their highest concentration was found in grape varieties of interspecific selection, which is apparently associated with adaptive plant defense mechanisms (Fig. 1). These varieties are characterized by the lowest must yield - 66%, respectively.

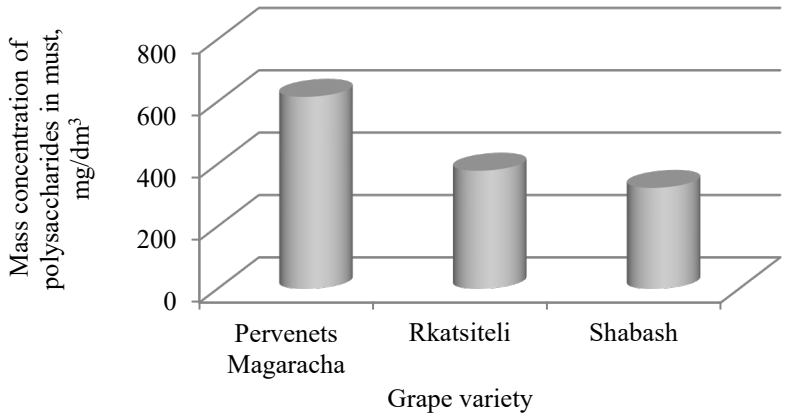

Fig. 1. The content of polysaccharides in the must of different origin grape varieties

The content of titratable acids in grapes also varies significantly depending on the origin of grape variety (4.7–6.8 g/dm^3), not ensuring their optimal level in brandy base wines (at least 8.0 g/dm^3). Recommendations for this indicator are closer met in interspecific grape varieties, amounting to 7.9 g/dm^3, to reach maximum values of 9.5–11.6 g/dm^3 (Fig. 2a).

In the contrast to intraspecific grape varieties, the phenolic-oxidase system of interspecific ones was characterized by lower values in the content of phenolic substances in berries, as well as the ability to release them when pressing whole berries - by 1.3 times ($p<0.05$), and to oxidize them – by 1.8 times ($p<0.05$) (Fig. 2b).

The oxidase activity of grapes is significantly influenced by both soil and climatic growing conditions and by the content of sugars in grape berries. An increase in grape carbohydrates before reaching the technical ripeness is accompanied by an increase in the oxidase activity of must (by 1.6 times), as well as by the ability to oxidize the phenolic substances (by 1.9 times). The technological stock of phenolic substances in the same grape variety with similar sugar content was changing by 1.5 times depending on climatic conditions and geographic zone; and the oxidase activity of must - by 2.5–4 times.

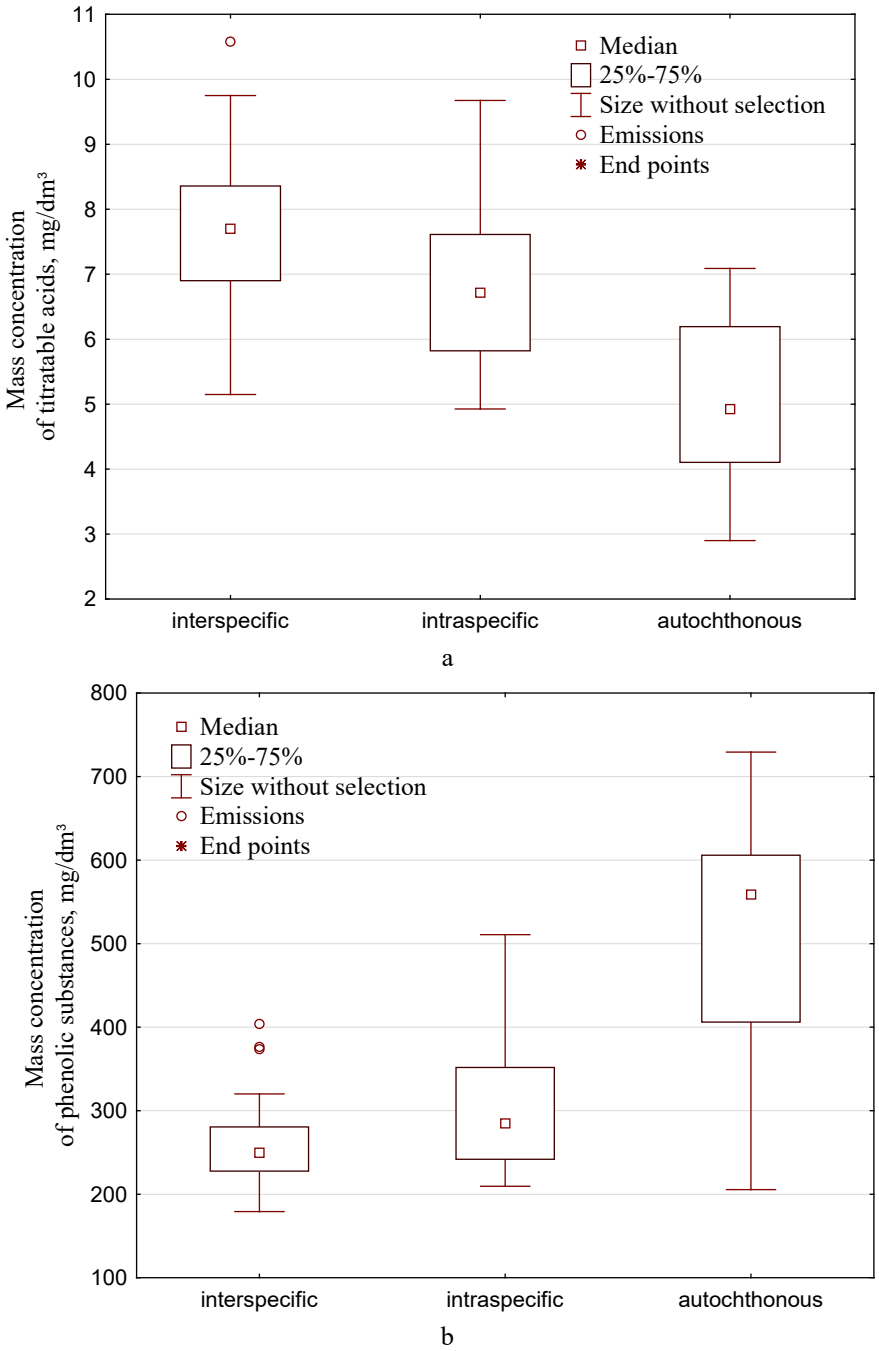

Fig. 2. Graph of distribution of the mass concentration of titratable acids and phenolic substances in must depending on the origin of grape variety

A comparative analysis of physicochemical composition of base wines from grape varieties of different origin showed a decreased (by 1.3–1.4 times) content of total esters, aldehydes and volatile acids, and an increased (by 1.2 times) level of higher alcohols in grape samples of interspecific selection. The profile of esters was characterized by a low

content (by 1.2 times) of ethyl acetate and general components of enanthic ester, as especially valuable for the quality of brandy distillates.

The balanced ratio of medium-chain esters and higher alcohols is characterized by the ME/HA indicator, which should be at least 0.2 in the high-quality brandy distillates. In base wines from interspecific grape varieties, this indicator values were inferior to those in samples from intraspecific varieties (0.17 and 0.31, respectively). This tendency is also represerved for brandy distillates (0.1 and 0.17, respectively), which is below the optimal indicator value.

Among the number of factors influencing the accumulation of aroma-producing substances in grapes, brandy base wines and distillates, the degree of grape ripeness plays a decisive role. Regardless the origin of variety, the content level of the sum of volatile components was increasing with an increase in the mass concentration of sugars. The highest content of medium-chain esters in base wines and distillates was found when using grapes with the mass concentration of sugars 175±15 g/dm^3. According to the organoleptic assessment, the obtained samples were superior to others.

The majority of esters are derived in the process of alcoholic fermentation; their qualitative and quantitative composition depends on the synthesizing ability of yeast strains, nutrient content and fermentation conditions [15]. As our studies show, the mass concentration of medium-chain esters in base wines, obtained under the same conditions, can differ by 1.7–3.8 times, depending on the yeast strain used. It should be noted that the origin of grape variety and its quality has a more significant impact on the composition and ratio of volatile components in base wines than microorganism properties have.

A close correlation dependence of component composition of aroma-producing complex in brandy base wines and distillates on the studied grape indicators was established showing a significant influence of biological characteristics of grape varieties, their ripeness degree, climatic conditions and geographical zone on product quality.

Based on the research results, problematic aspects of quality of raw and other materials for brandy production are identified. These are the high content of polysaccharides and phenolic substances in grapes, low titratable acidity of base wines, and composition of aroma-producing complex of poor in esters base wines and distillates.

Solvation of problematic issues is based on improving the control system for raw and other materials, as well as the process optimization. In this regard, for technological assessment of grapes used in brandy production, a number of additional indicators are recommended, as follows: mass concentration of titratable acids, phenolic substances in must, and their technological stock in grapes, pH and oxidase activity of must.

In order to reduce the content of polysaccharides and increase the coefficient of using raw materials (an increase in the must yield), it is advisable to use extracellular yeast enzymes with endopolygalacturonase activity. Testing of experimental enzyme obtained from the yeast strain *Kl. marxianus* during pulp and must processing, showed an increase in the must yield (on average by 7%), and in the quality of its clarification (a decrease in the must oxidase activity, and the content of clouds and phenolic substances). In experimental base wines and distillates, the mass concentration of methanol did not exceed the control level.

In order to regulate the acidity of base wines, a method of biological acidification using the yeast strain *L. thermotolerans*, which has the ability to synthesize lactic acid, was substantiated. Its use during must fermentation, individually or in combination with the yeast of *S. cerevisiae* species, increases the content of titratable acids in brandy base wine (on average by 1.4 times), contributing to conservation of varietal aroma, and improves the quality of brandy distillates.

To increase the content of esters, as well as CE/HA indicator, and reduce the level of higher alcohols in brandy base wines and distillates from grape varieties of different origin,

yeast strains of *S. cerevisiae* species (Kheres 20C/96, Artemovskaya 7, Magarach 17-35) are recommended for must fermentation as having all necessary properties. The fermentation of must without the access of atmospheric oxygen also contributes to an increase in the content of medium-chain esters in base wines (up to 21%).

In order to increase the content of the most valuable components of enanthic esters in brandy distillates, which have bright floral-soapy tones, distillation modes of base wines and raw alcohol using the potential of yeasts and their lysates in the amount of 7–15% are appropriate.

The developed technological methods to regulate the composition of brandy base wines and distillates depending on biochemical and physicochemical parameters of grapes ensure the production of a high-quality finished product.

4 Conclusion

A comparative analysis of brandy base wines and distillates from grape varieties of different origin was carried out, and their differences, determined by biochemical and physicochemical properties of grape varieties, were established. A system of indicators was developed to assess the quality of grapes used in brandy production. It was supplemented by the indicators of titratable acids, phenolic substances and their technological stock, pH and oxidase activity of must.

Based on the established dependence of component composition in the aroma-producing complex of must, brandy base wines and distillates on the properties of grape varieties, the parameters of process optimization were developed. It was shown that the use of yeast endopolygalacturonase, produced by the yeast of *Kluyveromyces* genus, helped to increase the yield and quality of must clarification, and the yeast of *Lachancea* genus increased the content of titratable acids. The expediency of using yeast strains of *S. cerevisiae* species with target properties during must fermentation and distillation of base wines and raw alcohol in order to increase the content of esters, including the basic components of enanthic esters, was revealed. The methods proposed for regulating the composition of brandy base wines and distillates in accordance with biochemical and physicochemical parameters of grapes contribute to a high-quality product recovery.

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