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TECHNOLOGY OF DRY WINES PRODUCTION ON THE BASE OF ALCOHOLIC CONTENT CORRECTION

253.03 TECHNOLOGY OF ALCOHOLIC AND NON-ALCOHOLIC BEVERAGES

Doctor of Philosophy Thesis

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TEHNOLOGIA DE PRODUCERE A VINURILOR SECI ÎN BAZA CORECTĂRII GRADULUI DE ALCOOL

253.03 –TEHNOLOGIA BĂUTURILOR ALCOOLICE ŞI NEALCOOLICE

Teză de doctor în □tiin□e tehnice

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ADNOTARE

Stoleicova Svetlana ”Tehnologia de producere a vinurilor seci pe baza corectării gradului de alcool”. Teză de doctor în □tiin□e tehnice, Chişinău 2015. Teza constă din introducere, 4 capitole, concluzii şi recomandări, bibliografia ce include 194 titluri, 9 anexe, 111 pagini de conținut de bază, 32 tabele, 27 figuri. Rezultatele au fost expuse în 12 publicații.

Cuvinte-cheie: vin, concentra□ia alcoolică , dealcoolizare, calitate.

Domeniul de studiu: 253.03 -Tehnologia băuturilor alcoolice şi nealcoolice.

Scopul şi obiectivele lucrării: scopul lucrării constă în perfec□ionarea tehnologiei de corectare a conținutului de alcool în vinurile albe şi roşii seci prin metoda distilării sub vid. Obiectivele sunt următoarele: elaborarea regimurilor tehnologice optimale pentru corectarea conținutului de alcool în vinurile prin metoda distilării sub vid, studiul influen□ei procesului de dealcoolizare asupra indicilor fizico-chimici, complexului volatil, notei organoleptice a vinurilor ob□inute; stabilirea influen□ei acestui proces tehnologic asupra stabilită□ii vinurilor albe □i ro□ii.

Noutatea şi originalitatea ştiințifică lucrării constă în argumentarea □tiin□ifică a tehnologiei de ameliorarea calită□ii vinurilor albe □i ro□ii seci prin corectarea gradului alcoolic cu utilizarea metodei de distilare sub vid. Argumentarea □tiin□ifică se bazează pe rezultatele cercetărilor teoretice □i experimentale, care denotă stabilitatea complexului volatil studiat, variația compozi□iei fizico-chimice □i ameliorarea calită□ii senzoriale ale vinurilor cu grad alcoolic corectat. Noutatea □tiin□ifică a lucrării este confirmată de brevetul de inven□ie „Procedeu de ob□inere a vinurilor naturale” (Hotărîre pozitivă, AGEPI, Nr: 8266 din 17.11.2015).

Problema ştiințifică soluționată constă în stabilirea şi argumentarea corela□iei dintre parametrii procesului tehnologic de dealcoolizare a vinului □i con□inutului de alcool în produsul final cu grad alcoolic corectat. Corela□ia determinată este exprimată prin ecua□ii de regresie pentru vinul alb □i ro□u.

Semnificația teoretică şi valoarea aplicativă a lucrării: În baza cercetărilor efectuate, referitor la metodele de producere □i ameliorarea calită□ii vinurilor obținute în urma corectării conținutului de alcool, au fost elaborate scheme tehnologice de fabricarea vinurilor cu grad alcoolic corectat □i parametrii procesului tehnologic de producere a vinurilor albe □i ro□ii naturale cu grad alcoolic corectat.

Implementarea rezultatelor ştiințifice: Rezultatele cercetării au fost testate şi implementate în condi□iile fabricii de vinuri ÎM„Nectar S” SRL prin producerea unor loturi de vinuri cu concentrația alcoolică corectată, în volum de 2000 dal după schema tehnologică perfec□ionată.

АННОТАЦИЯ

Столейкова Светлана «Технология производства сухих вина на основе корректирования содержания спирта». Диссертационная работа на соискание ученой степени доктора технических наук, Кишинэу, 2015 год. Диссертационная работа состоит из 4 глав, выводов и рекомендаций, библиографического списка из 194 источника, 9 приложений, 111 страниц основного текста, 32 таблиц, 27 рисунков. Результаты исследований представлены в 12 публикациях.

Ключевые слова: вино, содержание спирта, деалкоолизация, качество.

Специальность: 253.03- Технология алкогольных и безалкогольных напитков

Цель и задачи работы: цель работы заключатся в совершенствовании технологии корректировки содержания спирта в винах методом вакуумной перегонки. Задачи исследования: разработка оптимальных технологических режимов для корректирования содержания спирта в винах методом вакуумной перегонки; изучение влияния процесса деалкоолизации на физико-химические, органолептические показатели, а также на ароматический комплекс полученных вин; изучение влияния данного технологического процесса на стабильность белых и красных вин.

Новизна и научная оригинальность заключается в научном обосновании способа повышения качества белых и красных сухих вин путем корректирования содержания спирта методом вакуумной перегонки. Научное обоснование основывается на результатах теоретических и экспериментальных исследований, которые показывают стабильность изученного летучего комплекса, вариация физико-химического состава и улучшение вкусовых качеств вин с корректированным содержанием спирта. Научная новизна работы подтверждена патентом на изобретение «Способ производства натуральных вин» (Положительное решение, AGEPI, Nr: 8266 от 17.11.2015).

Теоретическая значимость и научная ценность работы. На основании проведенных исследований о методах производства и улучшения качества вин, полученных корректированием содержания спирта, были разработаны технологические схемы производства вин с корректированным содержанием спирта, а также параметры технологического процесса производства белых и красных натуральных вин с корректированным содержанием спирта.

Научная задача, рассматриваемая в диссертации, заключается в разработке и научном обосновании корелляции между параметрами технологического процесса деалкоолизации вин и содержанием спирта в конечном продукте. Определенная корреляция выражена уравнениями регрессии для белого и красного вина.

Внедрение научных результатов. Результаты исследований были проверены и внедрены на заводе ÎM„Nectar S” SRL путем производства экспериментальных партий белых и красных вин с корректированным содержанием спирта в объеме 2000 дал согласно усовершенствованной технологической схеме.

ABSTRACT

Stoleicova Svetlana «Technology of dry wines production on the base of alcoholic content correction». Doctor of engineering thesis, Chisinau, 2015. The thesis consists of introduction, four chapters, conclusions and recommendations, bibliography with 194 references, 9 anexes, 111 pages of basic content, 32 tables, 27 figures. The results were presented in 12 scientific publications.

Keywords: wine, dealcoholization, alcoholic content, quality.

Specialty: 253.03 - Technology of alcoholic and non-alcoholic beverages.

Purpose and objectives of research. The main purpose of the thesis consists in perfection of technology for correction of alcoholic content in dry white and red wines using vacuum distillation method. Objectives of research: elaboration of optimal technological regimes for correction of alcoholic content in wines using vacuum distillation method; study the influence of ethanol removal process on physical and chemical composition, organoleptic properties and on volatile complex of obtained wines; study the influence of ethanol removal process on stability of white and red wines;

Scientific novelty and originality of the thesis consisits in scientific substantiation of the method for amelioration of the quality of white and red dry wines by alcoholic content correction using vacuum distillation method. Scientific substantination is based on the results of theoretical and experimental investigations, which denotes the stability of volatile complex, variation of physical-chemical stability of wine composition as well as amelioration of the sensory properties of wines with corrected alcoholic content. Scientific novelty is confirmed by favourable decision of patent issuance “Method for obtaining of natural wines” (AGEPI, Nr: 8266 from 17.11.2015).

Theoretical significance and practicality applied value. On the base of the complex study regarding the methods of production and improvement of the quality of wines obtained by correction of alcoholic content, technological schemes for production of wines with corrected alcoholic content, parameters of the technological process for production of natural white and red wines with corrected alcoholic content was elaborated.

Scientific challenge solved within the thesis consists in elaboration and argumentation of the correlation between parameters of technological process of dealcoholization and alcoholic concentration in the final product with corrected alcoholic content. Correlation determined is expressed by regression equations for white and red wines.

Implementation of scientific results. On the base of obtained scientific results was tested and implemented, in production conditions at the winery “Nectar S” LTD experimental batches of white and red wines with corrected alcoholic content was obtained in the volume of 2000 dal according to the elaborated technology.

LIST OF ABBREVIATIONS

BAC- blood alcohol concentration

e.g.- for example

et al. – and others

EI –impact electron

ETR -Extended Temperature Range

EP- pertraction

Fig.- figure

FTIR- Fourier Transform InfraRed

FT- Fourier Transform

GOX- glucose oxidase OIV- International Organisation of vine and Wine

GMO-genetically modified microorganism

GC-MS - chromatography–mass spectrometry

IPCC- Intergovernmental Panel on Climate Change

IR-infra red

LDH- lactate dehydrogenase

Mhl – million liters

NADH- Nicotinamide adenine dinucleotide reduced form

NF – nanofiltration

NIST- National Institute of Standards and Technology

OD – osmotic distillation

OPD - Optical Path Difference

PP - pentose phosphate

RO- Reverse osmosis

SCC-spinning cone column

SPE - solid-phase extraction

SPIHFT – Scientific and Practical Institute of Horticulture and Food Technologies

UNEP- United Nations Environment Programme

VD – vacuum distillation

VMD – vacuum membrane distillation

WMO- World Meteorological Organization

WHO- World Health Organisation

ZSM-5 - Zeolite Socony Mobil–5

INTRODUCTION

Wine is a well-known ancient beverage spread all over the world and one of the most popular alcoholic drinks, which contributes to reduce the risk of cardiovascular diseases, thanks to a plenty of compounds playing a role of great significance from the aspect of human health [102]. It had an important role in the old civilizations and reached our days with no less importance. Nowadays, the wine industry is facing changes both due to the economic trends, such as reduced sales for certain types of products, and structural, as consumption in traditional producer countries decreases. In a global context, characterized by increasingly competitive non-European companies and competition from alternative products such as beer and soft drinks, companies face the difficulty of capturing the market signals to address the supply [163].

Wine demand is moving toward consumption patterns characterized by the pursuit of both healthier and more hedonistic lifestyles; moreover, public opinion is trending toward responsible consumption of alcoholic beverages because of public health recommendations and national campaigns against alcohol abuse. Market trends are predicted to change in the near future because, after the consumer orientation toward the demand of barrel-aged and well-structured high alcohol wines, a new enthusiasm toward light wines that are low in alcohol is arising [163].

Moreover, for the past several years there has been a steady increase of the alcoholic degree of wines because of climate change and the southwards shift of grape varieties from cooler areas, resulting more frequently in grapes that are very rich in sugar. This amount is changing every year, depending on various circumstances like occasionally unfavorable climate conditions. Statistical data has shown a consistent alcohol increase in Californian wines, from 12,5% vol. to 14,8% vol. between 1978 and 2001. In Australian wines, alcohol content has increased from 12,4% vol. to 14% vol. between 1984 and 2004 [55].

Hence, the production of wines with reduced ethanol concentration is an important aspect of wine production that has gained considerable attention over the past 10 years or so. Consumer demand for wines that are perceived as healthier, more favourable excise rates for lower alcohol products and changing attitudes of consumers regarding the social consequences of excessive ethanol consumption are just some of the attitude drivers for lowering ethanol levels in wine. Significant consumer demand is apparent for wines with lower ethanol levels [152].

These considerations as to high alcohol levels in wines stimulate great attention in improvement of the technologies for reducing alcohol content of wines by conserving organoleptic balance, flavour and high quality.

Relevancy and importance of the investigated problem

The wine industry is facing changes and technological innovation has developed new solutions, some involving grape growing techniques and some involving oenological practices including the reduction of the alcohol content. Since two decades, various strategies to reduce alcohol level in wines have been considered including the improvement of viticulture or winemaking practices, the development of physical approaches and the generation of low alcohol yeasts. The adoption of such technologies offers opportunities to develop new products and so to attract wide range of consumers.

Nowadays, the reduction of ethanol level in wine became a notable topic in wine production, however, the problem is not resolved until now that confirms the necessity and importance of conducted research. The main problem in the process of wine with reduced alcohol content production consists in obtaining of high quality wine without influence on its organoleptic properties. There are a lot of studies regarding the obtaining of high quality wines with reduced alcohol content carried out by M. Catarino, L. Liguori, Y. Belisario-Sánchez, N. Diban, A. Balanuță etc. Particular significance in the process of low alcohol wine production should be given the choosing of the most acceptable method and technique. The method chosen by wine producers to moderate ethanol levels are often determined by consideration of the important factors of wine style, production volume, the level of ethanol to be removed from the product, a desire to retain natural or organic association of the product, capital outlay, operating expenses, flexibility for use of equipment and staff training requirements.

According to literature data the most appropriate methods for reduction of alcoholic content from wines are considered the physical ones. In this regard, studies regarding the influence of different physical methods (reverse osmosis, spinning cone column etc.) on wine quality was performed. However, there are very few studies regarding the influence of vacuum distillation process on ethanol removal as well as on wine quality including organoleptic properties.

It is to be noted that, in the Republic of Moldova problem of alcohol removal from wine appears a few years ago (2008−2009) resulting from the market demand of the Republic of Belarus, but the problem has not been solved until now. Moreover, changing climate and utilization of grape varieties with high sugar accumulation required the correction of alcoholic content in wines. Consequently the necessity of production of wines with reduced alcoholic content is influenced by economic and environmental factors.

Evaluation of physical–chemical and organoleptic changes that take place in the process of wine dealcoholization continue to present a serious scientific challenge as well as improving the quality of this category of wines requires a competent scientific and technical guidance aimed at ensuring the finished product of superior quality.

Purpose and objectives of research

Thesis related research was conducted in order to study the influence of alcohol removal process from wines using vacuum distillation on physical and chemical composition of obtained product. The main purpose of the thesis consists in perfection of dry wines production technology on the base of alcoholic content correction.Therefore, in order to achieve the main purpose of research the following specific objectives were proposed :

- Scientific substantiation of optimal regimes for ethanol removal process from white and red dry wines using vacuum distillation method ;
- Study the influence of ethanol removal process on physical and chemical composition of obtained white and red dry wines with reduced alcoholic content;
- Study the influence of technological regimes of ethanol removal process on volatile complex of obtained white dry wines;
- Study the influence of ethanol removal process on stability of obtained white and red dry wines;
- Study the influence of ethanol removal process on sensory characteristics of obtained white and red dry wines;
- Study the techniques for optimization of optimal technological regimes for dry wines alcoholic content correction ;
- Elaboration and implementation the improved technology for correction of alcoholic content in white and red dry wines in industry conditions.

Scientific novelty and originality

Scientific novelty of the thesis consists in scientific substantiation of the method for amelioration of quality of white and red dry wines by removal of the excess of ethanol. Scientific substantination is based on the results of theoretical and experimental research, which denotes the stability of volatile complex, stability of physical-chemical characteristics as well as amelioration of the sensory properties of the wines with corrected alcoholic content.

Scientific novelty of the thesis includes obtaining of new scientific results regarding the elaboration of optimal technological regimes of vacuum distillation process for ethanol removal from wines as well as influence of technological factors (temperature, pressure, volume, operating time) on physical and chemical composition of obtained white and red dry wines.

For the first time, the scientific results regarding the changes of volatile complex of white wines in dependence of different technological regimes was obtained as well as values of losses of aroma compounds were calculated in dependence of extent of ethanol removal: reduction of esters content from 22% to 100%, higher alcohols from 8,2% to 90,7%, aromatic aldehydes and ketones from 12,9% to 70,8%, and fatty acids content from 7% to 30%.

In the thesis results regarding the influence of alcohol reduction using vacuum distillation method on the sensory perception of wines and their acceptability by wine professionals was obtained. According to obtained results, correction of alcoholic content in wines contributes the improvement of sensory characteristics of obtained white and red dry wines.

The results regarding the influence of ethanol removal process on stability of white and red wines was obtained. According to obtained results stability of wines depends on quality of initial wine material and extent of ethanol removed in the process of dealcoholization.

On the base of elaborated technological regimes technological scheme for correction of alcoholic content in white and red dry wines was elaborated, which provides elimination of 20% ethanol excess from wines.

On the base of obtained results technological scheme for production of white and red dry wines with reduced alcoholic content using blending method was elaborated. Scientific novelty is confirmed by Utility patent application "Method for obtaining of natural wines" Nr: s 2015 0056 from 2015.04.17 to State Agency on Intellectual Property of the Republic of Moldova (Annex 6).

Scientific challenge solved within the thesis consists in elaboration and argumentation of the correlation between parameters of technological process of dealcoholization and alcoholic concentration in the final product with corrected alcoholic content. The determined correlation is expressed by regression equations for white and red wines.

Theoretical significance and practicality applied value

On the base of the complex study regarding the methods of production and improvement of the quality of wines obtained by correction of alcoholic content, technological schemes for production of wines with corrected alcoholic content, parameters of the technological process for production of natural white and red wines with corrected alcoholic content was elaborated.

Technology for correction of alcoholic content in white and red dry wines using vacuum distillation method was elaborated. Elaborated technology was tested in production conditions at the wine factory „Nectar S" LTD (Straseni city) with obtaining of experimental batches of white and red wines in the volume of 2000 dal.

Technology for white and red dry wines with corrected alcoholic content using blending method was elaborated. According to sensory evaluation results it was established that blending of initial wine with dealcoholized wine in proportions 50%:50% and 70%:30% contributes the improvement of the effectiveness of process, leads to substantial reduction of operating time and amelioration of quality for wines with corrected alcoholic content.

Implementation of scientific results. In production conditions at the winery "Nectar S" LTD the elaborated technology for correction of alcoholic content in wines was implemented as a result experimental batches of white wine Aligote and red wine Merlot with corrected alcoholic content was obtained in the volume of 2000 dal.

Evaluation of results

Fundamental principles and results of research was discussed and reported at the proceedings of the Scientific Council of Scientific and Practical Institute of Horticulture and Food Technology (2011-2014) as well as at International Scientific and Practical Forum «Роль экологизации и биологизации в повышении эффективности производства плодовых культур, винограда и продуктов их переработки», 26-30 august, 2013 (Krasnodar, Russian Federation); International Scientific Symposium „Agricultura Modernă – Realizări şi Perspective", Agrarian State University, 27 September, 2013, (Chisinau, Republic of Moldova); International Scientific and Practical internet-Conference «Инновационные технологии и тенденции в развитии современного виноградарства и виноделия», 1-3 July, 2014 (Yalta, Crimea); The 5th International Conference on Food Chemistry, Engineering & Technology", 29-30 May, 2014, (Timisoara, Romania); International Conference "Tehnologii Moderne în Industria Alimentară -2014", Technical University of Moldova, 16-18 October, 2014, (Chisinau, Republic of Moldova); International Scientific and Practical Conference: «Современные проблемы и тенденции развития пищевой промышленности», May, 2015, (Maikop, Russian Federation); International Scientific Symposium „Horticultura modernă - Realizări şi perspective" 1-2 October 2015 (Chisinau, Republic of Moldova). Based on the research findings articles in national journal "Viticultura, Pomicultura şi Vinificație" was published. Moreover, results of research was reported to the World Federation of Scientists (Switzerland) within the National Scholarship of World Federation of Scientists in the period 2013-2014 and to the Academy of Science of Moldova within the project for young scientists (2013-2014) (Annexes 7, 8, 9).

Summary of the thesis chapters

The thesis is exposed on 111 pages of typed text and includes 32 tables, 27 figures and 10 anexes and is structured in four chapters, first of which is literature data analysis including the current state of the problem studied in the thesis, the second chapter represents description and brief analysis of materials and methods, and in the third and fourth chapters are exposed main scientific results and their analysis.

Introduction contains argumentation of the relevancy and importance of the thesis, scientific novelty and originality, theoretical significance and practicality applied value, evaluation of results as well as determination of the purpose and objectives of research.

In the Chapter 1 – "Technological aspects of reduced alcohol content wine production" general information regarding the factors influencing low alcohol wine production, the regulatory framework of the process of ethanol removal as well as classification and characteristics of existing methods and techniques for reduced alcohol content wine production is presented.

In the Chapter 2 - "Materials and methods of research" information regarding the methods for determination of physical–chemical and organoleptic indices, materials of research, the subjects of the study, statistical and mathematical treatment of experimental data is described.

In the Chapter 3 - "Elaboration of optimal regimes for correction of alcoholic content in wines using vacuum distillation method" scientific results regarding the influence of different technological factors such as temperature, pressure, operating time, volume on physical-chemical indices and aromatic complex of white and red wines as well as determination of optimal technological regimes for correction of alcoholic content in wines are demonstrated. Moreover, on the base of obtained results mathematical and statistical treatment of obtained results is performed.

In the Chapter 4 - "Improvement of technological regimes for correction of alcoholic content in wines " on the base of elaborated technological regimes the influence of ethanol removal on wine stability and sensory properties is demonstrated. Moreover, different schemes of corrected alcoholic content wine production as well as study of blending technique for the wine aroma recovery is presented.

Thesis ends with **General Conclusions** and **Recommendations**

On the base of obtained scientific results, improved technological scheme for correction of alcoholic content in wines without negative impact on wine quality was elaborated and implemented in production conditions. It was found that vacuum distillation technique can be used for effective correction of alcoholic content from wine in order to obtain more balanced wines and decrease of the harmful effect of alcohol on human health. Elaborations on this research are in exact accordance with normative framework of OIV and are focused on promotion of healthy lifestyle. Thus, thesis represents the complex and completed research, in which the main purpose concerning perfection and implementation in production of technology for correction of alcoholic content for production of quality white and red wines was achieved.

1.TECHNOLOGICAL ASPECTS OF REDUCED ALCOHOL CONTENT WINE PRODUCTION

1.1 Identification and analysis of factors which determined the necessity of reduced alcohol content wine production

1.1.1 Study of the regulatory framework in the process of low-alcohol wine production

Wine is one of most popular alcoholic drinks in the world and therefore, wine quality is a key issue for the winemakers [13]. Wine production worldwide ranged from 26 billion to 27 billion liters during the 2009 to 2012 period [90, 178]. According to the report regarding the state of the Vitiviniculture World market presented by the International Organisation of vine and Wine (OIV), world wine consumption consists 230 Mhl in 2013, the maximum was registered in 2007 when world wine consumption amounted 255 Mhl [136].

Doubtless, the impact of global wine production on the world economy is undeniable. In particular, since 2004 when the OIV has, for the first time, recognized the principle of the dealcoholization of wine under certain conditions, the Member-States of the OIV have revised the oenological practices in this area to allow the development of different products with reduced alcohol content or with low alcohol content. Thus, the OIV agreed to adopt definitions that cover these types of product which are available on the market [149].

It is to be noted, that the group of products resulting from the dealcoholization process or the reduction or removal of alcohol from wine is very heterogeneous due to the differences in regulations regarding the definition of wine, the classification of alcoholic beverages and the minimum alcohol level [149]. Foremost, different countries regulate minimum alcoholic strength for the definitions of wine. According to the OIV: “Wine is a beverage resulting exclusively from the partial or complete alcoholic fermentation of fresh grapes, whether crushed or not, or of grape must. Its actual alcohol content shall not be less than 8,5% vol., with the flexibility to be reduced to 7% vol. [81]. For example, in Australia the limit was established at 4,5% vol., in the European Union as well as in the Republic of Moldova the limit is at 9,0% vol. [6]. Whereas some countries there is no minimum specified [149].

In this framework, the General Assembly of the OIV adopted resolutions regarding the production of low-alcohol or directly dealcoholized beverages. Resolutions OIV-ECO 432-2012 and OIV-ECO 433-2012 delineate “beverage obtained by dealcoholization of wine” and “beverage obtained by partial de-alcoholization of wine", which was inserted in the International Code of Oenological Practices.

According to Resolution OIV-ECO 432-2012, "beverage obtained by dealcoholization of wine is a beverage obtained exclusively from wine or special wine as described in the International Code of Oenological Practices of the OIV, which has undergone exclusively specific for this type of products treatments in particular a dealcoholization and with an alcoholic strength by volume below 0,5% vol. [138].

According to Resolution OIV-ECO 433-2012, "beverage obtained by partial dealcoholization of wine is a beverage obtained exclusively from wine or special wine as described in the International Code of Oenological Practices of the OIV, which has undergone exclusively specific for this type of products treatments in particular a dealcoholization and with an alcoholic strength by volume equal or above 0,5% vol. and less than the applicable minimum alcoholic strength of wine or special wine [139].

Besides the definitions adopted and inserted in the International Code of Oenological Practices, OIV Member-States have specified the conditions for reducing the alcohol content of wine, differentiating between a correction of the alcohol content and a dealcoholization of the wine. Therefore, correcting the alcohol content means reducing the excessive level of ethanol from wine in order to improve its taste and balance. For the correction of alcohol content in wine a maximum reduction of 20% of the initial alcohol content is allowed. Wine obtained in the result of this process must still conform to the definition of wine, otherwise, if the alcohol content of the wine was reduced by more than 20% it will fall under a dealcoholization process [149].

In the Republic of Moldova correction of alcoholic content means the reduction of the excess of alcohol from wine in order to obtain more balanced wines and the process is performed by separation methods utilized separately or in combination. After the correction of alcoholic concentration wines must no have any organoleptic defects. For the correction of alcohol content in wine a maximum reduction of 20% of the initial alcohol content is allowed and must still conform to the definition of wine with alcoholic strength equal or above 9 % vol. [6].

Special attention should be given to the techniques used in the process of ethanol removal from wine. This important issue was discussed by OIV in order to obtain vitivinicultural products with a reduced or low-alcohol content [174]. Resolutions OIV-OENO 394A-2012 and OIV-OENO 394B -2012 specify the separation techniques that can be used in the process of dealcoholization and for the correction of alcohol content of wines. According to Resolutions OIV-OENO 394A-2012 and OIV-OENO 394B -2012 obtaining of vitivinicultural products with a reduced or low-alcohol content can be achieved by methods of separation techniques or a combination of techniques:

-partial vacuum evaporation;

-membrane techniques;

-distillation.

Process of alcohol elimination from wine must not be used on wine with any organoleptic defects and only under the responsibility of an oenologist or specialized technician [140, 141].

OIV recommends the utilization of different types of membrane techniques alone or in combination, including: microfiltration, ultrafiltration, nanofiltration, membrane contactor, reverse osmosis, electromembranes etc.

Resolutions OIV-OENO 450A-2012 and OIV-OENO 450B-2012 was adopted with the aim of reduction the sugar level of must before the fermentation process. Notwithstanding that the reduction of the sugar content in musts excludes the dealcoholization of the wines from which they originate and the end product must comply with the definition of wine [142,143].

The OIV is currently working to develop definitions for products that do not fall under the aforementioned resolutions. For example, dealcoholized products beyond 20% but respecting the minimum alcoholic strength of wine [149].

The OIV regulations provide a basic standard on definitions and practices that Member-States can take into account to facilitate technical innovation and offer quality products to the consumers.

Nowadays, low-alcohol wine production or correction of alcohol content in wines is a very discussing issue. Drafting of regulations will provide production of high quality wines with reduced alcohol content. Thereby, quality of wines became a very actual scientific challenge.

1.1.2 Global warming and its influence on the modern viticulture and winemaking

Climate change or global warming is defined as an increase of the average temperature on the Earth and is considered as one of the most actual and important challenges over the past decades [114].

According to Houghton et al., understanding climate change and the potential impacts on natural and human-based systems has become increasingly important as changing levels of greenhouse gases and alterations in earth surface characteristics bring about changes in the Earth's radiation budget, atmospheric circulation and hydrologic cycle [92]. Therefore, in the past two decades, through private and government-sponsored initiatives, the world community is calling for increased attention to the worsening climate crisis [80,160]. In order to monitor, investigate and provide the world with the scientific knowledge in climate change and its impacts on environment and socio-economic field the Intergovernmental Panel on Climate Change (IPCC) was created in 1988 by the United Nations Environment Programme (UNEP) and the World Meteorological Organization (WMO).

As documented in the last issue of the IPCC report, the average global temperature has increased by 0,6°C during the 20th century and are likely to rise by 2-6°C over the next century [55, 191]. The global temperature rising can be explained by an increase in the concentration of greenhouse gases. According to the Duchene et al. an annual increase in carbon dioxide concentration of 1,5 ppm from 1980 to 2000 was observed [55]. Similar trends are observed for methane (CH_4) and nitrous oxide (N_2O) [20]. Burney, Tate et al. in their researches have shown that the increase in atmospheric greenhouse gases has several primary contributors: the burning of fossil fuels, widespread deforestation, the loss of natural "carbon sinks", oceanic acidification, the use of landfills, and large scale cattle and sheep ranching [31, 176, 39].

Rising temperatures worldwide will have extraordinary effect upon agriculture; however, few crops are susceptible to minor changes in climate than grapes, especially premium wine quality grapes [66, 74]. It is generally agreed today, that agricultural industry is decidedly dependent upon and inherently interconnected to climate. Therefore, climate change profoundly influences the production of quality grapes and high-quality wines [114, 92]. Global warming can influence not only the process of berry formation and ripening, but also on chemical composition of grape and the changing of wine-growing regions. The shift in global warmth patterns may move premium grape growing regions out of areas currently devoted to that activity as well as may cause a shift in current grape variety cultivation [114]. It was demonstrated that the process of global warming is not uniform. According to the forecasts made by IPCC suggest a reduction of precipitations in sub-tropical land areas and an increase in precipitations in more northerly latitudes and the equator and will be registered greater warming over land, with greater warming at the higher latitudes, especially in the Northern Hemisphere [85, 91]. Climate change would influence the whole winemaking regions. Some of them may become completely inhospitable to grape production. For example, Italy, Greece and France can lose a great part of their suitable lands for grape production by 2050 [99, 114]. Alsace, for example, has been experiencing a shortening of the growing season: budburst and flowering dates were approximately 15 days earlier in 2003 compared with 1965 and moreover a shift of harvest from

October to September in the last three decades was observed [55]. But other wine regions such as Southern England, by contrast, is resembling Champagne and has had several vintages of note [114, 66]. According to Lallanilla, China may become a new grape production region open up to vineyard capability [99].

White et al notes, that potential premium winegrape production area in the USA could decline by up to 81% by the late 21st century [192]. The obtained results show that increase in heat accumulation will likely shift production to warmer climate varieties and production of lower-quality wines [91, 192].

In Australia, Ecos predicted an increase in temperatures by 2°C and a decrease in available fresh water by 30% [14]. Hence, the changes in Australian climate have tied future temperature regimes to reduced wine quality with southerly and coastal shifts in production regions being the most likely alternative to maintaining viability [90].

It was observed worldwide that increasing of carbon dioxide levels may cause considerable changes of grape chemistry and the resulting wine quality [114, 176]. Santisi has shown that colder than normal temperatures lead to incomplete ripening of grapes resulting in wines with high acid content and unripe flavors, whereas warmer-than-normal temperatures lead to high sugar grapes and consequently high alcoholic wines with low acidity and cooked flavors [22, 156].

Overall in the process of global warming the grapevine will go through its phenological events more rapidly resulting in higher sugar ripening while the winemaker is waiting for flavors to develop, the acidity is lost through respiration resulting in unbalanced wines with high alcohol content. Higher alcohol levels have been observed by different scientists in many grape growing regions. Vierra has shown that average alcohol levels in Napa (USA) increased from 12,5% vol to 14,8% vol from 1971 to 2001, while acids level decreased significantly and the pH climbed [185]. The same situation was observed in Alsace (France). It was found that alcoholic content of Riesling have increased by 2,5% vol over the last 30 years [55]. In an statistical study in Australia carried by Sadras et al. was found the temperature effects upon titratable acidity and pH was variety specific: Cabernet Franc and Chardonnay experienced the greatest shifts in both titratable acids and pH, Semillon experienced a wider variance in pH, yet Shiraz showed little change in either measurements [151].

Thus, climate change has a great impact on agriculture and particularly on viticulture and winemaking. Changes in climate affect the wine growing regions, chemical composition of grapes and wine quality, resulting in unbalanced and heavy wines with high alcohol content. Indeed, dealcoholization of wines deals with consequences of global warming.

1.1.3 Health policies and consumer demand on low-alcohol wines

Nowadays, the wine industry is facing changes both due to the economic trends, such as reduced sales for certain types of products, and structural, as consumption in traditional producer countries decreases [163]. The changes in wine industry can be associated with policies conducted and implemented by governments in order to reduce alcohol consumption.

Through media attention and government programs, greater awareness on both the positive and the negative effects of alcohol on health has encouraged more individuals to adopt safer consumption patterns [155].

The problem of alcohol consumption has different sides of the same coin. In general, regular and moderate drinking is associated with a number of health benefits, including lower overall mortality from all health causes [54, 79, 181]. According to the International Center for Alcohol Policies, for moderate drinkers, a decrease in risk has been described for several conditions, including coronary heart and other cardiovascular disease, as well as Type II diabetes [82]. On the other hand, excessive alcohol consumption contributes to a variety of health and social problems, including unintentional injuries, suicide, homicide, liver cirrhosis, gastrointestinal cancers, vandalism and lost productivity [177].

Mokdad states that excessive alcohol consumption is the third-leading actual case of death in the US and each year it accounts for approximately 79000 deaths [113, 58].

Statistical data presented by the World Health Organisation (WHO) demonstrates that alcohol consumption varies depending on culture, religion, economic well-being of the population. In Germany average alcohol consumption per capita consists 11,8 liters of pure alcohol in the period 2008-2010, in USA the amount of alcohol consumed is 9,2 liters per capita. According to the data presented by WHO, in the Republic of Moldova alcohol consumption per capita consists 16,8 liters compared to the period 2003-2005 in which alcohol per capita consumption was equal to 13,8 liters [137]. Doubtless, diseases and injuries attributed to alcohol kill millions and harm tens of millions of people worldwide [70]. Only in the Republic of Moldova approximately 50% of all road traffic accidents are result of alcohol abuse [137]. But the death and injury that strike at all strata of society can be reduced through prevention and treatment policies adopted and enforced by governments [70].

According to the WHO, "alcohol policy" is a collective noun, refers to the set of measures in a jurisdiction of society aimed at minimizing the health and social harms from alcohol consumption [162]. One of most effective policies is restriction on the availability of alcohol which encloses the restriction of sales and consumption by people below a legal drinking age [187]. Such restrictions may apply to alcohol purchased and consumed in the same place or alcohol purchased for consumption elsewhere. Statistical data presented in country profiles (by WHO) shows that in the Republic of Moldova national legal minimum age for on-/off- premise sales of alcoholic beverages is 18 years, in USA minimum age consists 21 years old. Age restrictions were as low as 15 years in Angola and as high as 25 years in Nepal [70].

In order to reduce road traffic accidents, the maximum blood concentration (BAC) was set by governments. According to Blomberg et. al the risk of traffic accidents begins to increase at a blood alcohol concentration of 0,04% [24]. For example, in Brasil drivers caught with a BAC of 0,2 g/l can be arrested and criminally charged of up to three years in prison and suspension of the offender's driver's license for one year [42]. In the Republic of Moldova national maximum legal blood alcohol concentration when driving a vehicle is 0,03% [137].

Countries use a wide range of policies to control alcohol advertising and marketing. For example, Belarus moved from a partial to s full ban on advertising of wine and spirits, Estonia shifted from a partial to a full ban on television advertising of wine, beer and spirits [70]. Other areas in which countries have moved to restrict alcohol marketing include bans on product placement, either on public or private television, complete or partial restrictions on industry sponsorship of sporting events and restrictions on sales promotions in the form of sales below cost [70].

Taxation is one of the most effective strategies for reducing consumption of alcohol at the population level [188]. Various studies carried by Smith, Cnossen, Rabinovich found a negative elasticity of alcohol consumption on price, meaning that an increase in the price of alcohol beverages induces a decrease in consumption [41, 133, 171]. Elasticity varies depending on the type of alcohol beverage, i.e. the lowest is mainly on beer and the highest on spirits [172]. For example, in the USA excise taxes on spirits are almost three times the rate of tax on still wine and over two times on beer [62, 83]. Furthermore, tax revenues from excise and other taxes on the production and sale of beverage alcohol can be an important source of government revenue in many countries [83]. For example in the former Soviet Union, excise taxes on beverage alcohol accounted for between 12-14% of all state revenue [52]. In Australia revenue from the taxation of alcohol in 2008-2009 is estimated at 6,1 billion dollars [189]. There is a wide variation between tax rates between countries and between alcohol types. According to the Alcohol and Tobacco Tax and Trade Burreau of the US federal wine excise rates are the following: 1,07$ per gallon for wine with less than 14% vol and 1,57$ per gallon for wine with alcohol between 14% vol to 21% vol. [11].

Increased taxation rates, health policies carried by governments have the indirect influence on consumer demand for low-alcohol wines. Research assessing demand for low-alcohol wine under different tax regimes in Australia using a discrete choice experiment, found that 6 - 8% of their respondents would adopt low-alcohol wine alternatives [115]. Lechmere states that in the US, Germany and the UK around 22% preferred wine with 10,5% vol alcohol by volume or less. China's results show that 91% from respondents desire a wine with 8,5%-10% vol. [100]. The adoption of wine products with lower alcohol content allows the enjoyment of wine, the corollary of this is that the wine industry may sell a greater volume of wine, thus helping industry profitability [155].

According to Rowley beverage preferences are tending toward lighter styles, i.e. light-bodied white, rose, Moscato wines and "substantial growth in the volume of wine exported with lower alcohol content" [147, 193]. Sophie Meillon et al. in the study regarding preference and acceptability of partially dealcoholized white and red wines points, that wine professionals did not like reduced-alcohol wines, whereas consumer likings were less clear and masked a strong segmentation. Experienced wine consumers behaved more like wine professionals and did not like reduced-alcohol wines, whereas other consumers liked the sensory properties of reduced alcohol wines [108]. Antony Saliba et al. states that negative attitudes to low-alcohol wine are linked, first of all, to the undesirable alterations in taste, but if these alterations could be made while preserving the taste and aroma of wine, consumers are much more willing to purchase them [154]. Furthermore, consumers didn't know what low-alcohol wine to be. For example, in Australia 17% of sample perceived a low alcohol wine to contain around 3-8% vol. alcohol, while 17,2% perceived low alcohol wine to contain approximately 1-2% vol. alcohol [154]. Moreover, consumers believe that dealcoholization process induces a loss in wine authenticity and tradition. Some consumers had a "tampering with" feeling and worried about dealcoholized wines that are excessively manipulated and about the final wine quality and long term storage consequences [109].

Thus, low-alcohol wines are in growing demand amongst consumers in consequence of health policies adopted and implemented by governments and promoting of healthy lifestyle by

WHO. However, special attention should be given to the problem of quality in order to obtain high quality wines with low-alcohol content.

1.2 Analysis and characteristics of the methods for low alcohol wines production

1.2.1 Utilization of viticultural and prefermentation practices for low alcohol wine production

Grape quality is a complex trait that mainly refers to berry chemical composition, including sugars, acids, phenolics and other aroma compounds [43] as well as playing a crucial role in shaping wine quality and determine the alcohol content of the wine, providing precursors for other compounds (e.g. anthocyanins) and regulate their synthesis [8, 186]. According to Schultz and Jones global warming could alter grape composition and physiology increasing berry sugar content and final alcoholic level in wines [159]. It is well known that elevate temperatures during berry ripening induce faster pulp maturation and enhance must total soluble solids and pH [118].

These considerations as to high alcohol levels in wines stimulate great attention in improvement of the technologies for reducing alcohol content of wines by conserving organoleptic balance, flavour and high quality. Over the past few decades, different production technologies for low alcohol wines manufacturing have been developed. However, the simplest way to avoid excess alcohol production during vinification is to start from berries containing the right amount of sugars [25]. A wide range of factors significantly affect sugar accumulation in the grape such as choice of vineyard site, soil composition, irrigation strategy, rootstocks, grape varieties, grape yield and leaf area managements [118].

Hence, scientists have developed and implemented different viticultural technologies on the basis of physiology and environmental factors of grape cultivation. Vittorio Novello presented a review of viticultural strategies for low alcohol wine production wherein the most obvious strategy to reduce alcohol level in wines is to reduce sugar content by increasing yield by means of enhancing the bud load, lowering cluster thinning and choosing a vigorous rootstock. Nevertheless, the yield increment should be carefully assessed and modulated in order to limit possible detrimental effects on wine quality [118, 87].

Another technique used in order to reduce sugar concentration in grapes is irrigation. It is thought that the temperature of the grapevine canopy can be reduced by up to 15°C through irrigation [53]. This practice includes a significant delay in the ripening of high crop loads and a prolonged maturation period might extend beyond the onset of autumn-winter rains [44]. Therefore, increase of water supply may cause dilution of phenols at the same time.

Grape sugar accumulation may be taken under control by basal leaf removal since it has a negative influence on sugar accumulation [96]. Contrary to limiting sugar accumulation, it evidently has a positive effect on phenolic development due to the fact that leaf removal increases rate of enzymatic activity responsible for the synthesis of phenolic compounds [51, 121].

Jakab and Bordenave stated that exploration of the genetic capacity of different autochtonous cultivars and clonal selection are the strategies that may be used to adapt the plant material to climate change. This may concern the rootstock, which control the vigour of the plant and scion. For example, Jakab and col. studied the influence of different rootstocks (125AA, Fercal, Richter 110, Ruggeri 140, Teleki 5BB and Teleki5C) on sugar accumulation of two varieties Chardonnay and Sauvignon Blanc. According to the obtained results, the lowest sugar content was observed on Teleki 5C for both varieties [25, 88].

Soil composition of vineyard and selection of vineyard location are also significant for proper ripening. According to Salomon excessive amount of nitrogen can lead to increased grapevine production, with the result of lower sugar accumulation and decrease in total fruit quality [153]. As to selection of vineyard location, the slopes shaded by mountains or having fewer sun exposures should be preferred since they have a tendency to be cooler. Furthermore, the fields exposed to some wind are appropriate for controlling the sugar accumulation by lowering the environmental temperature [170].

Except these methods, ‘‘double harvest’’technique could be put forward to reduce wine alcohol concentration. Therefore, this technique is based on a sequencing harvest consisting of green and normal maturity harvest. The must of grapes coming from bunch thinning at green harvest performed at veraison is conserved and blended with that of grapes harvested at normal maturity as a result lower alcohol wine with higher titratable acidity is obtained [105, 118, 121]. Among techniques aiming at slow down grape maturation, the use of plant growth regulators such as abscisic acid, ethylene, forchlorfenuron and auxin may be proposed. Forchlorfenuron, applied at pre-veraison stage, is able to reduce total soluble solid concentration and berry skin colour [73].

The application of shade nets over the vine canopy reduces the photosynthetic photon flux at the leaf surface available for photosynthetic process. At harvest, vine productivity decreased only by 14%, but sugar content decreased by 2-3% (from 21,9°Brix to 16,8 °Brix) [122].

Limiting excessive alcohol production prior to fermentation is possible by using various techniques aiming at reduction or alternation of fermentable sugar content and composition of the must [17, 153, 161].

Among these systems nanofiltration membranes have been utilised to remove sugar from must prior to fermentation. According to a study performed by Martin et al., it is reported that successful results were obtained by using control must and permeate mixture in wine making via two-step nanofiltration [67]. Adequate alcohol reduction (2%) was achieved with little color and aroma loss. It is suggested that reducing filtration time by increasing membrane area or applied pressure may be helpful for satisfactory sensory quality [67].

Glucose oxidase (GOX) enzyme treatment of the must is another popular technique for the purpose of reducing alcohol level of wine [129]. Glucose oxidase (β-D-glucoseoxygen 1-oxidoreductase) catalyzes the oxidation of β-D-glucose to gluconic acid and hydrogen peroxide. In this reaction molecular oxygen is used as an electron acceptor [85]. The conventional GOX enzyme is purified from various fungal sources mainly genus *Aspergillus and Penicillium*, of which *A. nigeris* the most commonly used in enzyme production [15, 132]. Since the optimum pH ranges for GOX from *A. nigeris* known within the limit of 3,5–6,5, the low pH musts is found a limiting factor of GOX performance. Therefore raising the pH of must via calcium carbonate before GOX treatment has been found effective in time saving and increasing the degree of glucose conversion [129].

According to a research performed with synthetic grape juice, the reduction in alcohol levels has been reached to 1 and 1,3% alcohol at pH 3,5 and pH 5 respectively in aerated (8 mg/dm^3 O_2) synthetic grape juice by using 30 kU enzyme [23]. Because of gluconic acid produced with the action of GOX, titratable acidy of the musts have been increased with a simultaneous decrease of pH. The aeration time of the must is recommended to be as short as possible with respect to microbial stability, aroma loss (especially fruity aroma) and processing costs [121, 127, 128].

Thus, a wide range of viticultural and prefermentation practices allows alcohol content reduction in wines. However, application of these practices is very difficult to control and should be carefully assessed and modulated in order to limit possible detrimental effects on wine quality.

1.2.2 Utilization of microbiological strategies for reduction alcohol levels in wine

The reduction of the alcohol content in wine has become a major objective in most winemaking areas worldwide. Since two decades, various strategies have been considered including the improvement of viticulture or winemaking practices, the development of physical approaches and the generation of low alcohol yeasts. The development of low-alcohol yeasts is a current challenge in wine industry since wines have more and more ethanol contents. During the last years, researchers have been investigating *Saccharomyces cerevisiae* metabolism to reduce the yield ethanol/sugar consumed [19]. As microbial strategy is an easy to implement and costless option, metabolic engineering of *Saccharomyces cerevisiae* for reduced ethanol production has been a very active field for the past two decades [179].

Different microbiological approaches in order to obtain wines with low alcohol content were used: metabolic engineering strategies or GMO strategies diverting sugar metabolism towards products other than ethanol [34, 57, 135] and more recently an adaptive evolution-based strategy [32, 33]. Moreover, an alternative to these approaches is to select low-ethanol producers of *Saccharomyces cerevisiae* or non-*Saccharomyces* species or to use mixed fermentations in order to reduce the alcohol production. [19, 59, 106].

Metabolic engineering strategies are based on the conversion of sugars into metabolites that cannot be fermented, thereby rendering it unavailable for ethanol production (e.g.expression of a glucose oxidase) or the modification of the central carbon pathway to divert carbons away from ethanol production, thereby resulting in the accumulation of other end-products [179]. Delquin and Barre studied the expression of a NADH-dependent bacterial lactate dehydrogenase (LDH) in S. *cerevisiae* [47]. In these cells, pyruvate is rerouted towards the formation of lactic acid at the detriment of the alcohol pathway, but in order to reduce substantially the ethanol yield, an amount of lactate, highly above acceptable levels in wine (> 10 g/dm^3), has to be produced [47, 179].

Another strategy investigated by Heux has been based on the expression of a bacterial NADH oxidase in yeast in order to reduce the intracellular level of NADH by introducing a system for NADH utilization which competes with the fermentative alcohol dehydrogenase [77]. This strategy allowed a 15% reduction in the ethanol yield under microaerobic conditions, accompanied by decreased fermentation rate, increased acetaldehyde production and stuck fermentation [77]. However, oxidized compounds were accumulated in wine as a result of the requirement for soluble oxygen to be supplied during fermentation [101].

Most effort in recombinant technologies for manipulation of wine yeasts has targeted increasing glycerol production at the expense of ethanol and has required multiple modifications. [45, 69, 101]. However, rerouting carbons towards glycerol led to a substantial decrease in ethanol [45, 110, 135] and concomitant concentrations of acetate, succinate, acetoin, acetaldehyde and 2,3- butandiol has increased [26].

An alternative approach to rational engineering is the selection of yeast variants using adaptive evolution. Adaptive evolution involves culturing yeast populations over a long period of time in selective condition. Adaptive evolution is based on the property of microorganisms to adapt rapidly to different environmental conditions [179]. Adaptive evolution can be applied by diversion of carbons towards the pentose phosphate (PP) pathway leading to lower availability of carbons for ethanol production by elimination of carbons in the form of CO_2 and reduced acetate production and increased ester formation. The other approach in this technique is culturing yeast populations in selective conditions like sulfite at alkaline pH, under hyperosmotic stress by high osmolority glycerol or in the presence of methylglyoxal over a long period of time. Evolutionary engineered yeasts with sugars diverted towards glycerol and 2,3- butanediol have ability to reduce the alcohol content of wine by 0,5 to 1% vol. [121, 179].

In the study conducted by Tilloy et al. adaptive laboratory evolution to develop low-alcohol wine yeasts by redirecting the metabolism of strain EC1118 toward glycerol was used. Yeast cultures were serially transferred under hyperosmotic conditions during 450 generations using KCl as osmotic and salt stress agent. As a result commercial yeast strain with low ethanol and high glycerol yield was obtained [180].

Another approach is to select low-ethanol producers in *Saccharomyces cerevisiae* or non-*Saccharomyces* species by screening wild yeast population or to use breeding strategies [19, 106]. According to Bely *Candida Zemplinina* can be used in the mixed fermentations with *S. cerevisiae* in order to reduce alcohol production [19].

Erten et al. examined aerobic yeasts of the genera *Pichia* and *Williopsis* for their ability to produce approximately 3% vol ethanol and a good estery and fruity flavor. According to the obtained results *Pichia subpelliculosa* and *Williopsis saturnus* produced significantly better quality wine with reduced alcoholic content [59].

In the Republic of Moldova the problem of obtaining wines with low alcohol content using immobilized yeast was studied by prof. Balanuța [1]. As a result of the study a scheme for obtaining of low alcohol wines by using immobilized yeast at alcoholic concentration was developed [1].

According to studied information, application of microbiological strategies has advantages and disadvantages. The main advantage is easy of use of yeasts in the process of fermentation, but the use of different yeast strains (non-Saccharomyces or GMO) for low-alcohol wines production can lead to formation of compounds with detrimental effect on wine quality. Thus, application of microbiological practices is constrained and requires supplementary investigations.

1.3.Physical methods for reducing alcohol content in wines

1.3.1 Membrane based technologies for reducing alcohol content in wines and their characteristics

Membrane based technologies have become a popular tool for wine processing due in part to the flexible configuration of equipment, size, portability and, compared to other technologies, the relatively modest capital requirements for establishing this capacity within wineries [152].

Various technologies in which a membrane is used for the selective removal of ethanol from beverages have been developed that rely upon molecular permeation of ethanol from the feed stock with high concentration, to a stripping phase with low concentration [101]. All membrane processes result in the partitioning of the wine into permeate (i.e. passes through the membrane), and retentate (i.e. retained in the feed) streams [152]. The most prevalent membrane-based technologies for the removal of organic constituents from beverages are reverse osmosis, osmotic distillation, nanofiltration and pervaporation. Presented technologies have advantages and disadvantages. In the table 1 comparative analysis of membrane-based technologies is presented [152].

According to the results presented in table 1.1 membrane separation processes used for alcoholic content reduction from wines differs from each other by size of membrane pores, driving force and separation mechanism. In this regard, every of presented methods has its andvantages and limitations.

Table 1.1 Membrane separation processes of relevance for moderating ethanol concentration [130, 152]

Separation Process	**Approximate size range**	**Separation mechanism**	**Driving force**	**Application**
Nanofiltration	0,5-5 nm	Sieving and charge effects	Pressure	Controlling juice sugar concentration
Reverse osmosis	0,1-1 nm	Transfer through a semipermeable membrane due to pressure	Trans Membrane Pressure	Ethanol removal
Osmotic distillation (evaporative perstraction/membrane contator)	0,03-0,5 nm	Transport of volatile component	Vapour pressure gradient	Controlling juice sugar concentrations Ethanol removal
Pervaporation	Nonporous permselective membrane	Partial vaporization	Difference in partial pressure	Dealcoholization of wine Aroma recovery

Reverse osmosis (RO) is the most used membrane separation process in wine industry for wine dealcoholization. However, the RO membranes allow the permeation of water and ethanol with high operation pressures (60 to 80 bar) which, in addition to considerable energy consumption, brings possible changes of the organoleptic properties of wine [13, 72]. Two streams are obtained from the original wine: one of permeate containing water and ethanol, and one of retentate with the dealcoholized wine. The wine is slightly heated before the entrance to the membrane module from approximately 15ºC (wine storage temperature) to a temperature of 22-25ºC in order to facilitate the ethanol flux, hence, supplementary a heat exchanger is applicable. Cellulose acetate or cellulose triacetate thin film membranes are commonly used for ethanol removal. These membranes have a high water and ethanol permeability and good rejection of compounds with high molecular weight such as proteins, polyphenols and carbohydrates. In the process of dealcoholization the water is removed from wine and significant concentration of wine components occurs. Wine must be restored to the original water concentration and this is usually accomplished by the continuous treatment of the permeate to separate the water and ethanol components, with the water redirected back to the treated wine during operations [152].

Besides this, the reverse osmosis membranes require the use of very high pressures, usually higher than 60 bar, which, in addition to considerable energy consumption, brings about possible changes of the organoleptic properties of the wine [72]. According to Pilipovik and Riverol the capital cost of reverse osmosis is higher and at removal of ethanol to below 0,45% vol. consumes more electricity per liter of ethanol removed [131]. Reverse osmosis does has advantages over the other dealcoholization process. It minimizes thermal degradation of aroma compounds and so preserves the sensory characteristics of wine along with ethanol removal [37, 98].

Osmotic distillation (OD), also referred to as isothermal membrane distillation or evaporative perstraction, is a promising membrane based technique for low to moderate rates of ethanol removal from beverages. The driving force of the process is the partial or vapour pressure differences between volatile solute feed and stripping solutions [184]. In OD the feed stock is circulated through a hydrophobic hollow fibre membrane contactor with the stripping liquid flowing on the opposing side of the membrane. In the removal of ethanol from wine, the stripping fluid is degassed water with hydrophobic membranes (polypropylene or polyvinylidenefluoride) employed to create the pressure differential [50, 184]. Advantages of OD are the following: processing can be conducted at ambient temperatures, without the requirement for high pressure, the unit is simple to build, the process is cost-effective (no heat exchange or pressurization required) and ability to function even with wine alcohol content > 17%. The main disadvantages of the OD: Process efficiency depends on the alcohol content of the wine and the extraction water, risk of wine oxygenation (suitable countermeasures required) and significant change of isotopic ratios [157, 173].

Pervaporation is a separation technique in which a liquid feed is separated by partial vaporization through a nonporous selectively permeable membrane. The feed mixture flows on one side of membrane and part of the feed vaporizes passing through the membrane to the opposite side where a carrier gas, or vacuum, removes the permeate whereupon it is condensed to liquid. An important aspect of pervaporation is a phase transfer of the diffusing compounds from the feed into the permeate [152].

Pervaporation technologies for ethanol removal have not been as widely adopted as osmotic distillation or reverse osmosis, this may possibly be attributed to higher temperatures required to achieve effective ethanol permeation compared to osmotic distillation as temperature elevation will also increase the flux of aroma compounds to the permeate [175]. One report in which a hydrophilic membrane was employed for ethanol reduction to a final concentration of

0,5% vol in Chardonnay resulted in the retention of 80% of the concentration of most aroma compounds [93]. The most obvious use for pervaporation is the recovery of aroma compounds from beverages and the techniques has been applied to both wine and beer before alcohol reduction using another process [35].

Another approach used for dealcoholization process is nanofiltration (NF). Nanofiltration membranes allow higher permeation flows than reverse osmosis membranes and higher permeation of solutes such as ethanol and salts. The use of NF membranes to remove ethanol appears to be advantageous over reverse osmosis since they allow a higher ethanol permeation flow and consequently a lower permeation volume is necessary. Another advantage of the use of this type of membranes is that the permeate is richer in ethanol than that obtained using RO membranes, resulting in a lower difference of osmotic pressures between the retentate and permeate, and so lower working pressures are necessary [124].

These membranes, contrary to reverse osmosis, allow permeation of some salts. Permeation of some ions can be an advantage, as in the case of the acetate ion, as it can be eliminated from the beverage. However, permeation of salts can result in instability of wine. Due to their large molecular weight polyphenols and macromolecules are retained in the retentate, so the body and flavor of wine are unaffected [71].

Thus, membrane based technologies are modern techniques which allows obtaining low-alcohol wines. Nevertheless, application of such techniques includes the necessity of use of the expensive membranes, which require a special care. But in spite of gentle conditions for alcohol removal, a significant aroma losses occurs in the process of dealcoholization, the fact that requires supplementary investigations.

1.3.2 Heat based technologies for reducing alcohol content in wines and their characteristics

In heat treatment processes, ethanol is removed from the original alcoholic beverage by means of heating. At atmospheric pressure, the ethanol boiling point is 78 ºC while water boils at 100 ºC, so applying a temperature lesser than 100 ºC, alcohol evaporates preferentially and its separation from alcoholic beverage is possible – single or multiple stage distillation. However, high temperature is unbeneficial to heat sensitive compounds, which can suffer physical or chemical modifications [94]. These changes lead to a decrease of beverage quality during the dealcoholization process. In order to overcome this disadvantage, it can be applied low pressure or vacuum and consequently the separation of ethanol can be achieved at moderate temperatures (lower than 78 ºC). Some separation processes like: vacuum distillation and spinning cone column (centrifugal distillation) are based on this principle [36, 60, 97].

According to Tomáš Brányik et al., advantages of thermal processes are: the potential to remove alcohol from alcoholic beverage completely, the possibility to commercialize the separated alcohol, the continuous and automatic operation with a short start-up period, and the flexibility in terms of volumetric performance and the input beverage composition [27]. Conversely, the purchase of these systems requires significant investment as well as there is considerable running costs (energy consumption) and some risks of thermal damage or loss of volatiles from beverages [27].

The spinning cone column (SCC) has wide applications in the food and beverage industries for flavour recovery, to preserve the freshness or taste of processed food or drinks, and preparation of concentrates [152].

The SCC is a gas-liquid contacting device composed of a vertical shaft rotating nearly 350 rpm, supporting up to 22 overturned (pointing downwards) cones. Between each pair of cones a stationary cone is attached to the casing of the column. The equipment is used to extract volatile components from a liquid via centrifugal force of rotation and driving force of gaseous flow. A stripping gas, like nitrogen, is allowed to the base of the column and flows through the voids between rotating and fixed cones. The gas is then gathered at the top of the column and exposed to a significant turbulence. Volatile components can be evaporated with the help of negative pressure applied at low temperatures, so that delicate flavors can be recovered [101, 121, 130, 152].

SCC is a two-stage distillation process used industrially for the production of wine with less 1% v/v of ethanol. In the first stage, the aroma compounds are removed at high vacuum conditions (0,04 atm), low temperature (26-28ºC) and collected in a high strength ethanol stream that represents approximately one percent of the original wine volume. The second stage in which ethanol is removed from the base wine is conducted at higher temperatures, usually around 38ºC. After ethanol reduction, the aroma fraction is added to the dealcoholized base wine. A number of ancillary devices are required for the SCC; heat exchangers to warm the product feed to operating temperatures, pumps and condensers to collect the gaseous vapor and collect the removed fraction. Therefore, this means a high capital outlay and operating costs [18].

Vacuum distillation is a method of distillation whereby the pressure above the liquid mixture to be distilled is reduced to less than its vapor pressure (usually less than atmospheric pressure) causing evaporation of the most volatile liquid(s) (those with the lowest boiling points). According to the obtained data, the most volatile compounds in wine are: ethanol and esters [64]. This distillation method works on the principle that boiling occurs when the vapor pressure of a liquid exceeds the ambient pressure. Vacuum distillation is used with or without heating the mixture [182]. It is worth noting that under vacuum, the boiling point of a liquid will be lower than the boiling point at atmospheric pressure. Thus, this property is used in the process of wine dealcoholization.

Another thermal method, although infrequently used, is freeze concentration. Water in wine can be removed by freezing and the alcohol in the residual liquid can be removed by vacuum distillation. Also, the wine can be cooled until crystals are formed, which are separated and late thawed. Low-alcohol wine results that can be adjusted to any alcohol content with the separated alcohol fraction. The process is relatively delicate and expensive [61, 130, 168].

According to studied information, regarding the utilization of thermal methods in the process of dealcoholization can be concluded that as in the case of membrane methods special attention should be given to the problem of wine quality. Thereby, necessity of studying the influence of dealcoholization process using thermal methods and improvement of the quality of obtained wines appeared.

1.3.3 Adsorptive and other methods for low alcohol wine production

Wine can be extracted directly by organic solvents such as pentane and hexane, or the alcohol - and aroma-containing condensate resulting from wine evaporation can be extracted. In both cases, the aroma compounds are largely in solution. Potential disadvantages of direct extraction of wine include thermal damage and, particularly, the presence of solvent residuals in the extract. The process is not used commercially [130].

In the case of liquid– liquid extraction, the solvent must be food-appropriate, and CO_2 is one of the most commonly used. A variation known as high-pressure extraction uses both extraction and distillation principles. Wine is extracted using liquid CO_2, which, under specific pressure and temperature conditions, has properties similar to those of solvents. Through subsequent and differential temperature and pressure adjustments, the extracted wine components precipitate and ethanol and aroma compounds can be separated. The aroma component can be returned later to the extracted wine. The process reportedly results in relatively good-quality products, but can be expensive [168].

Futhermore, in recent years, carbon dioxide (CO_2) extraction has been suggested as a promising alternative to the recovery of aroma compounds from natural matter [126, 150, 165].

On the other side, the removal of ethanol from aqueous solutions using high-pressure carbon dioxide has been comprehensively studied and thus, supercritical fluid extraction has appear as a promising alternative to other conventional dealcoholization of beverages techniques [29, 30, 68, 167]. According to the data presented by Medina et al. supercritical CO_2 extraction is particularly attractive, because water, salts, proteins and carbohydrates are not substantially removed or denatured [107].

Alcohol can be adsorbed onto porous resins such as styrol /divinylbenzol copolymers, or alternatively silica gels can be used. These processes are more suitable for laboratory rather than large-scale production [168, 130].

Another method of alcohol removal from wine is utilization of solid substances that has pores whose diameter allows only ethyl alcohol to pass through and fixes said alcohol by adsorption. In capacity of such substances zeolites, resins can be used.

Zeolites are three-dimensional, cristaline, microporous solids with well defined structures which contain aluminum, silicon and oxygen in their regular framework [28]. Since they have pore size of several angstroms, zeolites are able to separate components of a mixture on the basis of a difference in molecular size (i.e. molecular sieving effect). The zeolite pore size is mainly determined by its unique structure, but it can also be affected by zeolite composition [40].

According to Flanigen and Olson, silicalite-1 and ZSM-5 preferentially adsorb the alcohol from aqueous mixtures, the sorption capacity being about the same for both zeolites. The adsorption on silicalite can be described as physical adsorption [65, 120]. This means that desorption can be achieved under relatively mild conditions. Thermogravimetrical experiments by Milestone and Bibby show an almost complete desorption of adsorbed ethanol at a temperature of 100°C with air as purge gas [76, 111, 112]. The main disadvantage of using zeolites for alcohol removal is that the low effectiveness of the process and its unhandiness.

Processes including adsorption or extraction of ethanol from wine can be considered as alternative methods for low alcohol wine production, but in the same time are noted for their inefficiency. Thus, application of such methods has restricted applicability in production.

1.4.Characteristics of principal classes of wine aromatic compounds

1.4.1. Contribution of aroma compounds to wine quality

Aroma of a wine is one of the major factors that determine its nature and quality and it can be influenced by several factors: environment (soil and climate), grape variety, ripeness, fermentation conditions, biological factors (yeast and other components of the oenological microflora), the wine production process and aging [48, 89, 148, 164]. Main chemical classes of aroma compounds found in wine include esters, alcohols, acids, lactones, carbonyl compounds, acetals, phenols, sulfur containing volatiles, nitrogen-containing volatiles as well as other miscellaneous substances [134, 158].

Some authors attribute the basic odour of wines to four esters (ethyl acetate, isoamyl acetate, ethyl hexanoateand octanoate) and two alcohols, (isobutyl and isoamyl alcohol), all of which are fermentation products [63, 125, 158]. The vast majority of the other compounds typically function to modify the basic odor. The important fermentation-derived aroma compounds found in the highest quantities include 2-methyl-propanol, 3-methyl-butanol, 2-methyl-butanol and 2-phenol ethanol, which collectively account for 50% of the total volatiles [134]. According to Simpson the most important white wine aroma volatiles produced during fermentation are drawn from three chemical classes [169]. Ethyl esters of medium chain fatty acids (ethyl butyrate, hexanoate, octanoate, decanoate and dodecanoate) which are fruity and wine-like; acetate esters that are responsible for tropical fruit and banana-like aromas and a third group of higher alcohols such as isobutanol, isoamyl alcohol and hexanol which are harsh and unpleasant when alone. These compounds are an integral and desirable part of wine aroma if collectively below 300 mg/L.

In the thesis the characteristics of main classes of aroma compounds is presented below.

a) Higher alcohols, fusel alcohols, fusel oils

Alcohols with more than two carbon atoms are known as higher alcohols. Higher alcohols are formed by yeast from sugars or from grape amino acids by the Ehrlich reaction and reach concentrations on the order of 150–550 mg/l in wine [86, 144, 145]. Higher alcohols (fusel alcohols) are generally found to be responsible for aroma due to the fact that they are found in quantities above perception threshold.

Perception threshold varies widely for fusel alcohols with values of 150 mg/dm^3 for butanol to 25-105 mg/dm^3 for 2-phenylethanol [9, 166]. Phenylethanol, is the most important of the benzene-derived higher alcohols, and is also the only fusel alcohol described with positive terms such as sweet, perfumed, and dry rose [169]. The fusel alcohols found in the largest quantity in wine are 1-propanol, 2-methyl-1-propanol (isobutyl alcohol), 2-methyl-1-butanol, and 3-methyl-1-butanol (isoamyl alcohol). Quantitatively, isoamyl alcohol generally accounts for more than 50% of all fusel alcohol fractions [116].

According to Amerine at low levels (< 300 mg/dm^3), straight chain higher alcohols generally add complexity to the bouquet of a wine [9]. Quantities above 400 mg/dm^3 are regarded as negatively impacting wine quality and are frequently described as petroleum or tar-like [21, 134, 146, 194]. In table wines, the fusel alcohol contribution is typically found to range from 140-420 mg/dm^3 [10].

b) Fatty acids

Fatty acids have substantial contribution to wine aroma and contribute for the production of esters, lactones, aldehydes and ketones as a result of α- and β-oxidation [7].

Two different routes have been described for the formation of aliphatic saturated fatty acids in wines, they could be products of fatty acid synthetase complex or of the classic concept of β-oxidation of lipids. It is possible that both reaction mechanisms, degradation owing to β-oxidation in the initial phase of the fermentation as well as anabolic processes, play a role in the formation of these fatty acids [125, 158].

Free or saturated volatile fatty acids generally contribute negative characteristics, but are rarely above their aroma detection threshold [171].

The most important of these compounds is acetic acid, the essential component of volatile acidity. Its concentration, limited by legislation, indicates the extent of bacterial (lactic or acetic) activity and the resulting spoilage of the wine. As yeast forms a little acetic acid, there is some volatile acidity in all wines. Other C-3 (propionic acid) and C−4 acids (butyric acids) are also associated with bacterial spoilage. The C-6, C-8 and C-10 fatty acids are formed by yeast. As they are fermentation inhibitors at concentrations of only a few mg/dm^3, they may be responsible for stuck fermentations.

Unsaturated long-chain fatty acids (C-18, C-20) are related to the sterol family. These compounds are fermentation activators, mainly under anaerobic conditions. The most important of these are oleic (C-18 with one double bond) and linoleic acids (C-18 with two double bonds). They are active in trace amounts and come from the waxy cuticle of grape skins [145].

c) Aldehydes, Ketones

Aldehydes and ketones are carbonyl compounds produced in relatively small amounts in wines and do not play an important role in the creation of varietal wine aromas. Suomalainen and

Keranen showed that aldehydes and keto-acids participate in amino acid synthesis as well as for the formation of fusel alcohols. Aldehydes are formed during wine aging via carbohydrate degradation and originate from lignins [134]. Ketones are related compounds, with the carbonyl functional group located on an internal carbon.

Hexenal and hexenol are found in the most significant quantities and are associated with grassy and herbaceous descriptors of C−6 compounds [145].

Ethanal (acetaldehyde) is the most common aldehyde, it makes up more than 90% of the aldehyde content [119].

According to Schreir acetaldehyde is produced as an intermediary product of yeast metabolism (from pyruvate through irreversible decarboxylation by the pyruvate decarboxylase multienzyme complex) during alcoholic fermentation and as a result of oxidation of ethanol during storage [158]. Concentration of ethanol in newly fermented wine are less than 75 mg/dm^3 with sensory thresholds between 100 and 125 mg/dm^3. At levels above these values acetaldehyde imparts overripe, bruised fruit, and sherry like aromas [56, 194].

Aliphatic ketones are found in wines in small quantities. The most significant are ethyl acetate, acetoin and diacetyl which possesses characteristic odour, for example, diacetyl has the odour of butter. α- and β-ionone are presented in wines in concentrations up to 0,1 g/dm^3 and possesses the odor of the violet [5].

Aldehydes in the aromatic series are also present in wine. The most significant of these are vanillin, associated with barrel aging, which has a distinctive vanilla aroma, syrinaldehyde, cinnamaldehyde, coniferaldehyde etc. Aromatic aldehydes have pleasant fruit aromas and its intensity depends on their structure [5]. Several molecules with ketone functions have been identified, including propanone, butanone and pentanone. As previously mentioned, the most important of these are acetylmethyl carbinol and diacetyl. Finally, a mercaptopentanone has been identified among the specific components of Sauvignon Blanc aroma. The following molecules with several aldehyde or ketone functions have also been identified: glyoxal, methyl-glyoxal, and hydroxypropanedial [145].

d) Esters

The largest qualitative constituents of wines are esters, a condensation product between the carboxyl group of an organic acid and the hydroxyl group of an alcohol or phenol. There are a large number of different alcohols and acids in wine, so the number of possible esters is also very large [145]. More than 160 esters have been specifically identified with many being found in trace amounts with little contribution to wine aroma [145].

Ethyl esters are found in the largest quantities while acetates, though in less quantity, contribute to some of the intensity and quality of wine aroma [183]. These esters identified in the wine are found in the grape, but their main origin is from the secondary metabolism of yeasts during fermentation [158].

Esters based on ethanol and saturated fatty acids such as hexanoic, octanoic and decanoic acids generally contribute to the 'fruity' or 'wine-like' aroma of wine, their presence even at sub-threshold levels having a possible additive effect [9, 169].

Ethyl acetates of fatty acids have very pleasant odors of wax and honey which contribute to the aromatic finesse of white wines. They are present at total concentrations of a few mg/l. Acetic esters of higher alcohols (isoamyl acetate and phenylethyl acetate) should also be included among the fermentation esters. These compounds are present in moderate quantities, but have intense, rather unusual odors (banana, acid drops and apple). They contribute to the aromatic complexity of naturally neutral wines, but may mask some varietal aromas [145].

e) Volatile phenols and sulfur derivates

Among the other volatile products likely to contribute to wine aroma are volatile phenols and sulfur derivatives. The most widely represented compounds are vinyl-4-phenol, vinyl-4-guaiacol, ethyl-4-phenol and ethyl-4-guaiacol. The vinyl-phenols in white wines are formed due to enzymic decarboxylation by yeast of two cinnamic acids (p-coumaric acid and ferulic acid) in must, producing vinyl-4-phenol and vinyl-4-guaiacol, respectively. White wines contain variable quantities of vinyl-phenols but no ethylphenols [145]. On the contrary, red wines only contain small quantities of vinyl-phenols and have variable concentrations of ethyl-phenols. Vinyl- and ethyl-phenols are responsible for certain olfactory defects in wine. The most unpleasant smelling are vinyl-4-phenol (reminiscent of pharmaceuticals, gouache paint and 'Band Aids') and ethyl-4-phenol (stables and sweaty saddles). Vinyl-4-guaiacol (carnations) and ethyl-4-guaiacol (smoky, spicy aromas) are much less unpleasant, but they are unfortunately always associated with vinyl-4-phenol and ethyl-4-phenol, respectively [145].

The presence of sulfur derivatives in must and wine is always a matter of concern for winemakers, who are fully aware of the risk that they may cause unpleasant smells. Some sulfur-based compounds (especially those with thiol functions) make a positive contribution to the varietal aromas of certain grape varieties. The role of 4-methyl-4-mercaptopentanone in

Sauvignon Blanc aroma is well known. However, most sulfur derivatives have a very bad smell and have detection thresholds as low as 1µg/dm^3. These compounds are known as mercaptans, referring to their capacity to be precipitated by mercury salts. Organoleptic defects in wine due to the presence of thiols, or mercaptans, are often associated with a reduced character [145].

So called 'light' volatile sulfur compounds are less significant in reduction defects. Carbonyl sulfide is an odorless substance produced by a reaction between carbon dioxide and H_2S [185]. Dimethyl sulfide, synthesized by yeast from cystine, cysteine or glutathion, has no negative impact on wine aroma. Some authors even consider that it contributes to the bouquet [46, 145]. Although carbon disulfide is not actually perceptible in the concentrations present in wine, at high concentrations it may modify a taster's impression of the aroma. It 'masks' pleasant aromas in wine by raising their perception thresholds and accentuates unpleasant odors.

'Heavy' sulfur compounds in wine have rarely been studied. They are always produced by yeast metabolism during fermentation. The most important of these is undoubtedly methionol. It is produced by yeast from methionine in the must, via deamination, followed by decarboxylation (Ehrlich reaction) [16]. The aldehyde thus formed (methional) is then reduced by an enzyme reaction into an alcohol (methionol). Settling has a decisive influence on methionol concentrations. When a wine develops a reduction defect attributable to heavy sulfur compounds during alcoholic fermentation, its methionol content is always above the perception threshold. This compound therefore plays a major role in the reduction defects caused by yeast.

The 2-mercaptoethanol concentrations of some wines with reduction odors may also be in the vicinity of the perception threshold. This compound, produced by yeast from cysteine in must, may also contribute to the unpleasant odors in certain wines. At concentrations over 90µg/l, 2-methyl-tetrahydrothiophenone tends to mask other flavors [134]. The organoleptic impact of the other heavy sulfur compounds identified in wine is negligible. Indeed, although concentrations are higher in wines with reduction defects, they rarely reach the perception threshold.

Doubtless, aroma and flavor are a wine's most important distinguishing characteristics, which are capable to rely all the fullness and riches of obtained wines. Thus, study of aroma compounds and their concentrations in wine can give us information about wine quality.

1.4.2. Influence of dealcoholization process on aromatic complex of wines and recovery of aroma compounds

Process of ethanol removal by different physical methods has the great influence on aromatic complex of obtained wines. Hence, scientists elaborate new methods and techniques or the complex of techniques in order to reduce aroma losses during the ethanol removal process or to recover of aroma compounds and obtain high quality wines with low alcohol content.

According to Diban process of ethanol removal from wine using membrane contractor lead to significant depletion of wine's aromatic complex. Some flavors such as 2-phenylethanol and 2-phenylethyl acetate keep their initial feed concentrations, but in general the aroma compounds studied suffer a concentration reduction in the feed solution at the outlet of the membrane contactor. Aroma compounds with high value of hydrophobicity, i.e. ethyl octanoate, show adsorption phenomena on the hydrophobic membrane at the beginning of the dealcoholization process [49].

Study carried out by Liguori has shown a significant influence of osmotic distillation technique on aromatic complex of red wines. According to the obtained results after the 1st dealcoholization cycle (6,5% vol.), alcohols class suffered a deep loss (58%) than other aromatic classes, due to the great loss (66%) of isoamyl alcohols. In the subsequent cycles, isoamyl alcohols underwent a further reduction (95% in the 2^{nd}cycle (3,13% vol) up to 99% in the 5th cycle (0,19% vol). The 2-phenylethanol suffered a more gradual decrease, which became higher with greater alcohol removal up to disappear in totally dealcoholized wine. In the 5th cycle (0,19% vol), only some alcohol compounds remained in small amount less than 0,21 mg/dm^3. Esters concentration became lower with the alcohol concentration decrease: the percentage loss was just about 10% in the 1st cycle where ethyl lactate and monoethyl succinate amount remained almost unchanged; on the contrary, ethyl hexanoate, ethyl octanoate, β-phenylethyl acetate, ethyl acetate and isoamyl acetate were lost [103]. The results obtained by Liguori was confirmed by Schmitt, the higher the operating temperature and the higher the volume ratio between feed and strip phase, the higher aroma compounds passage through membrane was observed [157].

According to Margarida Catarino, reverse osmosis influences the aromatic complex in dependence of operation conditions. Higher pressures results in higher aroma rejection (although esters rejection slightly decrease with feed pressure) and in a higher permeate flux, despite ethanol rejection also increases. Low temperatures results in higher rejection to the aroma compounds; however, ethanol rejection increases as well [37].

Membrane technology based on direct osmosis was used to remove the alcohol from wine. According to the presented results a great depletion of wine aroma was observed, especially sweet aroma series suffered major changes in the samples with 0,75% vol and 0,42% vol. alcohol content [102].

According to studied information all the physical methods simultaneous with alcohol removal from wine lead to significant depletion of aromatic complex. A solution for this problem consists in separation of the aromatic compounds from the ethanol, which then are returned to the beverage. Thus, aroma recovery became a serious scientific challenge.

Margarida Catarino et al. studied the use of membrane separation processes for producing wine with low alcohol content by means of reverse osmosis and pervaporation membranes of polyoctylmethylsiloxane supported in polyetherimide were used to recover the aroma compounds before the dealcoholization step, and adding them back to the dealcoholized wine. A

According to the data presented the addition of pervaporated aroma compounds to the dealcoholized wine samples increased the flavour sensations during the wine tasting, making this combined process the one that originates the best dealcoholized wine samples [38].

The coupled operation of osmotic distillation (OD) and vacuum membrane distillation (VMD) for concentration of fruit juices and simultaneous recovery of their aroma compounds was studied. The simulated aqueous fruit juices containing four common aroma compounds were concentrated using osmotic distillation where the feed solution was in contact with a brine solution of $CaCl_2$, through a hydrophobic macroporous membrane contactor. Aroma compounds absorbed in the extraction brine were extracted using a membrane evaporator under vacuum and collected into a cold trap. This way, both concentration and aroma recovery of fruit juices were achieved simultaneously using two hollow fiber membrane modules [75].

Another technique described by Nazely Diban is evaporative pertraction (EP) process which has been experimentally and theoretically analyzed resulting in a mathematical model and set of parameters that can be used to search for the optimum operational conditions as a function of the feed wine characteristics. As a result under the selected working conditions the model predicts aroma compound losses below 20% whereas keeping the dealcoholization ratio, thus showing a huge improvement in comparison with other used techniques [50].

Supercritical CO_2 extraction is potential methods for used for recovery of aroma compounds from wine. Alejandro Ruiz-Rodríguez et al. elaborated the optimal technological conditions (9,5 MPa and 313 K) for extraction of aromatic substances with subsequent restitution in dealcoholized wine. As a result the two-step process was applied to rose wine and the low-alcohol beverage obtained proved to have similar antioxidant activity and similar aroma profile to that of the original wine [150].

Adélio Miguel Magalhães Mendes et al. patented the invention regarding the process for enriching the aroma profile of beverages, especially beer and wine, by means of extraction, using pervaporation, of aromas from the original beverage and subsequent addition of the extracted aromas to the beverage, after total or partial dealcoholization. The process of obtaining low-alcohol wine is performed in two steps: the original beverage is fed to the membrane separation module wherein the permeate side is under vacuum, provided by a vacuum pump. The feed contacts with the membrane surface and the aromas are selectively permeated to the permeate side of the membrane, where they suffer evaporation. The vapor permeate stream is condensed at an appropriate temperature, which can be cryogenic. After the aroma extraction, the beverage is fed to a dealcoholization unit for obtaining a non-alcoholic drink, however depleted in aroma compounds. Finally, the extracted aromas are added to the dealcoholized beverage, thus an aroma enriched product being obtained without considerably increasing its alcohol content [123].

According to the studied information, regarding the influence of dealcoholization process on aroma compounds of wines shows a significant influence of physical methods on aroma losses in the process of dealcoholization. However, there is no complete study regarding the influence of different regimes of vacuum distillation process on concentration of aroma compounds.

1.5. Conclusions to the chapter 1

In recent decades intensive development of global winemaking is observed using of new technologies in viticulture and winemaking industry. The main emphasis of the modern winemaking is made on production of competitive products and diversification of alcoholic beverages for the purpose of consumers attracting. In this chapter, information regarding the factors influencing low alcohol wine production as well as classification of methods and techniques is presented.

On the basis of studied scientific literature, several factors determined production of low-alcohol wines: economical factor, which involves receiving of profit through product diversification or reduction of excise taxes on alcoholic beverages; social factor is related to health policies, which include healthy life promotion and minimizing the social harms from alcohol consumption; environmental factor represents combating with consequences of global warming. Therefore, production of wines with low alcohol content is of interest not only from economic and social, but also from scientific point of view.

The central problem in the process of low alcohol wine production according to different opinions is quality of obtained wines. According to present scientific study, process of alcohol removal from wines is followed by changes in chemical composition of wines, especially in aromatic complex, which plays an important role in quality and perception of wine.

The problem of present research, which arises from literature review, consists in necessity of study the influence of alcohol removal process from wines using vacuum distillation method on physical and chemical composition as well as on quality of obtained product.

In order to achieve the main purpose of research the following objectives should be resolved:

- Scientific substantiation of optimal regimes for ethanol removal process from white and red dry wines using vacuum distillation method ;
- Study the influence of ethanol removal process on physical and chemical composition of obtained white and red dry wines with reduced alcoholic content;
- Study the influence of technological regimes of ethanol removal process on aromatic complex of obtained white dry wines;
- Study the influence of ethanol removal process on stability of obtained white and red dry wines;
- Study the influence of ethanol removal process on sensory characteristics of obtained white and red dry wines;
- Study the techniques for decreasing of aroma losses in the process of ethanol removal ;
- Elaboration and implementation the improved technology for low alcohol white and red dry wine production in industry conditions.

2. MATERIALS AND METHODS OF RESEARCH

2.1 Materials of research

Research methodology consists in performing of complex research for determining the influence of different technological factors of dealcoholization process (temperature, pressure, processing time, volume et al) on physical-chemical, biochemical and sensory indices of white and red dry wines with corrected alcoholic content. In order to study the influence of temperatures on physical-chemical composition as well as on quality of obtained white and red wines an interval of temperatures from 20ºC to 50ºC was studied. In the thesis pressure varies fron 40 kPa to 4 kPa in order to determine the optimal rate of ethanol removal process. Processing time varies from 5 to 120 min for white wines and from 5 to 35 min for red wines in order to study the dynamics of the dealcoholization process. In order to study the rate of ethanol removal process in dependence of wine volume, the different volumes of wine varying from 0,25 to 1 dm^3 was studied. Research regarding the influence of dealcoholization process using vacuum distillation on the quality of obtained wines was carried out in the laboratories of "Biotechnology and Microbiology of Wine", "Quality testing of alcoholic beverages", in the department of Microvinification at the Scientific and Practical Institute of Horticulture and Food Technologies, at the wine factories "Asconi" LTD and "Nectar S" LTD, as well as, in the laboratory "Wine Technology" of the North Caucasian Region Research Institute of Horticulture and Viticulture from Krasnodar (Russian Federation).

In the capacity of subjects of research experimental batches of white and red wines from Aligote, Chardonnay and Merlot grape varieties of italian clones, which in conditions of SPIHFT accumulate considerable amount of sugars (above 220 – 240 g/dm^3) and wine materials with excess of alcohol are obtained (above 13,5% vol.) as well as partial dealcoholized white and red wines with different alcohol content was used.

2.2. Methods of research

2.2.1 Operational principle of rotary vacuum evaporator for production of wines with low alcohol content

Rotary evaporation is the process of reducing the volume of a solvent by distributing it as a thin film across the interior of a vessel at elevated temperature and reduced pressure. This promotes the rapid removal of excess solvent from less volatile samples. In the process of ethanol removal rotary evaporator which have four major components: heat bath, rotor, condenser, and solvent trap was used. Additionally an aspirator or vacuum pump was attached, as well as a bump trap and round bottom flask containing the sample to be concentrated. Schematic illustration of rotary vacuum evaporator is presented on fig. 2.1.

The sequence of operations of working process on a rotary vacuum evaporator is the following:

The wine to be processed in the rotary evaporator is poured into the "pot", typically a round bottom flask. Next, cold water is circulated through the condenser to condense the alcoholic fumes on the condenser coils and to prevent, as much as possible, the volatile solvent from vaporizing into the vacuum pump.

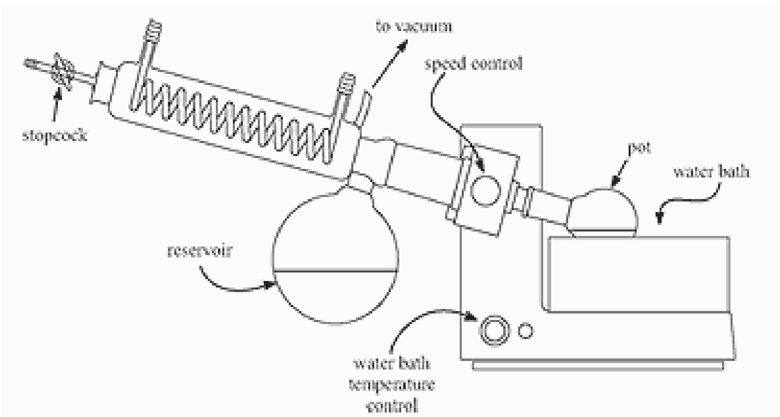

Fig. 2.1. Individual parts of the evaporator and their location

Then the condenser stopcock is turned at a 90 degree angle to the glass tube in the stopcock to instate the vacuum whereby the system is closed and after this the vacuum pump should be turned on full force.

The flask should be when rotated by turning on the appropriate dial. The distillation flask is immersed and indirectly heated by the water bath to which the necessary energy is fed in a regulated way by an electrical heating unit. Evaporation takes place in the externally heated distillation flask. In this way the rotational movement of the piston ensures a good intermixing of the medium, thus providing regular temperature distribution and thereby reduce the distillation time and the heating power, moreover rotation minimizes a phenomenon known as 'bumping" - an intermittent, uncontrolled boiling.

Alcohol vapors abandons the distillation flask and flows through a sleeve shaft feeding through the drive and reaches the condenser part there it is condensed in the condenser and cooled in cooler in the upper part of which is an entrance of the vacuum line (i.e., pumping air) and drains into the receiver flask.

On completing the dealcoholization process, the following steps are performed:

1. Raising the flask from the warm water bath. The rotation of the flask should be stopped and the stopcock is opened;
2. The vacuum pump is turned off ;
3. Removing the receiver flask and the distillation flask.

The wine remained in the distillation flask represents dealcoholized wine, and receiving flask contains condensed ethyl alcoholic vapors.

2.2.2. Instrumental procedure for routine measurement of all the main quality parameters of must and wine by using of FOSS WineScan$^{TM}SO_2$ (Denmark)

The WineScan measures multiple parameters of wine and must using Fourier Transform InfraRed (FTIR) technology to scan a wine sample.

FOSS WineScan$^{TM}SO_2$ is a FTIR spectrometer, which consists of a source, interferometer, sample compartment, detector, amplifier, A/D convertor, and a computer. FTIR is a method of obtaining infrared spectra by first collecting an interferogram of a sample signal using an interferometer, and then performing a Fourier Transform (FT) on the interferogram to obtain the spectrum. An FT-IR Spectrometer collects and digitizes the interferogram, performs the FT function, and displays the spectrum.

The source generates radiation which passes the sample through the interferometer and reaches the detector. Then the signal is amplified and converted to digital signal by the amplifier and analog-to-digital converter, respectively. Eventually, the signal is transferred to a computer in which Fourier transform is carried out [2].

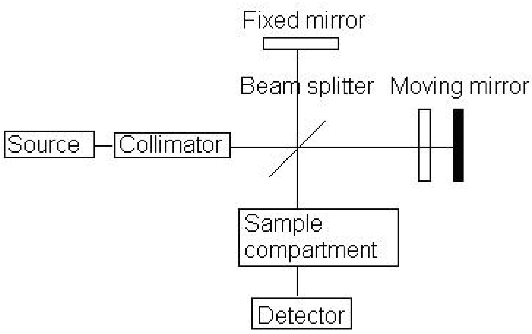

Fig. 2.2. Block diagram of an FTIR spectrometer

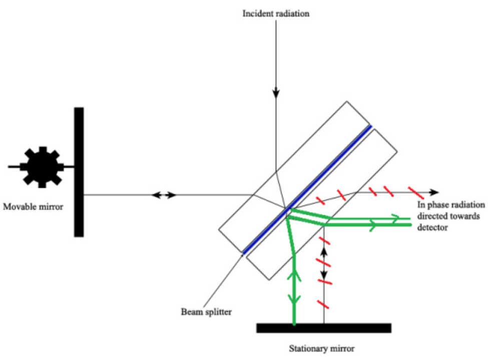

Fig.2.3. Schematic of the Michelson interferometer

An FT-IR is typically based on The Michelson Interferometer Experimental Setup; an example is shown in Fig. 2.3. The interferometer consists of a beam splitter, a fixed mirror, and a mirror that translates back and forth, very precisely. The beam splitter is made of a special material that transmits half of the radiation striking it and reflects the other half. Radiation from the source strikes the beam splitter and separates into two beams. One beam is transmitted through the beam splitter to the fixed mirror and the second is reflected off the beam splitter to the moving mirror. The fixed and moving mirrors reflect the radiation back to the beam splitter. Again, half of this reflected radiation is transmitted and half is reflected at the beam splitter, resulting in one beam passing to the detector and the second back to the source [2].

The interferogram obtained is a plot of the intensity of signal versus Optical Path Difference (OPD). A Fourier transform can be viewed as the inversion of the independent variable of a function. Thus, Fourier transform of the interferogram can be viewed as the inversion of OPD. The unit of OPD is centimeter, so the inversion of OPD has a unit of inverse centimeters, cm^{-1}. Inverse centimeters are also known as wavenumbers. After the Fourier transform, a plot of intensity of signal versus wavenumber is produced. Such a plot is an IR spectrum.

Prior to determination of analytical parameters of wine, a stage of sample preparation is required. 50 ml of wine to be analysed is filtrated, in order to obtain brilliantly clear wine, then poured into the glass and supposed to analysis.

2.2.3 Determination of volatile complex of wines

Analysis of volatile complex of partial dealcoholized wines and wines with corrected alcoholic content was performed using Gas chromatography–mass spectrometry method (GC-MS) in the laboratory "Wine Technology" of the North Caucasian Region Research Institute of Horticulture and Viticulture, Russian Federation (Krasnodar).

At the first stage, a process of solid-phase extraction (SPE) of volatile compounds from wine was performed. For solid-phase extraction cartridges of type ISOLUTE® C18/ENV + (Biotage, Switzerland) which contains two sorbents: hydroxylated copolymer of polystyrene-divinylbenzene and supplementary an adsorption film with reversed-phase were used [4].

Before the use, a stage of cartridge preparation is required by its washing of several times with 5 cm^3 of methylene chloride solution, then with 5 cm^3 of ethyl alcohol (concentration of 96% vol.), and finally with 10 cm^3 of water-alcohol solution (10% vol.).

Preparation of wine sample for the extraction process includes the following steps:

- 25 cm^3 of wine were diluted with distilled water to an alcoholic content to not exceed 10% vol.

- 5 g of ammonium sulfate (with mixing till complete dissolution) were added to the diluted wine.

- 5 cm^3 of standard solution (mixture of 2-heptanol and cyclohexanol) with the concentration 5 mg/dm^3 were added to the analyzed sample.

The sample prepared for analysis is passed through the cartridge at the velocity of one drop per second, and then the cartridge is washed with 10 cm^3 of 10% vol. water-alcohol solution and dried under air stream for 15 min. Elution of volatiles adsorbed on the surface of the cartridge is carried out with a mixture of ethyl acetate and methylene chloride in a ratio of 1:1 by volume (3 cm^3 of each). 0,5-1 g of anhydrous sodium sulfate was added to the obtained eluate, with subsequent transfer of obtained eluate in another flask and it is subjected to concentration in a stream of air to the volume of 0,5 cm^3.

The concentrated eluate was injected into the gas chromatograph with mass spectrometer Clarus 600T (Perkin Elmer, USA) equipped with a capillary column of ETR Elite-WAX type (with 50 m length, 0,32 mm inner diameter and 1 µm thickness, stationary phase being polyethylene glycol) (Perkin Elmer, USA). Initial temperature of programming cycle is 75°C, with a subsequent increase ramp of 4°C/min up to a final temperature of 225°C. The mass spectrometer operates at electron impact (EI), 70 eV and quantitative analysis took place in SCAN mode at the 20-300 amu. Overall analysis time constituted 60 minutes. Identification of chromatographic peaks was performed according to the general library of mass spectra NIST [4].

2.2.4 Conventional and standard methods of analysis

Physical and chemical composition of partial dealcoholized wines and wines with corrected alcoholic content was carried out using conventional and standard methods of analysis, which includes:

- SM GOST R 51621:2008 Method for determination of the mass concentration of titratable acidity;
- SM GOST R 51653:2010 Method for determination of the alcoholic concentration;
- SM GOST R 51654:2012 Method for determination of the mass concentration of volatile acidity;
- SM GOST R 51655:2008 Method for determination of the mass concentration of the sulphur dioxide (free and total);

- GOST 13192-73 Method for determination of sugars;
- pH in wines was determined by potentiometric method using pH-meter Metler Toledo;
- Concentration of phenolic compounds and antocyans in red wines was determined by spectrophotometric method using Folin's Ciocalteu reagent;
- Antioxidant and biologic active compounds in red wines was determined using method of liquid cromatography by Cromatograph Shimadzu using cromatography column C18 and UV detector;
- Kalium concentration was determined using flame emission spectroscopy.
- Crystal, colloidal, protein, phenolic, bio-chemical and microbiological stability of initial and partial dealcoholizaed wines was determined by methods developed by Institute of Vine and Wine „Magarach" (Yalta, Crimea);
- Concentration of organic acids was determined by the method of gas cromatography.

2.2.5. Organoleptic evaluation of white and red wines with reduced alcohol content

Organoleptic evaluation of obtained partial dealcoholized wines and wines with corrected alcoholic content was performed using discrimination and descriptive tests by the panel of 11 professionals (2 male and 9 female) at the SPIHFT. Discrimination test included triangle and ranking tests and descriptive test consists in performing sensory profiling.

Triangle test is a procedure for determining whether a perceptible sensory difference or similarity exists between samples of two wines. The method is a forced-choice procedure. The method applies whether a difference can exist in a single sensory attribute or in several attributes. Samples are prepared in all six combinations in threes (i.e. AAB, ABA, BAA, BBA, BAB, ABB) and then the panel members test the samples and identify the odd sample. In the result the number of "correct" responses counted.

Ranking test is a method for sensory evaluation with the aim of placing a series of test samples in rank order. This method allows for assessing differences among several samples of wine based on the intensity of a single attribute, of several attributes or of an overall impression. It is used to find if differences exist amongst the samples of white and red wines.

Descriptive sensory test is the most comprehensive and informative test used in sensory evaluation. Descriptive tests enable researchers to characterize their products through selective, critical scoring of specific attributes of each product. The descriptive techniques are frequently used for developing new products and for quality assurance.

Sensory profiling is a descriptive method where a group of highly trained panelist works together to develop the vocabulary needed to provide specific descriptions of beverage samples. This technique is used to detail the specific flavors (flavor profiling) or textures (texture profiling) of a beverage.

2.2.6. Statistical and mathematical analysis of the obtained results

Determination of physical-chemical indices of white and red wines was conducted in 3 replications. For each sample the confidence interval was calculated.

Determination of the confidence interval for a mean includes the following steps [84]:

1. Selection of the data and calculation of the mean:

   $\bar{X}= (X_1+\ldots+X_i)/n$, where (2.1)

   $X\ldots X_i$- each value in the sample

   n- the number of values (sample size)

   $\bar{X}$ - the mean of the values

2. Calculation of $|X_i-\bar{X}|$ for each value in the sample

3. Calculation of $\sum(X_i-\bar{X})^2$

   $\sum(X_i-\bar{X})^2= (X_1-\bar{X})^2+ (X_2-\bar{X})^2+\ldots+ (X_i-\bar{X})^2$ (2.2)

4. Calculation of sample variance and standard deviation of a sample:

   $S^2=\frac{1}{n-1}\sum_{i=1}^{n}(X_i-\bar{X})^2$ (2.3)

   $S=\sqrt{S^2}$ (2.4)

5. Calculation of confidence interval for a mean:

   $(\bar{X} - t_{\alpha,\, n-1}\frac{s}{\sqrt{n}};\ \bar{X} + t_{\alpha,\, n-1}\frac{s}{\sqrt{n}})$, where (2.5)

   $\bar{X}$ - the mean of the values,

   $t_{\alpha,n-1}$– Student's t-distribution,

   s - standard deviation,

   n-the number of values (sample size).

Multiple regression analysis is used to predict, estimate of an unknown Y value corresponding to a set of X values or to try to understand the functional relationships between the dependent and independent variables, to try to see what might be causing the variation in the dependent variable [84].

The multiple regression equation:

$$Y_j = a + b_1X_{1j} + b_2X_{2j} + ... + b_nX_{nj} + e_j, \quad (2.6)$$

where:

Y_j - is the predicted value of the dependent variable,

a - is a constant term (intercept),

b_i - is the estimated partial regression coefficient,

e_j - the deviation of the value Yj from the mean value of the distribution given X.

Multiple regression equation was fitted using application program StatGraphics Plus 5.0, MS Excel and ANOVA test (for setting the compliance of experimental data). Analysis of variance (ANOVA), was conducted for linear regression and multiple linear regression analysis, calculating the components of variance for the regression model (sum of squares, mean squares, F ratio).

2.3 Conclusions to the 2 chapter

In this chapter information regarding the methods, materials of research and the subject of the study is presented. For the purpose of obtaining consistant results and perform a complete study of the process of alcohol removal from wines, using vacuum distillation process, the adequate methodology was elaborated.

Research on this study was realized using modern methods of analysis (GC-MS and FTIR) an up-to-dated equipment, as well as, standard methods of analysis. Methodology of statistical analysis allowed to obtain valid data indicating the principal directions of alcohol removal process behaviour.

The complex of methods described in this chapter served as a tool for obtaining results which can be used in wine industry.

3. ELABORATION OF OPTIMAL REGIMES FOR CORRECTION OF ALCOHOLIC CONTENT IN WINES USING VACUUM DISTILLATION METHOD

Vacuum distillation process is based on evaporation of most volatile components with low boiling point [64]. Rate of alcohol removal depends on different technological factors: temperature, pressure, operating time, initial volume and alcoholic concentration of studied wine. In this chapter the influence of these technological factors on alcohol removal, physical - chemical composition and volatile complex inclusively was studied, in order to develop of optimal regimes for correction of alcoholic content in white and red wines.

3.1 Influence of dealcoholization process temperature on physical and chemical composition and volatile complex of obtained wines

Temperature is one of the most important factors influencing the rate of alcohol removal from wine using vacuum distillation process. It is commonly known that, the boiling point of the alcohol under atmospheric pressure is equal to 78˚C, but conduction of alcohol removal process under high temperatures can influence the composition of obtained wines and, in consequence, the quality of the final product is substantially deteriorated [130, 182]. However, the method of vacuum distillation can significantly reduce the boiling point of the alcohol to 25-30˚C. Thus, three temperatures of 20˚C, 30˚C and 40˚C were selected in order to study the influence of temperature on process rate and composition of white and red wines. Process of alcoholic concentration reduction was carried under constant pressure (4 kPa), volume (0,5 dm^3) and operating time (45 min). The obtained results are presented in tables 3.1 and 3.2.

Table 3.1. Influence of dealcoholization process temperature on physical- chemical composition of white wine Chardonnay

Parameter	Initial	Temperature		
		20^{0}C	30^{0}C	40^{0}C
Alcohol content, % vol.	13,5±0,1	13,2±0,1	10,0±0,1	4,7±0,1
Mass concentration of, g/dm³				
-titratable acidity	6,5±0,1	6,6±0,1	7,1±0,1	10,3±0,1
-volatile acidity	0,42±0,03	0,42±0,03	0,37±0,04	0,36±0,04
-residual sugars	1,3±0,5	1,3±0,5	2,1±0,5	4,8±0,5
-tartaric acid	3,4±0,1	3,4±0,1	3,6±0,1	4,9±0,1
-malic acid	2,4±0,4	2,4±0,2	2,6±0,1	3,9±0,1
-lactic acid	0,10±0,03	0,10±0,03	0,20±0,03	0,50±0,05
-citric acid	0,20±0,04	0,20±0,05	0,30±0,04	0,50±0,03
pH	3,07±0,01	3,07±0,01	3,04±0,01	2,94±0,01
Organoleptic evaluation, points	7,9±0,01	7,9±0,01	7,9±0,01	7,4±0,01

Table 3.1 presents the influence of temperature on chemical-physical indices of obtained wines with reduced alcohol content. Temperature 20^0C has unessential influence on chemical-physical indices, due to low rate of the dealcoholization process. In addition, unperceptible increase in the mass concentration of titratable acids in the range from 6,5 to 6,6 g/dm^3 can be observed. The concentration of volatile acids, concentration of residual sugars and the pH value remain unchanged in the process of alcohol removal. The changes of one of the most important components of the chemical composition – organic acids were studied. From obtained results, mass concentration of tartaric, malic, lactic and citric acids remains unchanged in the process of ethanol removal at the temperature of 20°C.

The chemical-physical indices of white wines with reduced alcohol content obtained at 30˚C are shown in table 3.1. At this temperature, the process rate increases significantly as well as efficiency of ethanol removal from wine. An increase in the mass concentration of titratable acids is observed in the process of dealcoholization in the range from 6,5 g/dm^3 to 7,1 g/dm^3. Mass concentration of residual sugars varied from 1,3 to 2,1 g/dm^3. Concentration of organic acids has changed insignificantly. pH is another index that has changed in the process of dealcoholization from 3,07 to 3,04.

Temperature of 40˚C has the greatest influence on the chemical-physical parameters of obtained wines. Mass concentration of titratable acids increased practically twofold, which is associated with an increase in the content of organic acids presented in wine. Tartaric acid content varies from 3,4 g/dm^3 to 4,9 g/dm^3, malic acid from 2,4 g/dm^3 to 3,9 g/dm^3, lactic acid from 0,1 g/dm^3 to 0,5 g/dm^3 and citric acid from 0,2 g/dm^3 to 0,5 g/dm^3. Mass concentration of volatile acids decreased significantly from 0,42 g/dm^3 to 0,36 g/dm^3. Concentration of residual sugars has increased due to significant concentration of wine from 1,3 g/dm^3 to 4,8 g/dm^3.

Sensory evaluation of obtained wines has shown the influence of temperature on wine quality. Increasing of dealcoholization process temperature leads to significant reduction of alcoholic content as well as the organoleptic properties of obtained white wines.

Volatile complex in the process of alcohol removal using different physical methods undergoes significant changes. In this regard, in the thesis the influence of temperature on volatile compounds losses was studied. Results presented in the figures 3.1, 3.2, 3.3 and 3.4 show % losses of main classes of wine's volatile compounds and more detailed losses of the main volatile compounds are presented in the table A1.1.

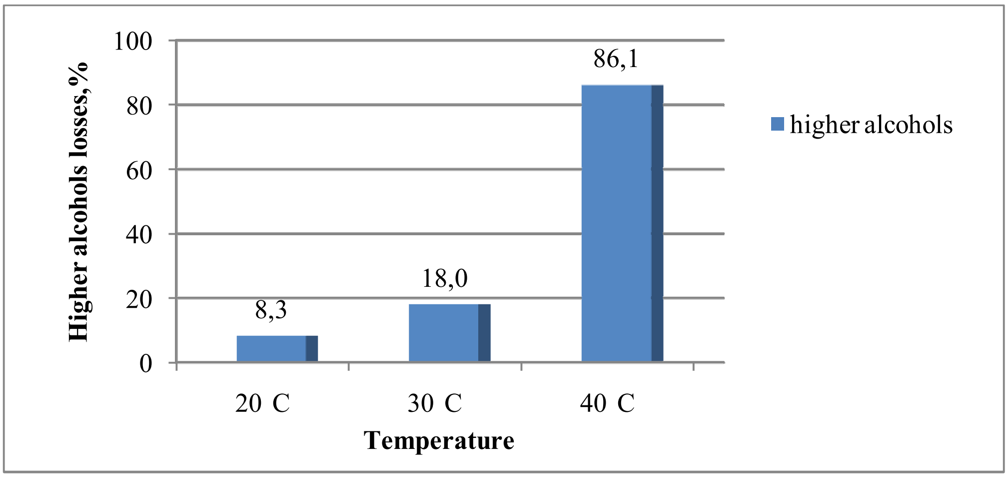

Fig.3.1 Influence of temperature of dealcoholization process on higher alcohols removal from wines

According to obtained results, temperature influences significantly on volatile complex of white wines. In the fig. 3.1 the losses of higher alcohols in the process of ethanol removal are presented. Obtained results demonstrate that at the temperature of 20°C losses of higher alcohols constitutes 8,3%, with subsequent increase of higher alcohols losses of 18,0% at the temperature of 30°C. Temperature of 40°C has the highest impact on higher alcohols losses and accounts for 86,1%.

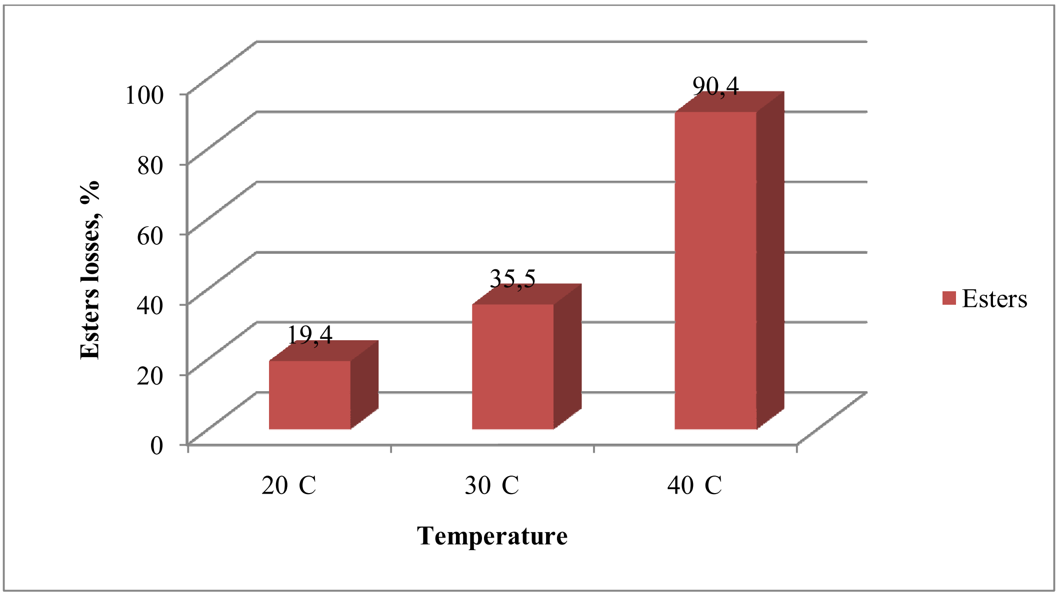

Fig.3.2 Influence of temperature of dealcoholization process on esters removal from wine

Esters are the most volatile wine components along with alcohol [18]. Therefore, temperature increase will exercise high impact on content of esters. Obtained results confirm the supposition made. Process of ethanol removal at the temperature of 40°C leads to practically complete removal of esters, which make up 90,4% from the total content. At the temperature of

20°C esters losses make up 19,4% and at the temperature of 30°C esters losses account for 35,5%.

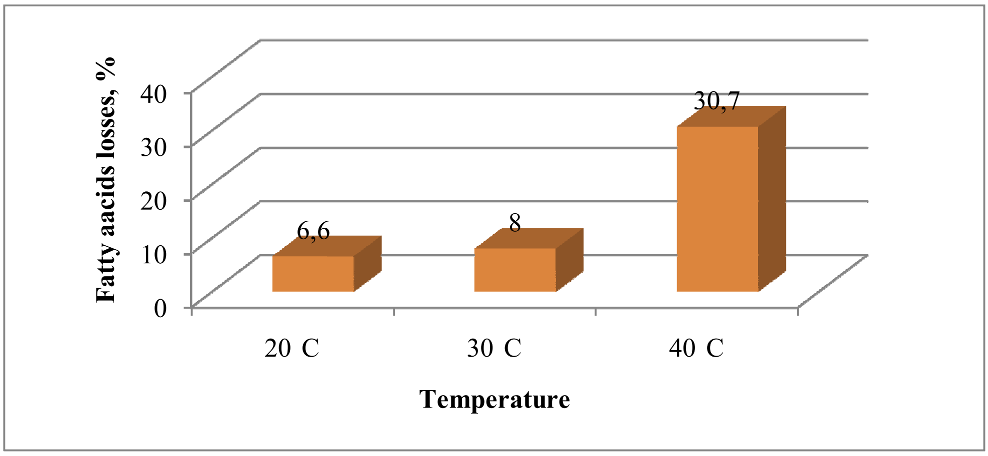

Fig. 3.3. Influence of temperature of dealcoholization process on acids removal from wine

Results regarding the losses of fatty acids in the dealcoholization process depending on the temperature are presented in fig. 3.3. Volatile acids are high boiling volatile compounds, as a result process of ethanol removal has minor impact on fatty acids losses. Results of research demonstrate that at the temperature of 20°C losses make up 6,6%, at the temperature of 30°C – 8,0%. As in the case of others volatile compounds temperature of 40°C influences significantly on fatty acids content, the percent of losses is equal to 30,7%.

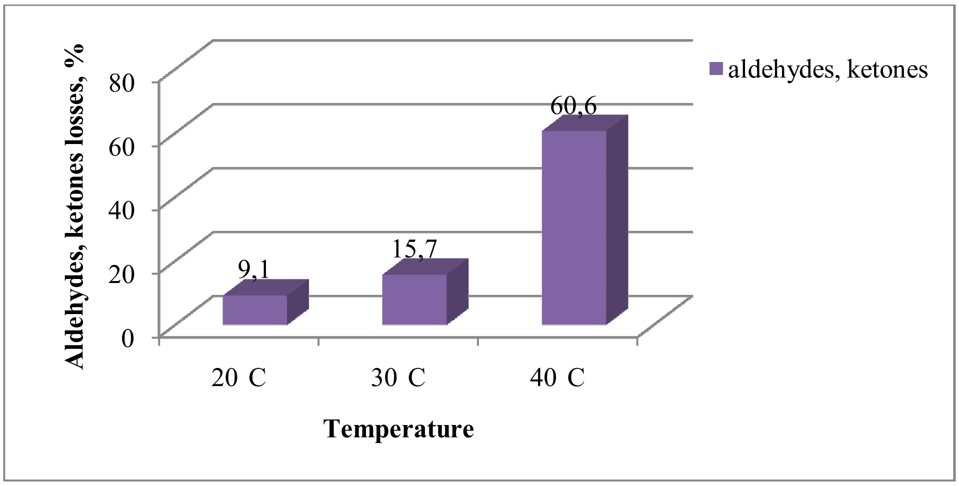

Fig.3.4. Influence of temperature of dealcoholization process on aldehydes and ketones removal from wine

In the fig. 3.4 the influence of temperature on aromatic aldehydes and ketones removal in the dealcoholization process was studied. The presented data demonstrate that losses of aldehydes and ketones depend on temperature. The highest loss is registered at the temperature of 40°C and is equal to 60,6%, followed by the temperature of 30°C with loss equal to 15,7%.

The temperature of 20°C has the minor impact on aldehydes and ketones losses in the process of ethanol removal and consists 9,1%. Minimal losses can be explained by low efficiency of the process of ethanol removal at this temperature.

Table 3.2. Influence of dealcoholization process temperature on physical- chemical composition of red wine Merlot

Parameter	Initial	Temperature		
		20^0C	30^0C	40^0C
Alcohol content, % vol.	13,1±0,1	12,8±0,1	10,5±0,1	5,0±0,1
Mass concentration of, g/dm³				
-titratable acidity	5,2±0,08	5,3±0,1	5,9±0,1	8,7±0,1
-volatile acidity	0,33±0,03	0,33±0,04	0,30±0,04	0,30±0,03
-residual sugars	1,1±0,5	1,1±0,5	1,3±0,5	2,1±0,5
-tartaric acid	1,9±0,2	1,9±0,1	2,2±0,2	2,6±0,1
-malic acid	0,7±0,1	0,7±0,1	0,9±0,2	1,2±0,1
-lactic acid	1,2±0,2	1,2±0,2	1,3±0,1	1,8±0,3
-citric acid	0,20±0,04	0,20±0,04	0,30±0,04	0,50±0,03
pH	3,30±0,01	3,30±0,01	3,20±0,01	3,12±0,01
Organoleptic evaluation, points	7,9±0,01	7,9±0,01	7,9±0,01	7,5±0,01

Table 3.2 presents the influence of temperature on chemical-physical indices of red partial dealcoholized wines. These data show that temperature of 20˚C affects slightly the composition of obtained wines. The mass concentration of titratable acids increased unessential, and ranges from 5,2 g/dm^3 to 5,3 g/dm^3. Mass concentration of volatile acids, residual sugars, the pH remains constant during the dealcoholization process. In the case of dealcoholization of red wines the concentration of organic acids remains unchanged and varies within acceptable limits for this category of wines.

Temperature of 30˚C influences in the greater degree on the chemical-physical indices of obtained wines. Mass concentration of titratable acids varies from 5,2 g/dm^3 to 5,9 g/dm^3. Increasing of the mass concentration of titratable acids is directly related to increased content of organic acids as tartaric acid ranges within 1,9 g/dm^3 – 2,2 g/dm^3, the concentration of malic acid from 0,7 g/dm^3 to 0,9 g/dm^3, lactic acid from 1,2 g/dm^3 to 1,3 g/dm^3 and citric acid varies from 0,2 g/dm^3 to 0,3 g/dm^3. Mass concentration of volatile acids and pH remained practically unchanged during the dealcoholization process.

Temperature of 40˚C has the greatest influence on the chemical-physical parameters of obtained dealcoholized red wines. Mass concentration of titratable acids increased significantly, and varies from 5,2 g/dm^3 to 8,7 g/dm^3. Mass concentration of residual sugars increased practically twofold, due to a significant concentration of wine. Volatile acids decreased from 0,33 g/dm^3 to 0,30 g/dm^3. The concentration of the main organic acids significantly increases. The greatest increase in concentration observed in the case of malic acid from 0,7 g/dm^3 to 1,2g/dm^3, tartaric acid from 1,9 g/dm^3 to 2,6 g/dm^3, lactic acid from 1,2 to 1,8 g/dm^3 and citric acid – 0,2 g/dm^3 to 0,5 g/dm^3.

Polyphenolic complex of red wines plays an important role in the taste of wine and influences the red wine colour. Moreover, red wines are rich in biologic active compounds and possess antioxidant activity [18]. Hence, the influence of dealcoholization temperature on concentration of phenolic compounds as well as rutin, quercetine and resveratrol and antocyanins profiles was studied. The results are presented in the table 3.3, 3.4.

According to the obtained results, temperature of dealcoholization influences the concentration of phenolic compounds, antocyanins and biologic active substances. Concentration of phenolic compounds as well as antocyanins increased from 1640 mg/dm^3 in the initial wine to 2257 mg/dm^3 at the temperature of 50^{0}C. The same situation was observed and for antocyanins concentration, with significant increase under the influence of temperature and varies from 174 mg/dm^3 to 219 mg/dm^3. In this study concentration of rutin, quercetine and resveratrol was studied.

Table 3.3 Influence of temperature of dealcoholization on polyphenolic complex of obtained red wines

Parameter	**Temperature**				
	Initial wine	**20^{0}C**	**30^{0}C**	**40^{0}C**	**50^{0}C**
Mass concentration of, mg/dm^3					
-phenolic compounds	1640±11	1648±9	1726±10	1805±14	2257±8
-antocyanins	174±3	174±4	183±7	194±5	219±9
-rutin	8,1±1,2	9,3±1,4	9,4±1,4	10,4±1,6	10,5±1,6
-quercetine	0,5±0,07	0,5±0,07	0,8±0,1	0,4±0,07	0,3±0,09
-resveratrol	0,3±0,04	0,3±0,04	0,6±0,07	0,3±0,04	0,3±0,04

Obtained data has shown that concentration of rutin increased significantly from 8,1 mg/dm^3 to 10,4 mg/dm^3. In the process of dealcoholization at the temperature of 30°C the increasing of resveratrol and quercitine concentrations was observed, but at the temperatures of 40°C and 50°C the concentration of studied compound decreased due to possible destruction of these substances under high temperature.

Table 3.4. Influence of temperature of dealcoholization on content (%) of bounded antocyanins

Parameter	%, of total content				
	Initial	$T=20^0C$	$T=30^0C$	$T=40^0C$	$T=50^0C$
delphinidin-3-glycoside	2,7	2,9	2,7	2,9	2,7
cyanidin-3- glycoside	0,1	0,1	0,1	0,1	0,1
diglycoside malvidin	0,4	0,4	0,4	0,3	0,4
petunidin-3- glycoside	4,8	5,1	4,8	4,9	4,8
peonidin-3- glycoside	3,2	3,1	3,2	3,2	3,2
malvidin-3- glycoside	50,1	52,2	50,2	50,3	50,1

In the table 3.4 the influence of different temperatures on antocyanins profile in the process of ethanol removal is demonstrated. Obtained experimental data allow concluding, that in the process of dealcoholization percentage ratings of most important bounded antocyanins didn't change significantly. Only in the case of malvidin-3- glycoside and petunidin-3- glycoside an increase of percentage ratings at the temperature of 20°C was observed.

Thus, the experimental data regarding the influence of temperature on ethanol removal in the dealcoholization process of white and red wines, as well as on physical-chemical composition of obtained wines demonstrated the major influence of temperature 40°C on the wine quality especially a significant depletion of wine aroma (major losses of esters and higher alcohols). Temperature of 20°C has the minimal impact on composition of wine as a result of low efficiency of dealcoholization process. Temperature of 30°C can be recommended for removal of alcohol from wine using method of vacuum distillation because of efficiency improving of the process and insignificant influence on wine composition.

3.2. Influence of pressure of dealcoholization process on physical- chemical composition and volatile complex of obtained wines

Pressure is very important technological factor that influences the process of dealcoholization using vacuum distillation method. Wine from the chemical point of view is a complex homogeneous system, a major component of which is ethyl alcohol and water which create azeotropic mixture. However, under normal pressure, ethanol couldn't be separated from water and dealcoholization process in this case will be accompanied by a significant loss of volume [12]. Pressure reduction lead to decrease of alcohol boiling temperature, furthermore, the azeotropic mixture is enriched with alcohol or in the case of vacuum distillation the azeotropic mixture doesn't form and ethanol can be eliminated from the wine. The experiment was conducted at constant temperature (30°C), volume of wine (0,5 dm^3), processing time (45 min) and variable pressure from 40 kPa to 4 kPa. In order to determine the influence of pressure on the dealcoholization process in the samples of white and red dealcoholized wines, the main chemical-physical parameters were determined. Obtained results are presented in tables 3.5, 3.6.

Table 3.5. Influence of dealcoholization process pressure on physical- chemical composition of white wine Chardonnay

Parameter	Initial wine	Pressure, kPa				
		40	30	20	10	4
Alcohol content,% vol.	13,5±0,1	13,5±0,1	13,2±0,1	12,5±0,1	10,4 ±0,1	10,0±0,1
Mass concentration of: g/dm³						
-titratable acidity	6,5±0,1	6,5±0,1	6,60±0,11	6,80±0,08	7,0 ±0,1	7,1±0,1
-volatile acidity	0,42±0,03	0,42±0,03	0,42±0,04	0,41±0,04	0,39±0,03	0,37±0,04
-residual sugars	1,3±0,5	1,3±0,5	1,3±0,5	1,5±0,5	1,9 ±0,5	2,1±0,5
-tartaric acid	3,4±0,1	3,4±0,1	3,4±0,2	3,5±0,3	3,6±0,2	3,6±0,1
-malic acid	2,4±0,4	2,4±0,2	2,4±0,2	2,5±0,1	2,5 ±0,3	2,6±0,1
-lactic acid	0,10±0,03	0,10±0,03	0,10±0,02	0,20±0,03	0,20±0,03	0,20±0,03
-citric acid	0,20±0,04	0,20±0,03	0,30±0,05	0,30±0,04	0,30±0,05	0,30±0,04
pH	3,07±0,01	3,07±0,01	3,07±0,01	3,07±0,01	3,06±0,01	3,04±0,01

Table 3.5 presents the influence of pressure on chemical-physical indices of dealcoholized white wines. According to the analysis results it may be concluded, that pressure influences significant on the rate of alcohol removal in the dealcoholization process. Pressure of 4 kPa has the greatest influence on the dealcoholization process. Thus, alcohol content has decreased only about 0,3% vol. at pressure of 30 kPa and at the pressure of 4 kPa alcohol content decreased by about 3,5 % vol.

The mass concentration of titratable acids increases from 6,5 to 7,1 g/dm^3, concentration of residual sugars varies from 1,3 to 2,1 g/dm^3 in obtained dealcoholized white wines. A moderate decrease of mass concentration of volatile acids in range from 0,42 to 0,37 g/dm^3 was registered. The changes of the one of the most important wine components - organic acids were studied.

From obtained results, there is a insignificant increase in the content of tartaric and malic acids from 3,4 to 3,6 g/dm^3 and 2,4 to 2,6 g/dm^3 respectively , the content of lactic acid varies from 0,1 to 0,2 g/dm^3 and citric acid- from 0,2 to 0,3 g/dm^3 in dependence of pressure.

Furthermore, influence of pressure of dealcoholization process on white wine aromatic complex was studied. Results regarding this study are demonstrated in the fig. 3.5, 3.6, 3.7, 3.8 and table A1.2 (Annex 1).

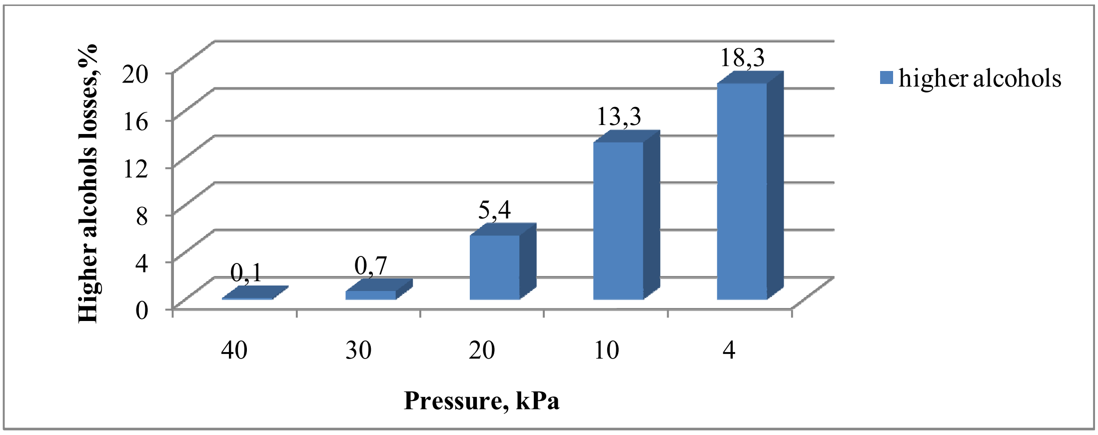

Fig.3.5. Influence of pressure of dealcoholization process on higher alcohols removal from white wine Chardonnay

In the fig. 3.5 results regarding higher alcohols losses in the process of ethanol removal at different pressures are demonstrated. Dealcoholization process at pressures of 40 and 30 kPa don't occur practically and losses of higher alcohols are inconsiderable and constitute 0,1 and 0,7 % respectively. Simultaneously with pressure reduction the rate of alcohol removal increases resulting in rising of higher alcohols losses. Thus, at pressure of 20 kPa the value of losses consists 5,4% as well as at the pressure of 4 kPa the percent of higher alcohols losses is equal to 18,3%.

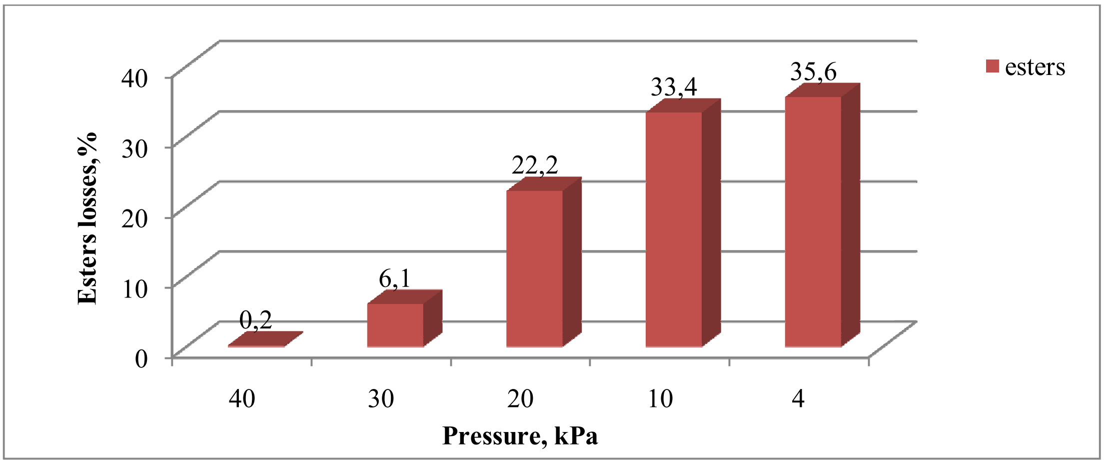

Fig.3.6. Influence of pressure of dealcoholization process on esters removal from white wine Chardonnay

Esters confer the wine floral and fruit flavours, but in the process of ethanol removal depletion of aroma occurs [63, 158]. At the pressure of 4 kPa esters losses account for 35,6% as well as at the pressure of 40 kPa and 30 kPa the losses are minimal and consists only 0,2% and 6,1% respectively.

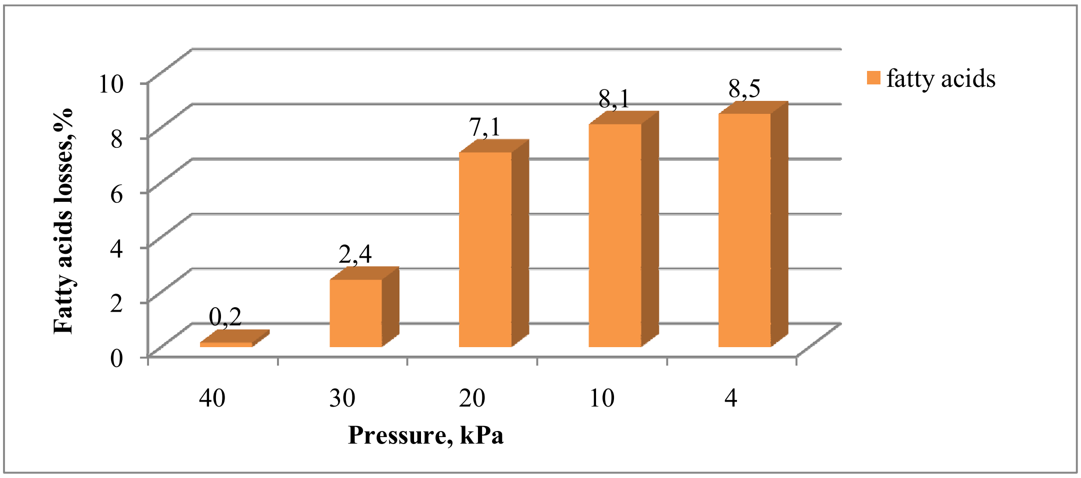

Fig.3.7. Influence of pressure of dealcoholization process on fatty acids removal from white wine Chardonnay

Results regarding the influence of pressure on losses of fatty acids in the dealcoholization process was studied and presented in fig. 3.7. Process of ethanol removal at different pressures has minor impact on fatty acids losses. Results of research demonstrate, that at the pressure of 10 kPa and 4 kPa losses make up 8,1% and 8,5% respectively. As in the case of others volatile compounds pressure of 40 kPa and 30 kPa influences inconsiderable on volatile acids content, the percent of losses is equal to 0,2 and 2,4 respectively.

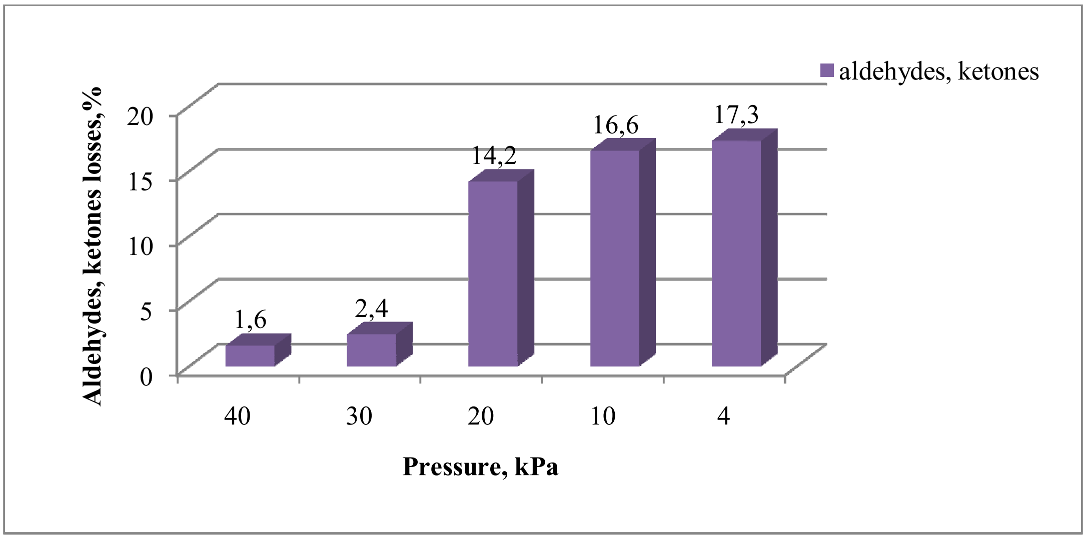

Fig.3.8. Influence of pressure of dealcoholization process on aldehydes and ketones removal from white wine Chardonnay

In the fig. 3.8 the influence of pressure on aldehydes and ketones removal in the dealcoholization process was studied. The presented data demonstrate that losses of aldehydes and ketones depend on the pressure of the process. The highest loss of this class of volatile compounds is registered at the interval of pressure from 20 kPa to 4 kPa and is equal to 14,2% to 17,3% respectively. The pressure of 40 kPa and 30 kPa has the minor impact on aldehydes and ketones losses in the process of ethanol removal and consists 1,6% and 2,4% respectively.

Red wines differ from the white wines not only in chemical composition, but also have different organoleptic characteristics. Consequently, the influence of dealcoholization process on the physico- chemical parameters of red wines may differ significantly from white wines.

Table 3.6 presents the influence of the pressure of dealcoholization process on chemical physical indices of dry red wines. As in the case of white wines pressure 4 kPa has the greatest influence on chemical and physical indices of obtained wines. The influence of dealcoholization process pressure on alcohol content in red wines demonstrates that as in the case of white wines there is a relationship between alcohol removal rate and pressure. Thus, when the pressure quantity is equal to 30 kPa, alcohol content in wine decreased by about 0,2 % vol. and at a pressure of 4 kPa alcohol content decreased of 2,6 % vol. The alcohol content in obtained samplesof red wines ranged from 13,1% vol to 10,5 % vol.

Mass concentration of titratable acids in the obtained wines has increased and varies from 5,2 to 5,9 g/dm^3 , mass concentration of residual sugars ranges from 1,1 to 1,3 g/dm^3. Mass concentration of volatile acids and pH remained practically unchanged during the dealcoholization process. Simultaneously, in the obtained samples of red wines, an increase of organic acids is observed. Mass concentration of tartaric acid varies from 1,9 to 2,2 g/dm^3, malic acid from 0,7 to 0,9 g/dm^3, lactic acid varies from 1,2 to 1,3 g/dm^3 and citric acid varies from 0,2 to 0,3 g/dm^3.

In this research the influence of pressure of dealcoholization process on polyphenolic complex of red wine was studied. According to the obtained results concentration of phenolic compounds and antocyanins depends on the pressure of dealcoholization process. At the pressure of 4 kPa concentration of phenolic compounds increased on 86 mg/dm^3 and concentration of antocyanins increased insignificantly from 174 mg/dm^3 to 183 mg/dm^3.

Table 3.6. Influence of dealcoholization process pressure on physical- chemical composition of red wine Merlot

Parameter	Initial wine	Pressure, kPa				
		40	30	20	10	4
Alcohol content, % vol.	13,1±0,1	13,1±0,1	12,9±0,1	12,2±0,1	10,7±0,1	10,5±0,1
Mass concentration of, g/dm³						
-titratable acidity	5,2±0,08	5,2±0,1	5,3±0,1	5,5±0,2	5,8±0,1	5,9±0,1
-volatile acidity	0,33±0,03	0,33±0,03	0,33±0,04	0,33±0,03	0,30±0,03	0,30±0,04
-residual sugars	1,1±0,5	1,1±0,5	1,1±0,5	1,2±0,5	1,3±0,5	1,3±0,5
-tartaric acid	1,9±0,2	1,9±0,1	1,9±0,3	2,0±0,1	2,1±0,1	2,2±0,2
-malic acid	0,7±0,1	0,7±0,1	0,7±0,2	0,8±0,1	0,8±0,1	0,9±0,2
-lactic acid	1,2±0,2	1,2±0,1	1,2±0,2	1,3±0,1	1,3±0,3	1,3±0,1
-citric acid	0,20±0,04	0,20±0,04	0,20±0,05	0,20±0,03	0,3±0,04	0,30±0,04
phenolic compounds, mg/dm³	1640±11	1640±9	1647±8	1650±6	1654±11	1726±5
antocyanins mg/dm³	174±3	174±4	174±4	176±6	178±4	183±3
pH	3,30±0,01	3,30±0,01	3,30±0,01	3,30±0,01	3,20±0,01	3,20±0,01

According to obtained results, pressure influences the process of ethanol removal from wines. Pressure decrease improves the efficiency of dealcoholization process, followed by positive influence on wine quality. Thus, pressure of 4 kPa significantly improves the efficiency of ethanol removal from wine. Moreover, pressure decreasing can significantly decrease the processing time of dealcoholization being economically profitable.

3.3. Influence of the process time of dealcoholization process on physical and chemical parameters of obtained white and red wines

Process time of the dealcoholization process is the period during which wine is transformed into a finished product with desired alcoholic content by a manufacturing procedure. Process time depends on the efficiency and productivity of technique. Thus, process time is an important parameter influencing the dealcoholization process.

In the research the influence of the process time of the dealcoholization on the chemical-physical parameters of wines and mechanism of the ethanol removal process was studied. The research was conducted at the temperature of 30˚C for white wines and 40˚C for red wines, at the constant pressure of 4 kPa and volume of wine equal to 0,5 dm³. Obtained results are shown in tables 3.7 and 3.8. Obtained data indicates that process time of dealcoholization affects physico-chemical indices of wines in varying degrees. Besides this, the influence of process time on losses of man aroma compounds is presented in fig. 3.10, 3.11, 3.12 and 3.13 as well as in table A1.3.

Table 3.7. Influence of the dealcoholization process time on chemical and physical parameters of white dry wine Chardonnay

Time, min	**Alcohol content, % vol.**	**Mass concentration of, g/dm³**							**pH**	**Organoleptic evaluation, points**
		Titratable acids	**Volatile acids**	**Residual sugars**	**Tartric acid**	**Malic acid**	**Lactic acid**	**Citric acid**		
Initial wine	13,5±0,1	6,50±0,10	0,42±0,03	1,3±0,5	3,4±0,1	2,4±0,4	0,10±0,03	0,2±0,04	3,07±0,01	7,90±0,01
5	13,1±0,1	6,60±0,09	0,42±0,03	1,3±0,5	3,4±0,1	2,4±0,2	0,10±0,02	0,30±0,05	3,07±0,01	7,90±0,01
10	12,8±0,1	6,70±0,08	0,42±0,03	1,5±0,5	3,5±0,2	2,4±0,1	0,10±0,02	0,30±0,05	3,06±0,01	7,90±0,01
15	11,3±0,1	6,80±0,09	0,42±0,03	1,6±0,5	3,5±0,1	2,5±0,1	0,10±0,02	0,30±0,05	3,06±0,01	7,90±0,01
20	10,7±0,1	6,90±0,11	0,40±0,04	1,8±0,5	3,5±0,3	2,5±0,1	0,10±0,03	0,30±0,06	3,06±0,01	7,90±0,01
25	10,4±0,1	7,0±0,1	0,39±0,03	1,9±0,5	3,6±0,1	2,5±0,1	0,20±0,04	0,30±0,06	3,06±0,01	7,85±0,01
30	10,1±0,1	7,00±0,12	0,38±0,04	2,0±0,5	3,6±0,1	2,5±0,2	0,20±0,03	0,30±0,05	3,05±0,01	7,85±0,01
45	9,8±0,1	7,1±0,1	0,37±0,04	2,1±0,5	3,6±0,1	2,6±0,1	0,2±0,03	0,30±0,04	3,04±0,01	7,85±0,01
60	8,3±0,1	7,9±0,1	0,37±0,02	2,5±0,5	4,1±0,2	2,8±0,3	0,30±0,03	0,40±0,06	3,05±0,01	7,75±0,01
90	7,9±0,1	9,2±0,1	0,37±0,03	2,6±0,5	4,5±0,4	3,2±0,1	0,40±0,04	0,50±0,03	3,00±0,01	7,60±0,01
100	5,8±0,1	10,50±0,09	0,35±0,04	4,1±0,5	5,0±0,1	4,0±0,1	0,50±0,03	0,60±0,08	2,96±0,01	7,40±0,01
120	4,1±0,1	11,2±0,09	0,33±0,04	5,1±0,5	5,3±0,1	4,3±0,1	0,60±0,02	0,60±0,07	2,90±0,01	7,40±0,01

Table 3.7 presents the influence of process time of dealcoholization on chemical-physical indices of obtained white wines. According to expectations, processing time has the greatest influence on alcohol content, which varies from 13,5 % vol. to 4,1% vol. Mass concentration of titratable acids and residual sugars is in direct relation to the process duration, that is, with lengthening of the operation time mass concentration of titratable acids increased from 6,5 g/dm^3 to 11,2 g/dm^3 and mass concentration of residual sugars varies from 1,3 g/dm^3 to 5,1 g/dm^3. Dealcoholization process marginally affects the mass concentration of volatile acids and pH. Thus, concentration of volatile acids decreased from 0,42 to 0,33 g/dm^3, probably as a consequence of some acetic acid molecules losses during distillation. Value of pH is directly associated to concentration of titratable acidity, in this regard a decrease of pH is registered. In the obtained

samples of white wines, an increase of organic acids is observed. The concentration of tartaric acid varies from 3,4 g/dm^3 to 5,3 g/dm^3, malic acid from 2,4 g/dm^3 to 4,3 g/dm^3, lactic acid from 0,1 g/dm^3 to 0,6 g/dm^3 and citric acid - from 0,2 g/dm^3 to 0,6 g/dm^3. According to results of sensory evaluation can be concluded that process of ethanol removal influences significantly on quality of obtained wines. Thus, 20% reduction of alcoholic content doesn't affect the quality of wines, but reduction of alcoholic strength to 4,1% vol reduces significantly the organoleptic properties of white wines.

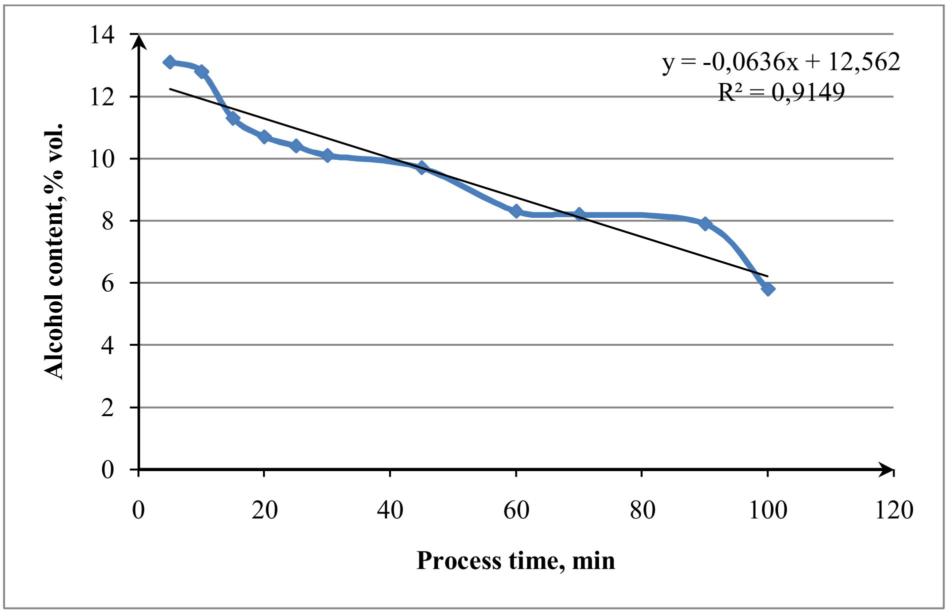

Fig. 3.9. Mechanism of ethanol removal from white wine Chardonnay (T=30°C, P=4 kPa)

Figure 3.9 shows the mechanism of ethanol removal from white wine Chardonnay. Presented curve indicates the dependence between process time and ethanol removal from wine. Analysis of the data shows that the process of the ethanol removal proceeds nonuniformly. Thus, at the start of the process gradual decreasing of the alcohol content occurs, for 30 min. 3,4 % vol of alcohol is removed, and thereafter the rate of alcohol removal is reduced and a balance is created by system. Linear segments on the diagram show the modification of wine composition, which can be explained by ethanol removal and concentration of wine. Further, a sharp decrease of alcohol content is observed and reaches the value of about 4,1 % vol.

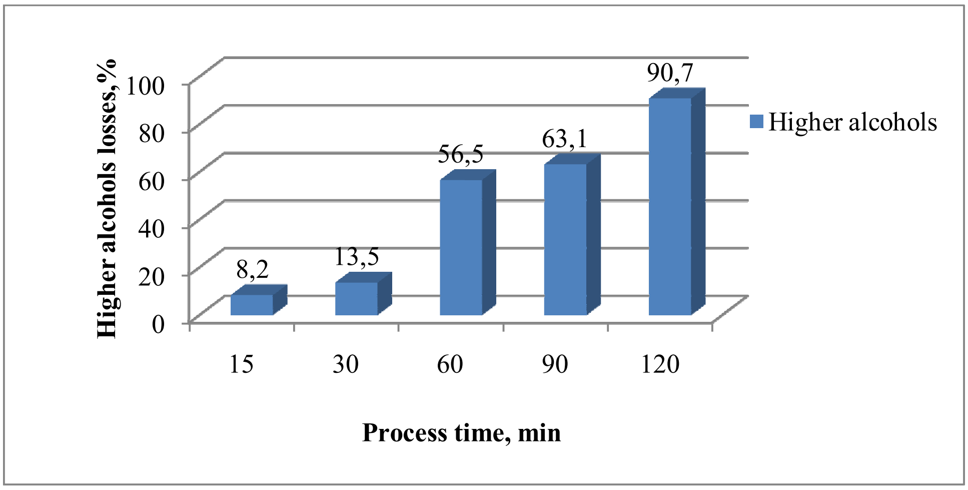

Fig. 3.10. Influence of the process time of dealcoholization process on higher alcohols removal from white wine Chardonnay

In the fig.3.10 the influence of process time on higher alcohols losses is presented. According to the obtained results, losses depend on the extent of alcohol removal. Thus, decreasing of alcohol content to 10,1% vol. (30 min) results in losses of 13,5% of higher alcohols. Starting with 60 min of ethanol removal process significant losses of higher alcohols are reported and account for 56,5%. After 120 min (4,1% vol) of the process history, 90,7% of higher alcohols are removed from wine.

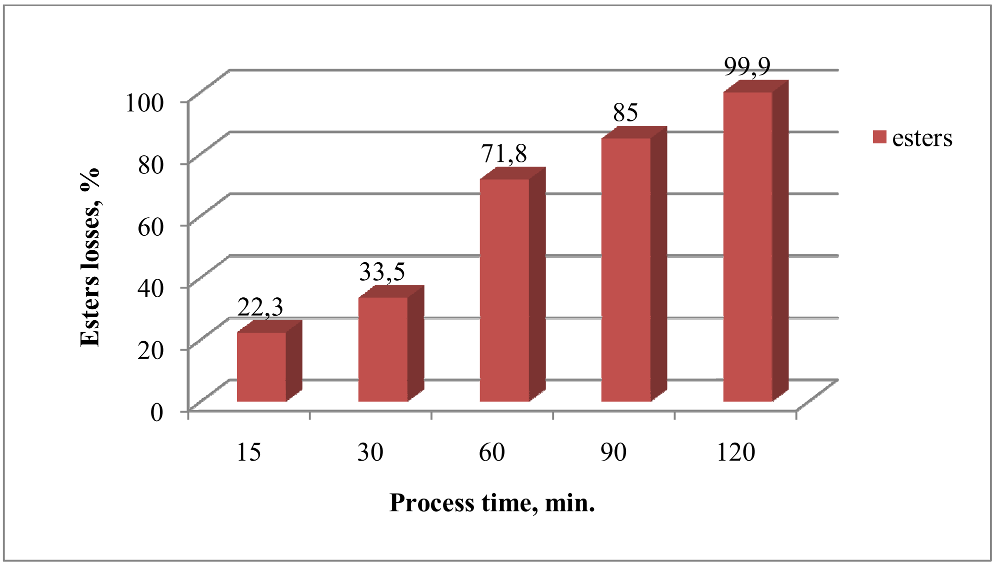

Fig. 3.11. Influence of the process time of dealcoholization process on esters removal from white wine Chardonnay

Information regarding the losses of esters in the process of dealcoholization in dependence of process time is demonstrated in the fig. 3.11. As in the case of higher alcohols, a significant loss (71,8%) of esters is observed at the 60 min of dealcoholization process, further alcohol removal process leads to complete removal of esters from wine, after 120 min 99,9% of esters losses are recorded.

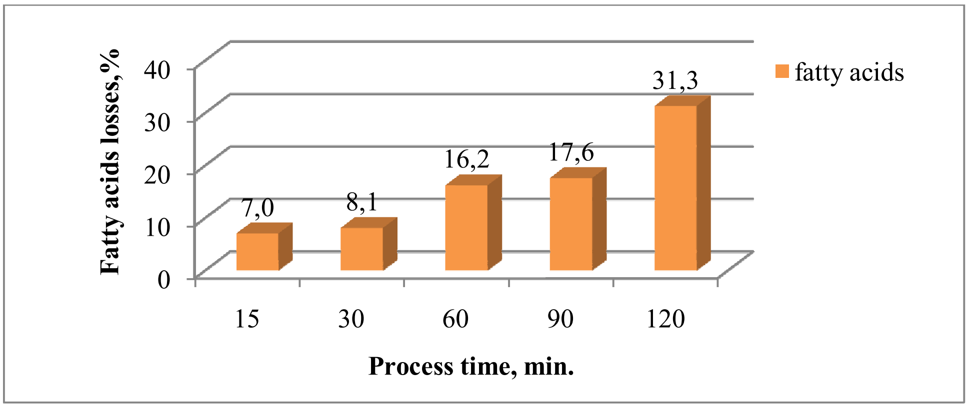

Fig. 3.12. Influence of the process time of dealcoholization process on fatty acids removal from white wine Chardonnay

Fatty acids represent another class of volatile compounds studied in this research. According to the obtained data, losses of fatty acids depend on alcohol removal level, however, in comparison with losses of higher alcohols and esters, the percent of fatty acids removal is significantly lower in the process of dealcoholization. At the 60 min. of processing time fatty acids losses constitute 16,2%, and after 120 min losses increased practically twofold and constitutes 31,3%. Whereas after 30 min (10,1% vol) fatty acids losses constitute 8,1%.

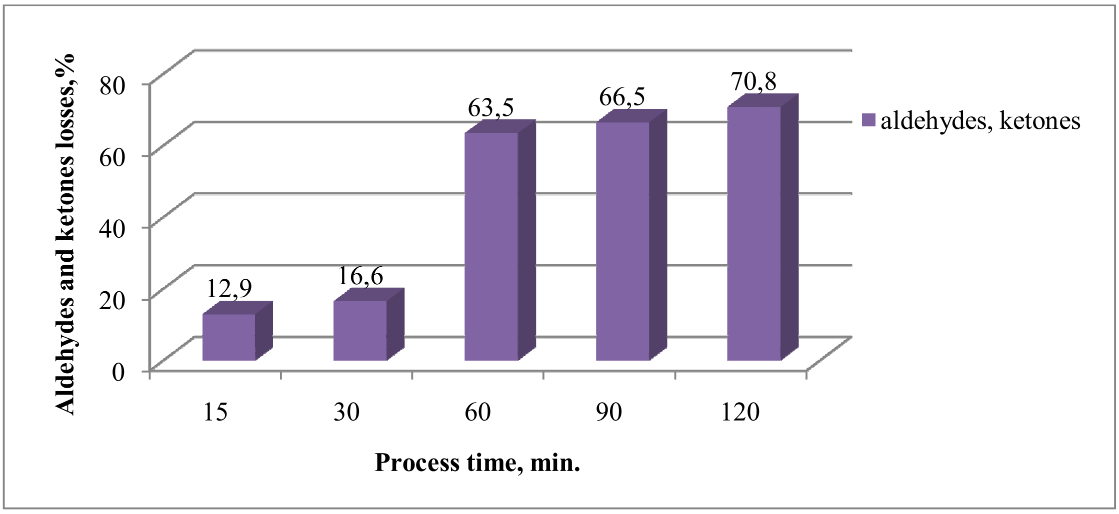

Fig. 3.13. Influence of the process time of dealcoholization process on aldehydes and ketones removal from white wine Chardonnay

In the fig. 3.13 graphic representation of aldehydes and ketones losses in the process of dealcoholization depending on process time is demonstrated. Removal of alcohol in the limits from 13,5% vol to 10,1% vol is accompanied by inconsiderable aldehydes and ketones losses from 12,9% to 16,6% respectively. Further reduction of alcohol content from wine leads to an increase of aldehydes and ketones losses up to 63,5% (8,3% vol) after 60 min of processing time, reaching the maximum after 120 min. of alcohol removal process with losses of 70,8%.

In order to investigate the influence of dealcoholization process time on composition of red wine Merlot and the mechanism of ethanol removal process, the experimental samples of red wines was obtained and main physical-chemical indices was determinated. Results are presented in the table 3.8 and fig. 3.14.

The chemical-physical indices of red dealcoholized wines obtained at different processing time are shown in table 3.8. Increasing of the processing time contributes to significant decrease of alcohol content in obtained wines. A significant increase in the mass concentration of titratable acid is observed in the process of dealcoholization. These changes are associated with the fact that except of the removal of alcohol, a part of the water contained in the wine is removed too and the concentration of the wine occurs.

Table 3.8. Influence of the dealcoholization process time on chemical and physical parameters of red dry wine Merlot

Time, min	**Alcohol content,% vol.**	**Mass concentration of, g/dm³**							
		Titratable acids	**Volatile acids**	**Residual sugars**	**Tartaric acid**	**Malic acid**	**Lactic acid**	**Citric acid**	**pH**
Initial wine	13,1±0,1	5,20±0,08	0,33±0,03	1,1±0,5	1,9±0,2	0,7±0,1	1,2±0,2	0,20±0,04	3,30±0,01
5	10,5±0,1	5,90±0,12	0,30±0,02	1,3±0,5	2,2±0,3	0,9±0,1	1,3±0,3	0,30±0,02	3,20±0,01
10	8,4±0,1	6,90±0,09	0,30±0,03	1,9±0,5	2,4±0,1	1,1±0,3	1,5±0,1	0,50±0,05	3,18±0,01
15	6,8±0,1	7,40±0,10	0,30±0,04	2,3±0,5	2,6±0,1	1,4±0,2	1,6±0,1	0,60±0,04	3,16±0,01
25	4,5±0,1	8,10±0,11	0,29±0,04	2,5±0,5	2,8±0,1	1,6±0,2	1,8±0,3	0,70±0,03	3,12±0,01
35	3,4±0,1	9,70±0,12	0,29±0,04	2,7±0,5	3,0±0,1	1,8±0,1	2,1±0,3	0,90±0,05	3,09±0,01

Mass concentration of titratable acids increases in the range from 5,2 g/dm^3 to 9,7 g/dm^3 giving the wine "green " coarse acidity due to a significant increase in the content of organic acids which varies in the limits: tartaric acid from 1,9 g/dm^3 to 3,0 g/dm^3, malic acid from 0,7 g/dm^3 to 1,8 g/dm^3, lactic acid from 1,2 g/dm^3 to 2,1 g/dm^3 and citric acid from 0,2 g/dm^3 to 0,9 g/dm^3 in dependence of removed ethanol. pH is another index that has changed in the process of dealcoholization and varies in the range from 3,30 to 3,12. Concentration of residual sugars varies in dependence of processing time from 1,1 g/dm^3 to 2,7 g/dm^3.

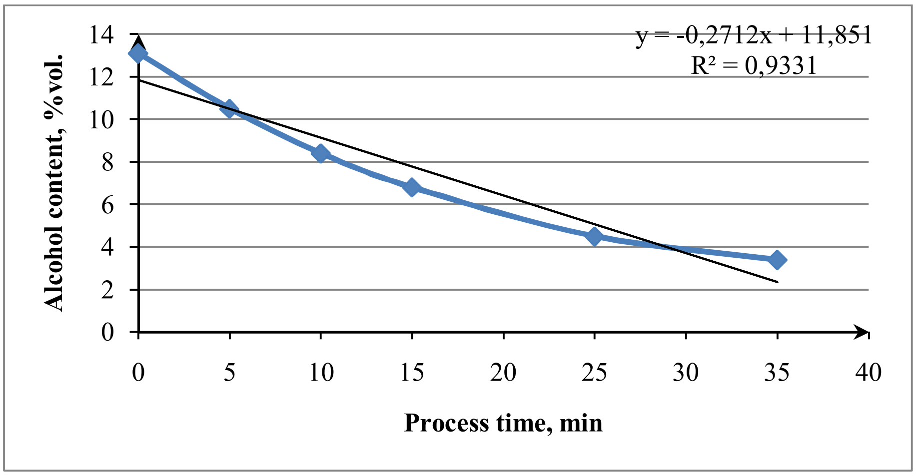

Fig.3.14. Mechanism of ethanol removal from red wine Merlot (T=40°C, P=4 kPa)

Figure 3.14 graphically demonstrates the mechanism of ethanol removal from red wine at the temperature of 40ºC. In the time interval from 5 to 35 minutes uniform removal of the alcohol in red wines is observed and significant influence of processing time on alcoholic content in the process of dealcoholization is demonstrated. Contrary to the temperature of 30ºC, process of ethanol removal from wine at the temperature of 40ºC represents the linear relation between process time and alcohol content.

Experimental data regarding the influence of processing time on ethanol removal allows concluding that extent of alcohol reduction increases in dependence of operating time. Furthermore, mechanism of ethanol removal from wine at different temperatures was investigated and obtained data demonstrated, that ethanol removal at the temperature of 30°C and 40°C differs significantly. At the temperature of 30°C the process of ethanol removal proceeds nonuniformly contrary to the temperature of 40°C where the process of ethanol removal flows regularly because of rapid adaptation of the system to new equilibrium.

3.4. Influence of the initial wine volume for dealcoholization on physical and chemical parameters of obtained white and red wines

According to Alvarez et al. alcoholic reduction percent increases with the time and it depends on the initial volume of wine [12]. Hence, next stage of research included the study of influence of initial wine volume, to be directed to dealcoholization process, on physical-chemical parameters of white and red wines. Investigation regarding the influence of initial volume on composition of wines was carried out by dealcoholization of experimental samples of white and red wines at the constant temperature (30°C), pressure (4 kPa) and processing time (45 min) and volume of initial wine varied from 0,25 dm³ to 1,0 dm³. Results of research are presented in the table 3.9, 3.10.

Table 3.9. Influence of volume of wine on physical-chemical parameters of white wine Chardonnay

Parameter	Initial wine	Volume of wine, dm³			
		0,25 (1/4)	0,50 (1/2)	0,75 (3/4)	1 (1/1)
Alcohol content, % vol.	13,5±0,1	8,9±0,1	10,0±0,1	11,9±0,1	13,2±0,1
Mass concentration of, g/dm³					
-titratable acids	6,5±0,1	7,4±0,1	7,1±0,1	6,7±0,1	6,6±0,1
-volatile acids	0,42±0,03	0,37±0,04	0,37±0,04	0,41±0,03	0,42±0,04
-residual sugars	1,3±0,5	2,3±0,5	2,1±0,5	1,4±0,5	1,3±0,5
-tartaric acid	3,4±0,1	3,8±0,1	3,6±0,1	3,4±0,2	3,4±0,2
-malic acid	2,4±0,4	2,7±0,3	2,6±0,1	2,4±0,1	2,4±0,1
-lactic acid	0,10±0,03	0,20±0,02	0,20±0,03	0,10±0,03	0,10±0,03
-citric acid	0,20±0,04	0,30±0,04	0,30±0,04	0,30±0,03	0,30±0,05
pH	3,07±0,01	3,04±0,01	3,04±0,01	3,06±0,01	3,07±0,01
Volume losses, %	-	12	8	4	<1
Organoleptic evaluation, points	7,9±0,01	7,7±0,01	7,8±0,01	7,9±0,01	7,9±0,01

According to the data presented in the table 3.9, significant dependence between the initial volume of wine and alcohol removal is observed. Ethanol removal process is inversely proportional the initial volume of wine. Thus, at the volume of 0,25 dm³ a significant reduction of alcoholic content from wine occurs and constitutes 4,6% vol. Besides the alcoholic content reduction an increase of mass concentration of titratable acids –from 6,5 g/dm³ to 7,4 g/dm³ and residual sugars from 1,3 g/dm³ to 2,3 g/dm³ was marked. Increase of mass concentration of titratable acids is related to the change of concentrations of organic acids: tartaric acid concentration increased from 3,4 g/dm³ to 3,8 g/dm³, malic acid from 2,4 g/dm³ to 2,7 g/dm³, lactic acid from 0,1 g/dm³ to 0,2 g/dm³ and citric acid from 0,2 g/dm³ to 0,3 g/dm³. A decrease of mass concentration of volatile acids from 0,42 g/dm³ to 0,37 g/dm³ was observed.

Increasing of initial volume to 1,0 dm³ leads to significant decrease of ethanol removal rate from wine which is confirmed by the results of analysis. Alcoholic content decreased only on 0,3% vol. during the same period. Mass concentration of titratable acids, residual sugars, volatile acids, pH and concentration of organic acids remained unchanged in the process of dealcoholization. Thus, can be concluded, that increasing of initial wine volume requires a lengthening of the processing time, in order to obtain desirable alcohol reduction. Besides this, volume increase to 1 dm^3 leads to insignificant volume losses (<1%), as well as reduction of initial volume to 0,25 dm^3 demonstrated 12% losses of volume. Sensory evaluation demonstrates significant influence of the initial wine volume on the quality of obtained wines. Reduction of wine volume leads to negative influence on sensory properties of wines.

Furthermore, results regarding the losses of volatile compounds in the process of dealcoholization in dependence of the initial wine volume have the significant practical interest. In this study the influence of initial wine volume on behavior of volatile compounds was studied. Obtained redults are presented in fig. 3.15, 3.16, 3.17, 3.18 and table A.1.4.

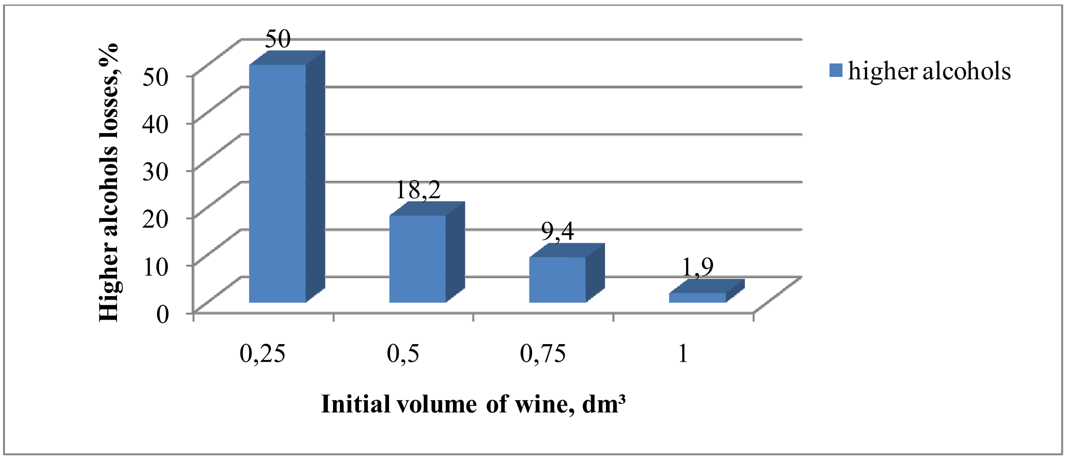

Fig.3.15.Influence of initial wine volume on higher alcohols removal during the dealcoholization process

It has been established that at low concentrations higher alcohols generally add complexity to the bouquet, but higher quantities are regarded as negatively impacting wine quality [9, 134]. Consequently, reduction of higher alcohols in the process of ethanol removal can contribute in some ways to improvement of aroma of wine, i.e. dealcoholization process not only reduces alcoholic content of wine, but also contributes to obtaining of more balanced and harmonious wine. In the process of dealcoholization reduction of initial volume of wine to 0,25 dm^3 facilitates not only ethanol removal, but also that of higher alcohols. The percentage of higher alcohols losses is equal to 50%. Increasing of initial volume to 0,5 dm^3 leads to reduction of higher alcohols more than twofold and consists 18,2%, with further increase of initial wine volume to 0,75 dm^3 losses of higher alcohols account for 9,4%. Minimal losses of higher alcohols was marked at the initial wine volume at 1,0 dm^3 and accounts for 1,9%.

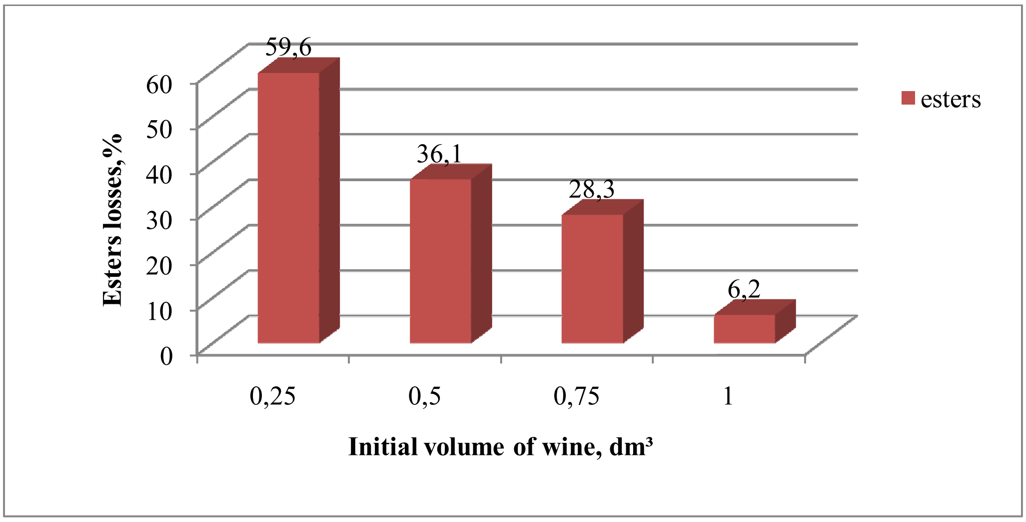

Fig.3.16. Influence of initial wine volume on esters removal during the dealcoholization process

Esters occur in wines as major volatile constituents, and are typically responsible for 'fruity' wine odors, thus, removal of esters from will contribute to significant depletion of wine aroma [63, 89]. Fig. 3.16 shows the experimental results regarding the influence of initial wine volume on losses of esters from white wine Chardonnay. Obtained results demonstrate, that alcohol removal from wine is followed by significant esters losses in dependence of initial wine volume. At the volume of 0,25 dm^3 losses of esters in the dealcoholization process are equal to 59,6% , as a result of volume increase the effectiveness of the alcohol removal process decreases and losses of esters decreased too, which is confirmed by experimental results. For example, at the initial wine volume of 0,5 dm^3 losses constitutes 36,1% and at the volume of 1,0 dm^3 esters losses account for 6,2%.

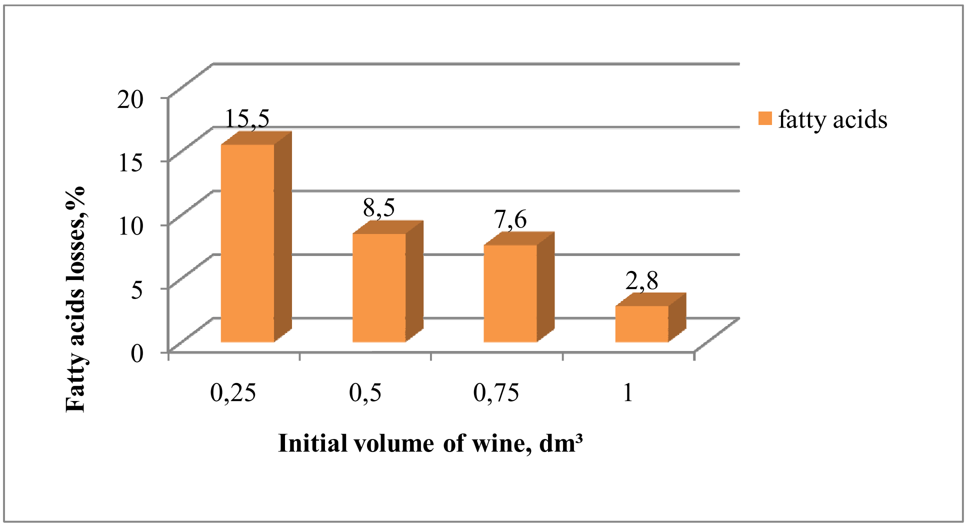

Fig.3.17. Influence of initial wine volume on fatty acids removal during the dealcoholization process

Fatty acids confer the wine, in dependence of chemical structure and concentration, different aromas being aromas of rancid, cheese, vinegar or sweat [169, 183]. Removal of fatty acids in the process of dealcoholization could have positive or negative consequences for wine quality. The positive consequences are connected with removal of fatty acids with unpleasant aromas thus improving the wine aroma. Negative consequences are connected with fact that in the process of dealcoholization besides the fatty acids other classes of volatile compounds are removed, which can lead to intensification of fatty acids unpleasant odors. Results regarding the influence of initial wine volume on fatty nacids removal from wine in the process of dealcoholization are presented in fig. 3.17. As in the case of other volatile compounds dealcoholization process is accompanied with fatty macids removal from wine, but in the smaller extent due to higher boiling temperatures. Fatty acids losses at the volume of 1,0 dm^3 are equal to 2,8% (for example, esters losses at the same volume are equal to 6,23%). At the volume of 0,25 dm^3 percentage of fatty acids removal consists of 15,5%.

Aromatic aldehydes and ketones are present in wines in small quantities, some of them confer the wine pleasant odours of violets, vanilla aromas or unpleasant flavors such as overripe, bruised fruit of butter [56, 116, 146].

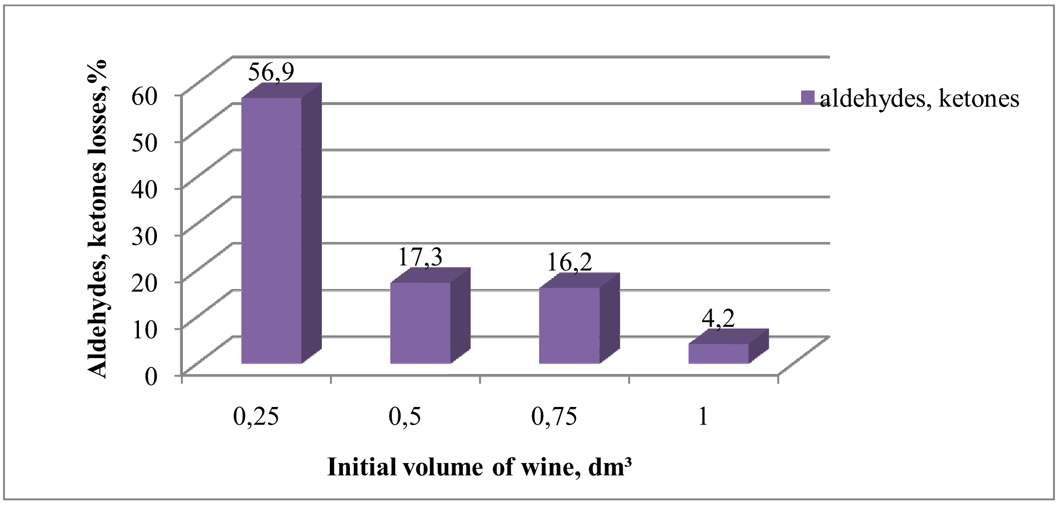

Fig.3.18. Influence of initial wine volume on aldehydes and ketones removal during the dealcoholization process

Data shown in fig. 3.18 indicate that volume of wine influences the extent of aldehydes and ketones removal during the dealcoholization process. Thus, maximal losses of aldehydes and ketones are obtained at the initial wine volume of 0,25 dm^3 (56,9%), followed by 0,5 dm^3 with losses equal to 17,3%. At the volume of 0,75 dm^3 losses reduced to 16,2% and minimal percentage of reduction was registered at the volume of 1,0 dm^3 (4,2%).

Influence of initial volume of wine on physical-chemical parameters of red wine Merlot was studied. The results are presented in table 3.10.

Results of research have demonstrated explicit dependence between initial volume of wine to be dealcoholized and physical-chemical composition. Thus, a reduction of alcoholic content from 12,9 % vol. (1,0 dm^3) to 9,2% vol. (0,25 dm^3) demonstrates dependence between volume reduction and ethanol removal extent. Moreover, mass concentration of titratable acids increased from 5,2 g/dm^3 (initial wine) to 6,1 g/dm^3 (0,25 dm^3), through increasing of organic acids concentrations. For example, tartaric acid concentration varies from 1,9 g/dm^3 (1,0 dm^3) to 2,4 g/dm^3 (0,25 dm^3). Mass concentration of volatile acids remain practically unchanged in the process of ethanol removal and varies from 0,33 g/dm^3 to 0,30 g/dm^3.

Mass concentration of residual sugars depends on initial wine volume and varies from 1,2g/dm^3 (1,0 dm^3) to 1,7 g/dm^3 (0,25 dm^3). Value of pH varies insignificantly from 3,3 to 3,2. Furthermore, significant losses are demonstrated at the volume of 0,25 dm^3(11%) and 1% at the volume of 1,0 dm^3.

Table 3.10. Influence of volume of wine on physical-chemical parameters of red wine Merlot

Parameter	Initial wine	Volume of wine, dm^3			
		0,25 (1/4)	**0,50 (1/2)**	**0,75 (3/4)**	**1,0 (1/1)**
Alcohol content, % vol.	13,1±0,1	9,2±0,1	10,5±0,1	11,8±0,1	12,9±0,1
Mass concentration of, g/dm^3					
-titratable acids	5,20±0,08	6,10±0,12	5,9±0,1	5,60±0,12	5,30±0,11
-volatile acids	0,33±0,03	0,30±0,03	0,30±0,04	0,33±0,03	0,33±0,03
-residual sugars	1,1±0,5	1,7±0,5	1,3±0,5	1,3±0,5	1,2±0,5
-tartaric acid	1,9±0,2	2,4±0,1	2,2±0,2	2,0±0,3	1,9±0,2
-malic acid	0,7±0,1	1,1±0,1	0,9±0,2	0,9±0,1	0,8±0,1
-lactic acid	1,2±0,2	1,2±0,2	1,3±0,1	1,3±0,2	1,2±0,1
-citric acid	0,20±0,04	0,40±0,04	0,30±0,04	0,20±0,04	0,20±0,04
pH	3,30±0,01	3,20±0,01	3,20±0,01	3,30±0,01	3,30±0,01
Volume losses, %	-	11	7	4	<1
Organoleptic evaluation, points	7,9±0,01	7,7±0,01	7,8±0,01	7,9±0,01	7,9±0,01

Sensory evaluation of obtained wines demonstrate that organoleptic properties of wines decreased significantly in the case of volume of 0,25 dm^3 and varies from 7,9 points to 7,7 points.

Thus, the influence of initial volume of wine on ethanol removal and physical-chemical composition was studied. According to the obtained results can be concluded that volume of wine influences to a considerable extent the rate of ethanol removal, as well as, on modification of physical-chemical composition. It should, however, be noted that initial volume of wine is closely related to processing time of dealcoholization process. Thus, increasing of initial volume requireth the concomitant increasing of processing time of process for achievement of desired alcoholic concentration.

3.5 Influence of initial alcohol content on physical-chemical parameters of white and red wines.

Initial alcohol content influences the process of ethanol removal from white and red wines. It is known, that highest alcoholic content in wines means the highest concentration of ethanol and its vapors, that facilitate the process of ethanol removal under reduced pressure. Furthermore, water-alcohol mixture is enriched by ethanol, which accelerates the process of dealcoholization too. In order to determine the influence of initial alcohol content on the dealcoholization process in the samples of white and red wines pure alcohol was added in order to obtain samples of wine with different alcohol content. The dealcoholization process was carried out after 24 hours in order to allow the assimilation of alcohol added to wine. Process of ethanol removal was carried out at constant pressure (4 kPa), temperature (30°C), processing time (30 min) and volume of wine (0,5 dm^3). The main chemical-physical parameters in obtained wines were determined. Obtained results are presented in tables 3.11, 3.12 and fig. 3.19, 3.20.

Table 3.11. Chemical-physical parameters of white dealcoholized wines with different alcohol content in the initial wine

Parameter	**Alcoholic content, % vol.**			
	13±0,1	**14±0,1**	**15±0,1**	**16±0,1**
% of reduced alcoholic content, % vol.	1,8	2,6	3,5	4,2
Mass concentration of, g/dm^3				
-titratable acids	6,40±0,11	6,3±0,1	6,30±0,12	6,2±0,1
-volatile acids	0,32±0,03	0,33±0,04	0,33±0,04	0,33±0,03
-residual sugars	1,3±0,5	1,3±0,5	1,3±0,5	1,3±0,5
-tartaric acid	3,6±0,3	3,6±0,1	3,6±0,2	3,5±0,1
-malic acid	1,2±0,1	1,2±0,1	1,2±0,2	1,1±0,1
-lactic acid	0,5±0,02	0,5±0,04	0,5±0,02	0,5±0,03
-citric acid	0,3±0,03	0,3±0,04	0,3±0,03	0,3±0,03
pH	3,23±0,01	3,23±0,01	3,23±0,01	3,23±0,01

Table 3.11 presents the influence of initial alcohol content on chemical-physical indices of dealcoholized white wines. According to the obtained results mass concentration of titratable acids, residual sugars remain unchanged and vary within the permissible range in obtained dealcoholized white wines. Mass concentration of volatile acids remains constant and constitutes 0,33 g/dm^3. The changes of one of the most important components of the chemical composition - organic acids were studied.

From these results, mass concentration of tartaric, malic, lactic and citric acids does not change practically in the process of dealcoholization.

Fig. 3.19 shows the influence of the initial alcohol content on the rate of ethanol removal during the dealcoholization process. Concomitantly, with increasing of the initial alcohol content the fraction of removed alcohol from wines in the process of dealcoholization increases too.

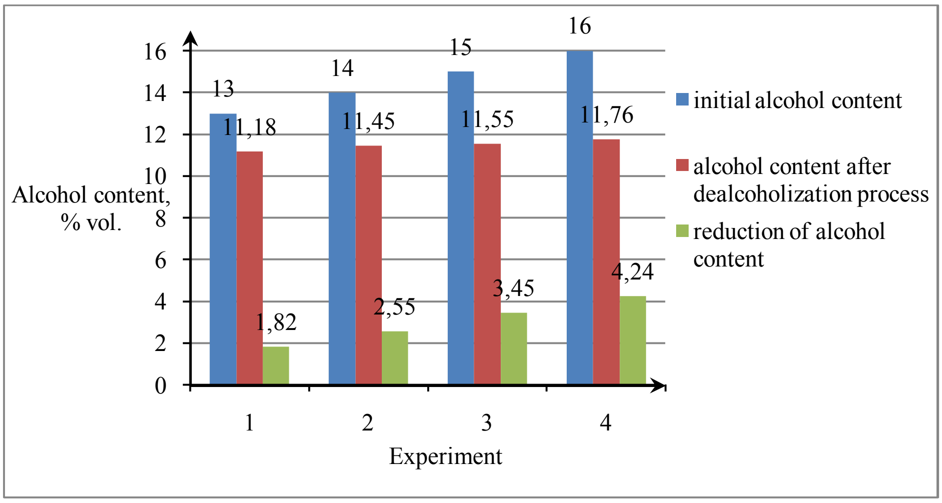

Fig.3.19. Influence of initial alcohol content on dealcoholization process of white dry wines (Experiments: **1**- 13% vol initial alcoholic concentration, **2**- 14% vol initial alcoholic concentration, **3**- 15% vol initial alcoholic concentration, **4** - 16% vol initial alcoholic concentration)

Realization of the experiment and analysis of obtained data has shown, that in the initial wine with alcohol content 13% vol. the fraction of removed alcohol consists 1,82%.vol and at 16% vol. fraction of removed alcohol content increased significantly and consists 4,24% vol.

Table 3.12. Chemical-physical parameters of red dealcoholized wines with different alcohol content in the initial wine

Parameters	**Alcoholic content, % vol.**		
	14±0,1	**15±0,1**	**16±0,1**
% reduction of alcoholic content, % vol	2,3	3,2	4,0
Mass concentration of, g/dm³			
-titratable acids	6,4±0,08	6,1±0,12	6,0±0,1
-volatile acids	0,36±0,03	0,36±0,04	0,36±0,04
-residual sugars	2,7±0,5	2,7±0,5	2,6±0,5
-tartaric acid	2,9±0,2	2,7±0,1	2,7±0,2
-malic acid	1,9±0,2	1,9±0,2	1,8±0,1
-lactic acid	0,7±0,1	0,6±0,06	0,6±0,08
-citric acid	0,3±0,04	0,2±0,02	0,2±0,02
pH	3,30±0,01	3,30±0,01	3,30±0,01

According to obtained results there are no significant changes in physical-chemical composition of obtained wines with reduced alcohol content. There is an insignificant varying of mass concentration of titratable acids (from 6,0 g/dm^3 6,4 g/dm^3) and concentration of residual sugars (from 2,6 g/dm^3 to 2,7 g/dm^3) is observed. Volatile acidity and pH remain unchanged in the process of dealcoholization.

Organic acids composition change was studied. According to the obtained results concentration of tartric acid varies from 2,7 g/dm^3 to 2,9 g/dm^3, malic acid – from 1,8 g/dm^3 to 1,9 g/dm^3, lactic acid from 0,6 g/dm^3 to 0,7 g/dm^3 and citric acid varies from 0,2 g/dm^3 to 0,3 g/dm^3.

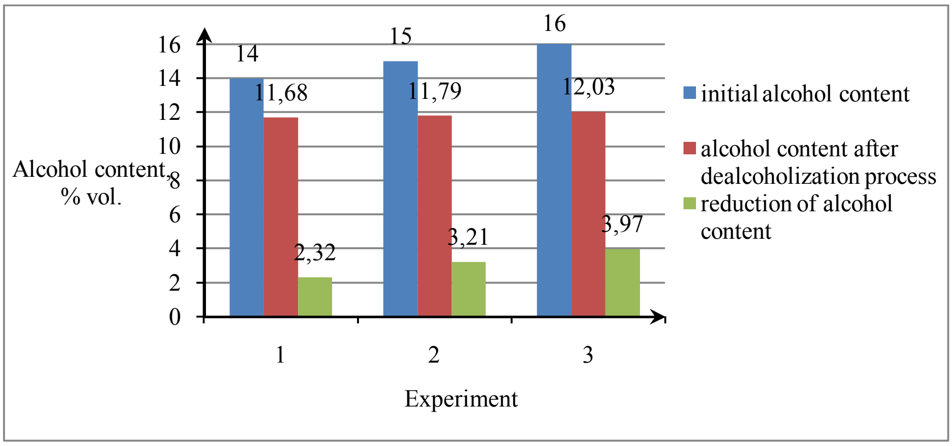

Fig. 3.20. Influence of initial alcohol content on dealcoholization process of red dry wines (Experiments: **1**- 14% vol initial alcoholic concentration, **2**- 15% vol initial alcoholic concentration, **3**- 16% vol initial alcoholic concentration)

Fig. 3.20 shows the influence of the initial alcohol content on the rate of its removal during the dealcoholization process. As well as in the case of white wines, initial alcohol concentration influences on the rate of removal of alcohol in the dealcoholization process. Realization of the experiment and analysis of obtained data has shown, that in initial wine with alcohol content 14% vol. the fraction of removed alcohol consists 2,32% vol. and at 16% vol. fraction of removed alcohol content increased significantly and consists 3,97% vol.

On the basis of obtained results can be concluded that initial alcohol content in wines influences the rate of ethanol removal. Increasing of alcoholic concentration influences the saturation level of ethanol in alcohol-water relation in wine that leads to more rapidly removal of ethanol vapors from wine.

3.6. Statistical and mathematical analysis of the results

Example of determination of confidence interval for a sample:

1. Determination of the mean, $|X_i - \bar{X}|$ and $(X_i - \bar{X})^2$. Results are presented in the table 3.13.

Table 3.13. Determination of the $\bar{X}$, $|X_i-\bar{X}|$ and $(X_i-\bar{X})^2$

X_i	$\bar{X}$	$\lvert X_i-\bar{X}\rvert$	$(X_i-\bar{X})^2$
6,45	6,5166	0,0667	0,00444
6,50		0,0167	0,000278
6,60		0,0833	0,00694

2. Calculation of sample variance and standard deviation of the sample:

$$S^2 = \frac{0.0117}{2} = 0.00583$$

$$s = \sqrt{S^2} = \sqrt{0.00583} = 0.0764$$

3.Determination of t-distribution:

$$t_{(n-1;\alpha/2)} = t_{(2;0.025)} = 4,303$$

4.Calculation of confidence interval for a mean:

$$\varepsilon = 4,303\frac{0,0764}{\sqrt{3}} = 0,19$$

Confidence interval- (5,62±0,19).

In the thesis obtained data regarding the influence of physical factors: temperature, pressure, operating time and volume on ethanol removal from white and red wines was statistically evaluated using program StatGraphics.

Analysis of obtained results has shown that rate of alcohol removal from wines depend the following factors: operating time (X_1), temperature (X_2), pressure (X_3) and volume (X_4) and alcoholic content was selected as dependent variable (Y). General representation of multiple regression equation is presented in formula 3.1.

$$\mathbf{Y = a + b_1X_1 + b_2X_2 + ... + b_nX_n,} \quad (3.1)$$

Where, a - Y intercept point,

$b_1, b_2, ... , b_n$ - Slope of $X_1, X_2, ... , X_n$ respectively

In the table 3.14 the matrix of studied values for Chardonnay is represented:

Table 3.14 Matrix of studied values for Chardonnay

Time, min **X1**	Temperature, °C **X2**	Pressure, kPa **X3**	Volume, dm^3 **X4**	Alcoholic content, % vol. **Y**
10	20	4	1	13,4
10	20	30	1	13,5
10	40	4	1	7,9
10	40	30	1	12,6
10	20	4	0,25	12,8
10	20	30	0,25	13,4
10	40	4	0,25	6,1
10	40	30	0,25	12
30	20	4	1	13

Continuation of the table 3.14

30	20	30	1	13,2
30	40	4	1	5,3
30	40	30	1	11,5
30	20	4	0,25	12,1
30	20	30	0,25	12,9
30	40	4	0,25	1,5
30	40	30	0,25	10,9

Table 3.15. Analysis of Variance for **Y** (Alcoholic content) - Type III Sums of Squares for white wine Chardonnay

Source	**Sum of squares**	**Degrees of freedom**	**Mean square**	**F_{ratio}**	**P-value**
Time	24,22	1	24,22	6,93	0,0117
Temperature	253,46	1	253,46	72,49	0,0000
Pressure	146,65	1	146,65	41,94	0,0000
Volume	12,51	1	12,51	3,59	0,0653
Residual (Error)	150,34	43	3,58		
Total (corrected)	**587,19**	**47**			

The ANOVA table decomposes the variability of Alcoholic content into contributions due to various factors. Since Type III sums of squares (the default) have been chosen, the contribution of each factor is measured having removed the effects of all other factors. The P-values test shows the statistical significance of each of the factors. According to obtained data 3 P-values (Time, temperature and pressure) are less than 0,05, these factors have a statistically significant effect on Alcoholic content at the 95,0% confidence level.

The results of fitting a multiple linear regression model to describe the relationship between Alcoholic content and 4 independent variables (time, temperature, pressure and volume) for white wine Chardonnay are presented below.

The equation of the fitted model is :

$\mathbf{Y = 16{,}0394 - 0{,}0710417*X_1 - 0{,}229792*X_2 + 9{,}9881*X_3 + 1{,}36111*X_4}$, where

Y-alcoholic concentration, % vol.; 16,0394-2,13 – 6,891+0,399+0,68

X_1 – operating time, min;

X_2 – temperature, ºC;

X_3 – pressure, kPa;

X_4 – initial volume of wine, dm^3.

According to obtained results, the model can be simplified, the highest P-value on the independent variables is 0,0653, belonging to Volume and so Volume can be removed from the model.

Simplified equation of regression:

$$Y = 16{,}0394 - 0{,}0710417*X_1 - 0{,}229792*X_2 + 9{,}9881*X_3$$

Table 3.16. Analysis of Variance of regression equation for white wine Chardonnay

Source	Sum of squares	Degrees of freedom	Mean square	F_{ratio}	P-value
Model	436,84	4	109,21	31,24	0,0000
Residual	150,34	43	3,50		
Total (correted)	**587,19**	**47**			

R-squared = 74,4%

R-squared (adjusted for df) = 72 %

Since the P-value in the ANOVA table is less than 0,01, there is a statistically significant relationship between the variables at the 99% confidence level.

The R-Squared statistic indicates that the model as fitted explains 74,4% of the variability in Alcoholic content. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 72%.

Statistical and mathematical analysis was performed for red wine Merlot. In table 3.17 the matrix of values for Merlot is presented.

Table 3.17. Matrix of values for red wine Merlot

Time, min X_1	Temperature, °C X_2	Pressure, kPa X_3	Volume, dm^3 X_4	Alcoholic content, % vol. Y
10	20	4	1	13
10	20	30	1	13,1
10	40	4	1	8,7
10	40	30	1	12,7
10	20	4	0,25	12,7
10	20	30	0,25	13
10	40	4	0,25	6,8
10	40	30	0,25	12,4
30	20	4	1	12,7
30	20	30	1	12,9
30	40	4	1	6,1
30	40	30	1	12,1

Continuation of the table 3.17

30	20	4	0,25	12,4
30	20	30	0,25	12,8
30	40	4	0,25	2,3
30	40	30	0,25	11,2

Table 3.18. Analysis of Variance for **Y** (Alcoholic content) - Type III Sums of Squares for red wine Merlot

Source	Sum of squares	Degrees of freedom	Mean square	F_{ratio}	P-value
Time	18,00	1	18,01	5,30	0,0262
Temperature	171,76	1	171,76	50,59	0,0000
Pressure	126,75	1	126,75	37,33	0,0000
Volume	10,27	1	10,27	3,02	0,0892
Residual (Error)	146,00	43	3,40		
Total (corrected)	**472,79**	**47**			

The ANOVA table 3.18 analyses the variability of dependent variable Alcoholic content into contributions due to various factors. P-values test shows the statistical significance of each of the physical factors. According to obtained results 3 P-values (Time, temperature and pressure) are less than 0,05, these factors have a statistically significant effect on Alcoholic content at the 95,0% confidence level. P-value of Volume is greater than 0,05 suggesting that Volume has no statistically significant effect on Alcoholic content.

On the base of practical results the regression analysis was performed. Multiple linear regression model to describe the relationship between dependent variable Alcoholic content and 4 independent variables (time, temperature, pressure and volume) for red wine Merlot is presented below.

$Y = 15,0452 - 0,06125*X_1 - 0,189167*X_2 + 9,28571*X_3 + 1,23333*X_4$, where

Y-alcoholic concentration, % vol.;

X_1 – operating time, min;

X_2 – temperature, ºC;

X_3 – pressure, kPa;

X_4 – initial volume of wine, dm^3.

According to obtained results, the model can be simplified, the highest P-value on the independent variables is 0,0892, belonging to Volume and so Volume can be removed from the model.

Simplified equation of regression:

$Y = 15,0452 - 0,06125*X_1 - 0,189167*X_2 + 9,28571*X_3$

Table 3.19. Analysis of Variance of regression equation for red wine Merlot

Source	Sum of squares	Degrees of freedom	Mean square	F_{ratio}	P-value
Model	326,79	4	81,70	24,06	0,0000
Residual	146,00	43	3,40		
Total (correted)	**472,79**	**47**			

R-squared = 69 %

R-squared (adjusted for df) = 66,2 %

The R-Squared statistic indicates that the model as fitted explains 69% of the variability in Alcoholic content. The adjusted R-squared statistic, which is more suitable for comparing models with different numbers of independent variables, is 66,2%.

According to the obtained mathematical model model the influence of initial volume can be excluded from regression equation. It was established that Temperature and Pressure are the main technological factors influencing the process of ethanol removal.

3.7. Conclusions to the chapter 3

In the chapter 3 scientific results concerning the elaboration of optimal technological regimes for correction of alcoholic content in wines using vacuum distillation process was studied. On the base of theoretical data main physical factors which have the influence on distillation under vacuum was evidentiated. Temperature, pressure, operating time and initial volume of wine are the main factors influencing ethanol removal process from wine.

Process of ethanol removal using vacuum distillation method influences the physical-chemical composition of obtained wines in dependence of technological regimes. Significant temperature, processing time increase and decrease of volume leads to concentration of wine by removal of the part of water from wine and followed by increasing of titratable acidity, residual sugars, organic acids concentration and decrease of volatile acidity, pH value. Moreover, concentration of phenolic compounds and antocyanins increases significantly in red wines.

Thus, obtained data demonstrated the major influence of temperature 40°C on ethanol removal process as well as on physical-chemical composition. Alcohol content varies from 13,5% vol. to 4,7% vol. for white wines and from 13,1% vol. to 5,0% vol. in the case of red wines. A significant depletion of white wine aroma as a result of major losses of esters up to 90,4%, higher alcohols – 86,2%, acids- 30,7% and aldehydes and ketones up to 60,6%. Temperature of 20°C has the minimal impact on composition of wine as a result of low efficiency of dealcoholization process. Alcoholic concentration in white and red varies from 13,5% vol. to 13,2% vol. and from 13,1% vol. to 12,8% vol. subsequently. According to obtained data temperature of 30°C can be recommended for removal of alcohol from wine using method of vacuum distillation because of improvement of the process efficiency and insignificant influence on wine composition. Alcoholic concentration decreases to 3,5% vol. for white wines and to 2,6% vol. for red wines. Volatile compounds losses at the temperature of 30ºC consists 18,01% for higher alcohols, 35,5% for esters, 8% of acids and 15,7% of aldehydes and ketones.

Obtained results have shown the significant influences of pressure on the process of ethanol removal from wines. Pressure decrease improves the efficiency of dealcoholization process, thus, pressure of 4 kPa increases the efficiency of ethanol removal from 13,5% vol. to 10 % vol. with aroma losses of higher alcohols to 18,3%, esters to 35,6%, acids to 8,5 % and aldehydes and ketones to 17,3% for white wines. Alcoholic strength of red wines at the pressure of 4 kPa decreased from 13,1% vol. to 10,5% vol. Also worth noting, that pressure of 10 kPa permits effective reducing of alcoholic strength of studied wines. Thus, alcoholic concentration of white wine varies from 13,5% vol. to 10,4% vol. and for red wines varies in the range from 13,1% vol. to 10,7% vol. It should be noted, that pressure decrease allows the significant reducing of processing time of the dealcoholization process. At the pressure of 40 kPa ethanol removal don't occur for both white and red wines. Thus, interval of pressure from 10 kPa to 4 kPa can be recommended for effective of ethanol removal from wines.

Experimental data demonstrated direct relationship between the operating time and alcoholic strength reduction as well as on concentration of volatile complex in white and red wines. Thus, increasing of the process time to 120 min for white wines allows the reduction of alcohol content from 13,5% vol. to 4,1% vol. with significant depletion of volatile complex, thus, ester losses consist 99,9% and higher alcohols – 90,7% which have negative impact on quality of resulting wines. In the case of red wines increasing of interval to 35 min permits reducing of alcohol content from 13,1% vol. to 3,4% vol.

Result of research has shown the evident dependence between initial volume of wine and ethanol removal process. According to the obtained results variation of initial volume from 0,25 dm^3 to 1,0 dm^3 influences on the rate of ethanol removal, as well as, and on modification of physical-chemical composition. At the volume of 0,25 dm^3 a significant decrease of alcoholic concentration as well as increasing of volatile compounds losses was detected. Alcoholic concentration varies from 13,5% vol. to 8,9% vol for white wines and 13,1% vol to 9,2% vol. for red wines. In obtained wines a significant degradation of aroma characteristics by removal of 50% of higher alcohols concentration, 59,6% of esters, 15,5% of acids and 56,9% of aldehydes and ketones was found. By comparison, increasing of initial volume to 1,0 dm^3 lead to lowering of the rate of ethanol removal from 13,5% vol. to 13,2% vol. for white wine Chardonnay and from 13,1% vol. to 12,9% vol. for red wine Merlot. On the basis of resulting data, it should, however, be noted that increasing of initial volume of wine requires the expanding of the processing time of dealcoholization.

Obtained results have shown significant influences of initial alcohol content in wines on the rate of ethanol removal in the process of dealcoholization. Increasing of alcoholic concentration influences the saturation level of ethanol in alcohol-water relation in wine that leads to more rapidly removal of ethanol vapors from wine. Thus, increasing of alcohol content from 13% vol. to 16% vol. for white wines and from 14% vol. to 16% vol. leads to increasing of part of removed ethanol from 1,82% vol. to 4,24% vol. and from 2,32% vol. to 3,97% vol.

On the base of undertaken study in laboratory conditions an adequate mathematical model, reflecting the influence of physical factors of dealcoholization process on alcohol removal was obtained. According to obtained model the influence of initial volume can be excluded from regression equation. It was established that Temperature and Pressure are the main technological factors influencing the process of ethanol removal.

4. IMPROVEMENT OF TECHNOLOGICAL REGIMES FOR CORRECTION OF ALCOHOLIC CONTENT IN WINES

4.1. Perfection of technological regimes for dry wines alcoholic content correction

Detailed examination of existing technologies for low-alcohol wine production has shown that process of alcohol reduction leads to significant losses of aroma compounds from wine that exert a detrimental effect on wine quality. According to obtained results 20% reduction of alcohol content using vacuum distillation method leads to insignificant losses of aroma compounds, however, at the greater ethanol removal extent a depletion of aroma is observed. Hence, recovery of aroma of wine obtained in the process of dealcoholization represents very important scientific challenge.

In order to establish optimal conditions of ethanol removal for production of wines with corrected alcoholic content without significant aroma losses the process was carried out at the different stages of wine production:

1. Dealcoholization of the fermenting wort (**Scheme 1**);

2. Dealcoholization of the dry wine resulting from complete fermentation of sugars (**Scheme 2**).

Investigation was carried out was by vacuum distillation process using technological regimes elaborated in chapter 3: temperature 30°C, at the pressure of 4 kPa and influence of dealcoholization process on physical-chemical composition and aromatic complex was studied.

Scheme 1. Dealcoholization of the fermenting wort. In winemaking season in the laboratory conditions the must from grape variety Chardonnay in the volume of 10 liters was obtained, which after clarification was sent to fermentation. After initiation of the fermentation process, a part of fermenting wort (with an alcohol content of 5% vol.) was aimed at dealcoholization. Dealcoholization process was carried out by rotary evaporation in the result dealcoholized part of fermenting wort with an alcohol content of about 3% vol. was received. This part of dealcoholized fermenting wort is blended with the main part of fermenting wort and sent for further fermentation. Upon reaching the alcohol content of 10% vol., a part of fermenting wort is taken and sent to dealcoholization process to the alcohol content of 8% vol. after then blended again and sent to the end-fermentation. Thus, this method allows obtaining the wine with reduced alcohol content.

Scheme 2. Dealcoholization of the wine resulting from complete fermentation of sugars. This method of dealcoholized white and red wine production consists in removing a part of the alcohol from dry wines after the completing of fermentation process. In winemaking season dry white wine Chardonnay was obtained. After the process of fermentation and clarification obtained wine was aimed at the process of ethanol reduction. As a result, the wine with corrected alcoholic content was obtained. Chemical-physical characteristics of white wines with corrected alcoholic content obtained according to the schemes 1 and 2 are shown in table 4.1.

Table 4.1. Chemical- physical indices of white wines with corrected alcoholic content

Parameter	**Initial wine**	**Scheme**	
		1	**2**
Alcohol content, % vol.	13,1±0,1	11,5±0,1	11,3±0,1
Mass concentration of, g/dm^3			
-titratable acidity	6,6±0,10	6,9±0,1	7,0±0,1
-volatile acidity	0,26±0,03	0,26±0,03	0,26±0,04
-residual sugars	1,5±0,5	1,6±0,5	1,6±0,5
-tartaric acid	3,4±0,1	3,5±0,2	3,5±0,2
-malic acid	2,7±0,1	2,8±0,3	2,8±0,3
-lactic acid	0,10±0,03	0,20±0,05	0,20±0,03
-citric acid	0,20±0,06	0,30±0,04	0,30±0,04
pH	3,07±0,01	3,07±0,01	3,06±0,01
Organoletic evaluation, point	7,9±0,01	7,7±0,01	7,9±0,01

The experimental data presented in table 4.1 indicate, that obtained wines with corrected alcoholic content differ in chemical-physical indices in comparison with initial wine. Practically there is no significant difference between alcoholic concentration of wines obtained by Scheme 1 and 2 and varies from 11,5 % vol (scheme 1) to 11,3% vol (scheme 2). Mass concentration of titratable acids in dealcoholized wines increased from 6,6 g/dm^3 (initial wine) to 6,9 g/dm^3 (scheme 1) and 7,0 g/dm^3 (scheme 2). Concentration of residual sugars increased insignificantly in the process of dealcoholization. Mass concentration of volatile acids and pH value remain stable after the process of ethanol removal. Organoleptic evaluation has shown that wine obtained by scheme 2 received 7,9 points and wine obtained by scheme 1 only 7,7 points in comparison with initial wine which received 7,9 points.

Information regarding the losses of aroma compounds in the process of ethanol removal in dependence of using scheme is demonstrated in the table 4.2.

Table 4.2. Variation of volatile compounds concentration in dependence of used scheme

Parameter	Initial wine	Scheme	
		1	2
Alcohol content, % vol.	13,1±0,1	11,5±0,1	11,3±0,1
Higher alcohols, mg/dm³	179	100	133
Esters, mg/dm³	60	25	40
Fatty acids, mg/dm³	218	103	116
Aldehydes and ketones, mg/dm³	32	24	18

According to results presented in table 4.2, volatile complex of white wines obtained using vacuum distillation process for ethanol removal at different stages of wine production demonstrate, that wine obtained using scheme 1 differ significantly from wine obtained by scheme 2 on the basis of concentrations of main classes of volatile compounds. Significant losses of esters (from 60 mg/dm³ to 25 mg/dm³) and higher alcohols (from 179 mg/dm³ to 100 mg/dm³) are observed in wines obtained by scheme 1 resulting in oxidated wines with unexpressed aromas due to the fact that dealcoholization of fermenting wort is accompanied by considerable exhalation of CO_2, which contributes to significant volatile compounds removal from wine. Whereas, losses of volatile compounds in wines obtained by scheme 2 are much less than in wines obtained by scheme 1, resulting in more balanced wines with low-alcohol content. Concentration of higher alcohols constitutes 133 mg/dm³, esters 40 mg/dm³, fatty acids-116 mg/dm³ and aldehydes and ketones- 18 mg/dm³.

Production of wines with corrected alcoholic content by blending

The primary objective in the production of wines with corrected alcoholic content is obtaining of high quality wines, which do not differ in quality from ordinary alcoholic wines. Thus, for the production of wines with corrected alcoholic content a method of blending the partial dealcoholized wine with full natural dry wine was proposed. For this, the part of the wine is dealcoholized and then blended in different proportions with natural full wine. In the result a wine with corrected alcoholic content was obtained. This method allows restoring the fullness of wine, and to regulate the composition of the wine. Chemical-physical data of white and red wines obtained using blending method are presented in tables 4.3, 4.5

Table 4.3. Chemical-physical indices of white wines with corrected alcoholic content obtained by blending method

Relation, %	Alcohol content,% vol.	Mass concentration of, g/dm³							Sensory evaluation, points
		Titratable acids	Volatile acids	Residual sugars	Tartaric acid	Malic acid	Lactic acid	Citric acid	
wine 1*	13,5±0,1	6,50±0,10	0,42±0,03	1,3±0,5	3,4±0,1	2,4±0,4	0,10±0,03	0,20±0,04	7,9 ±0,01
wine 2 **	9,0±0,1	7,2±0,1	0,37±0,03	2,2±0,5	3,7±0,2	2,6±0,1	0,20±0,02	0,30±0,04	7,7±0,01
1:2=50:50	11,3±0,1	6,80±0,09	0,39±0,02	1,7±0,5	3,5±0,2	2,5±0,1	0,10±0,03	0,30±0,02	7,9±0,01
1:2=60:40	11,6±0,1	6,70±0,11	0,40±0,04	1,6±0,5	3,5±0,2	2,4±0,2	0,10±0,04	0,30±0,02	7,8±0,01
1:2=40:60	10,7±0,1	6,90±0,08	0,39±0,02	1,9±0,5	3,6±0,1	2,5±0,2	0,20±0,03	0,20±0,03	7,8±0,01
1:2=30:70	10,5±0,1	7,1±0,1	0,38±0,03	1,9±0,5	3,6±0,1	2,5±0,1	0,20±0,04	0,30±0,04	7,8±0,01
1:2=20:80	9,7±0,1	7,10±0,12	0,38±0,04	2,0±0,5	3,6±0,2	2,6±0,2	0,20±0,04	0,30±0,04	7,8±0,01
1:2=70:30	12,2±0,1	6,70±0,09	0,40±0,03	1,6±0,5	3,3±0,1	2,4±0,1	0,10±0,03	0,30±0,02	8,0±0,01
1:2=80:20	12,5±0,1	6,50±0,08	0,41±0,03	1,5±0,5	3,4±0,1	2,4±0,12	0,10±0,03	0,20±0,03	8,0±0,01

*Wine 1- Initial white dry wine Chardonnay
**Wine 2- Partial dealcoholized white wine Chardonnay obtained using vacuum distillation process

The data presented in table 4.3 indicate that blending of wines can serve a method of producing and improving the quality of wines with corrected alcoholic content. The alcohol content in white wines ranges from 9,7 % vol to 12,5% vol. depending on the ratio of blended components. The mass concentration of titratable acids in wines with corrected alcoholic content varies from 6,5 g/dm^3 (1:2=80%:20%) to 7,1 g/dm^3 (1:2=20%:80%) and also depends on the ratio of blended components. The mass concentration of the residual sugars reaches a maximum of 2,0 g/dm^3 in the case wine blending ratio 1:2 = 20 %:80% and the minimum value of 1,5 g/dm^3 in the case of 1:2 = 80%:20%. The mass concentration of the organic acids are reliant on the ratio of blended components of wines. Results of sensory evaluation demonstrate that blending ratios 1:2=50%:50% and 1:2=70%:30% allows obtaining of high quality wines with corrected alcoholic content. Sensory evaluation of obtained wines allows evidentiating wines obtained by blending of initial wine with dealcoholized one in the ratio of 1:2=50%:50% and 1:2=70%:30% which was characterized as more balanced and harmonious wine. (Annex 2).

In order to demonstrate that blending method can be used for aroma recovery of obtained wines with corrected alcoholic content the analysis of the main volatile compounds was performed. Obtained results are demonstrated in the table 4.4.

Table 4.4. Concentrations of volatile complex in dependence of blending ratio

Parameter	**Initial wine**[1]	**Dealcoholized wine**[2]	**Blending ratio**		
			1:2=30%:70%	**1:2=50%:50%**	**1:2=70%:30%**
Alcohol content, % vol.	13,5±0,1	9,0±0,1	10,5±0,1	11,3±0,1	12,2±0,1
Higher alcohols, mg/dm³	179	103	121	149	168
Esters , mg/dm³	59	32	42	47	50
Fatty acids, mg/dm³	218	184	191	203	209
Aldehydes and ketones, mg/dm³	32	12	18	20	28

Wine [1]- Initial white dry wine Chardonnay
Wine [2]- Partial dealcoholized white wine Chardonnay obtained using vacuum distillation process

Results regarding the influence of blending ratio on concentrations of volatile compounds demonstrate, that blending method can be used to obtain quality wines with corrected alcoholic content with subsequent partial recovery of aroma. The highest higher alcohols concentration of 168 mg/dm^3 was detected in sample 1:2=70%:30% and the lowest of 121 mg/dm^3 in the sample 1:2=30%:70%. Practically this means a reduction of 7% in comparison to initial wine and increasing of 38% in comparison to dealcoholized wine (with alcoholic content of 9% vol.)

The same is true for esters concentration in obtained wines, which contribute to fruit aromas of wine. Results have shown that in the process of ethanol removal, esters because of their high volatility are removed from wine. Reduction of esters in the result of ethanol removal process consists almost 47%. The concentrations of esters in obtained wines varies in dependence of blending ratio, with highest concentrations of 59 mg/dm^3 (initial wine) and 50 mg/dm^3 (1:2=70%:30%) the lowest concentration of esters is observed in the wine with alcoholic content of 9,0% vol. (32 mg/dm^3) and after blending with the ratio of 30%:70% (42 mg/dm^3).

A similar picture is shown for fatty acids, aldehydes and ketones concentrations. The concentration of 218 mg/dm^3 of fatty acids was the highest in the initial wine and the lowest of 184 mg/dm^3 in sample of partial dealcoholized wine with alcohol content of 9% vol. Wines with corrected alcoholic content obtained by blending has the intermediate results and varies from 191 mg/dm^3 to 209 mg/dm^3. Regarding the concentrations of aldehydes and ketones the highest concentration of 28 mg/dm^3 was detected in sample 1:2=70%:30% and the lowest of 18 mg/dm^3 in the sample 1:2=30%:70%. Practically this means a reduction of 10% in comparison to initial wine and increasing of almost 40% in comparison to partial dealcoholized wine used in the blending process.

Table 4.5. Chemical-physical indices of red wines with corrected alcoholic content obtained by blending method

Ratio, %	**Alcoholic content, % vol.**	**Mass concentration of, g/dm³**							**Sensory evaluation, points**
		Titratable acids	**Volatile acids**	**Residual sugars**	**Tartaric acid**	**Malic acid**	**Lactic acid**	**Citric acid**	
wine 1*	13,5±0,1	6,20±0,09	0,36±0,04	1,6±0,5	3,0±0,3	2,3±0,1	0,30±0,04	0,10±0,06	7,9±0,01
wine 2**	8,7±0,1	7,10±0,11	0,33±0,02	2,1±0,5	3,4±0,1	2,6±0,2	0,40±0,04	0,20±0,04	7,7±0,01
1:2=50:50	11,1±0,1	6,7±0,1	0,34±0,03	1,9±0,5	3,2±0,3	2,5±0,2	0,40±0,03	0,10±0,03	7,9±0,01
1:2=70:30	12,1±0,1	6,50±0,09	0,36±0,03	1,8±0,5	3,1±0,1	2,4±0,1	0,30±0,02	0,20±0,04	8,0±0,01
1:2=30:70	10,2±0,1	6,80±0,11	0,34±0,02	2,0±0,5	3,3±0,09	2,5±0,1	0,30±0,04	0,20±0,06	7,8±0,01

*Wine 1- Red dry wine Merlot

**Wine 2- Partial dealcoholized red wine Merlot obtained using vacuum distillation process

According to the data presented in table 4.5, experimental samples of red wines with different alcohol content varying from 10,2% vol. to 12,1% vol. were obtained. The mass concentration of titratable acids varies from 6,5 g/dm^3 to 6,8 g/dm^3, residual sugars are in the range from 1,8 g/dm^3 to 2,0 g/dm^3 depending on the ratio of blended components . The concentration of volatile acids varies slightly. The concentration of the organic acids of obtained wines varies depending on the ratio of blended components, tartaric acid varies from 3,1 g/dm^3 to 3,3 g/dm^3, malic acid, - from 2,4 g/dm^3 to 2,5 g/dm^3, lactic acid ranges from 0,3 g/dm^3 to 0,4 g/dm^3 and concentration of citric acid varies slightly during blending . Sensory evaluation of obtained wines has shown that blending in proportions 1:2=50%:50% and 1:2=70%:30% allows improving the quality of wines with corrected alcoholic content (Annex 2).

Thus, analyzing the experimental data can be concluded that process of ethanol removal from wines with excess of alcohol should be carried out after complete fermentation of sugars and after wine clarification and stabilization in order to avoid negative consequences related to apparition in wines of unpleasant aroma. The main disadvantages of scheme 1 besides low organoleptic properties and significant losses of aroma compounds are the following:

- Energy-intensive process ;
- Leads to more rapid oxidation of wine, because of the work under vacuum;
- Impossibility of applying for dealcoholization of red wines, as the fermentation process takes place on the seeds and skins.

Experimental data regarding the obtaining of wines with corrected alcoholic content by blending method was obtained. Obtained results demonstrate that blending method has some advantages:

- Possibility of obtaining quality wines with corrected alcoholic content;
- Restitution of the aromatic complex of wine;
- Possibility of adjusting the chemical composition of wine without the use of artificial additives.

4.2. Influence of dealcoholization process on wine stability

Stability of wine is one of the main indicators of the quality of the finished product. Even a slight haze of wine, despite the complete harmlessness and natural composition, causing the consumer's negative attitude, reduces appearance of the produce but usually also affect the flavor [3]. The stability can never be guaranteed under all circumstances, the winemaker must predict the conditions that the wine will endure prior to being consumed, and then use stability tests to see if the wine will remain stable under these conditions. Any wine failing a stability test must be treated appropriately prior to bottling. If these precautions are not taken, the wine may alter or throw a deposit in the bottle, which would lead to all the wine being recalled and either destroyed or treated and re-bottled, which is a very expensive operation.

Moreover, evaluation of the sustainability of wines to microbial clouding is one of the most important stages in the production of wines. Microbiological control can detect a variety of infections and to prevent their development. Ongoing microbiological control of qualitative and quantitative composition of the microflora, its physiological state, provides obtaining of wines microbiologically stable without chemical and organoleptic changes. Thus, a special attention should be given at the problem of microbiological stability of wine.

Dealcoholization process is followed by ethanol removal from wine and concomitant process of wine concentration occurs which leads to increasing of the concentrations of its non-volatile components. Certain change of wine balance can lead to instability against different hazes. Thus, influence of dealcoholization process on wine stability is very complex question and requires the follow-up study.

In order to study the influence of ethanol removal process on stability of wine, the samples of white and red wines with different alcohol content were obtained using optimal technological regimes (temperature of 30°C, at the pressure of 4 kPa, volume of wine 0,5 dm^3). Scientific results regarding the influence of dealcoholization process in dependence of quantity of removed ethanol on wine stability was studied and presented in the table 4.6 and 4.7.

Table 4.6.Influence of dealcoholization process on stability of white wine Chardonnay to different hazes

Parameter	**Initial wine**	**Alcoholic concentration in dealcoholized wines, % vol**				
Alcohol content, % vol	14,3	13,2	12,1	11,3	8,5	5
Potassium, mg/dm^3	421	422	435	459	506	715
Tartaric acid, g/dm^3	2,0	2,0	2,1	2,1	2,4	3,3
Stability:						
-bio-chemical	+	+	+	+	+	-
-protein	+	+	+	+	+	-
-colloidal	+	+	+	+	+	-
-crystal haze	+	+	+	+	+	-
-microbiological	+	+	+	+	-	-

Legend: + stable
-unstable

Wine is a complex system and its stability is influenced by interaction of substances and different external factors [3]. It was established that in the process of dealcoholization besides the ethanol removal, a concentration of wine occurs which leads to increasing of organic acids, proteins, metals and other compounds concentration. These increasing can be responsible for apparition of hazes of different nature.

According to obtained results, dealcoholization process has the influence on the stability of white wines in dependence of stability of initial wine and rate of ethanol removal. Obtained white wines are stable to crystal haze instead of increasing of tartaric acid concentration in the range from 2,0 g/dm^3 to 3,3 g/dm^3 and potassium 1,7 fold in obtained wines with different alcohol content. Reducing the alcoholic content to 5% vol leads to decrease of wine stability to crystal hazes.

Obtained results demonstrate that colloidal stability of wine depends on the stability of initial wine and quantity of alcohol removed from wine. According to the obtained results, initial wine is stable to colloidal hazes and consequently after the process of ethanol removal, obtained wines remains stable to colloidal hazes upon reaching the reduction of alcoholic content to 5% vol. Protein instability of wines occurs due to significant concentration resulting in increasing of proteins, polysaccharides and tannin quantities. These substances are capable of forming complex compounds provoking instability to colloidal haze.

All obtained wines except of wine with alcoholic content 5% vol are stable to protein haze which indicates on the fact that stability to protein haze depends on quantity of removed alcohol from wines.

Special attention should be given to the influence of ethanol removal from wine on microbiological stability. Correction of alcohol content in wines (20% alcohol reduction) do not effects the microbiological stability of wines, but further ethanol removal significant reduces the microbiological stability of wines because of decreasing of wine's preservative units as well as apparition of nutritive substances such as sugars, acids etc. which contribute and facilitate undesirable microorganisms growth.

Table 4.7. Influence of dealcoholization process on stability of initial red wine Merlot to different hazes

Parameter	**Initial wine**	**Alcoholic concentration in dealcoholized wines, % vol**				
Alcohol content, % vol	13,8	12,7	11,9	10,5	8,8	5,1
Potassium, mg/dm^3	517	517	524	536	619	667
Tartaric acid, g/dm^3	1,8	1,8	1,8	1,9	2,1	2,9
Stability:						
-bio-chemical	+	+	+	+	+	-
-protein	+	+	+	+	+	-
-colloidal	+	+	+	+	+	-
-crystal haze	+	+	+	+	+	-
-phenolic	+	+	+	+	+	-
-microbiological	+	+	+	+	-	-

Legend: + stable
-unstable

During the investigations, it was found that process of ethanol removal leads to substantial changes in the composition of red wines. Correction of alcohol content in limits accepted by OIV practically has no influence on physical-chemical composition of red wines. Further dealcoholization affects not only wine intrinsic composition as well as contribute to decreasing of red wine stability. Special attention should be given to polyphenolic haze stability of red wines. Phenolic compounds in wine are responsible for color, bitterness, astringency and some of the odors and flavors. Some types of phenolic material polymerize just like protein molecules [3]. These phenolic molecules slowly grow in size, and they can cause haze problems and excessive bottle deposits in red wines. Results have shown that wines with alcohol content reduction from 1% vol. to 5% vol. are stable to phenolic haze in comparison with 9% vol. alcohol content reduction which is unstable due to presence of polyphenols excess in wine after dealcoholization process.

Red wines obtained in the process of ethanol removal have decreased microbiological stability contrary to white wines. According to obtained results red wines with alcohol content reduction of 5% vol. and 9% vol. are microbiological unstable as a result of absence of alcohol inhibitory action.

Obtained red wines are stable to crystal haze except for wine with alcoholic content of 5,1% vol., as a result of significant increasing of tartaric acid and potassium concentration. Concentration of potassium increased from 517 mg/dm^3 to 667 mg/dm^3 and tartaric acid varies in limits from 1,8 g/dm^3 to 2,9 g/dm^3.

Thus, analyzing the data obtained it can be concluded that process of ethanol removal influences the stability of the obtained white and red wines in dependence of initial wine stability and ethanol removal extent. It was found that initial white and red wines was stable before the treatment and the process of ethanol removal did not affect its stability except for wine with alcoholic content of 5% vol (white wine) and 5,1% vol. (red wine).

Therefore, after the process of ethanol removal obtained wines should be tested and treated in order to obtain stable wines before they are bottled.

4.3. Influence of dealcoholization process on organoleptic properties of white and red wines

Ethanol plays an important role in wine perception not only by adding texture and gustative sensations but also by interacting with wine components. It is commonly known that ethanol serves in wine as a main carrier of aroma and bouquet and hence flavours of wine, moreover, ethanol creates a sweet sensation in the mouth and adds body to wine due to its viscosity. At the same time excessive concentrations of alcohol in wines have the negative effect on organoleptic properties making the wine too heavy and unbalanced [155, 163].

It is known, that the process of ethanol removal could negatively affect the organoleptic properties of wine, leading in the worst cases to an unacceptability of the product, by altering the complex equilibrium among hundreds of organic compounds responsible for its taste, flavor and mouthfeel [104].

In order to establish the influence of ethanol removal from wine using vacuum distillation process, experimental samples of white wine Chardonnay and red wine Merlot with different alcohol content as well as white wines with corrected alcoholic content obtained in the result of blending was studied. Organoleptic evaluation of obtained wines was performed by the panel of 11 professionals (2 male and 9 female) at the SPIHFT using several types of sensory tests such as discrimination test (triangle, ranking) which was used to determine whether two wines are perceptibly different from one another due to reduction of alcoholic content and descriptive sensory test used to evaluate the sensory characteristics and obtain a more detailed description of white and red wines with low alcohol content.

Preliminary sensory evaluation of white and red wines aroma was done on 6 wine samples (3 different temperatures of dealcoholization process and 3 different pressures) in order to select the sensory characteristics and to obtain a list of descriptive attributes for white wine Chardonnay and red wine Merlot aroma. In the second part of the evaluation, the judges were asked to evaluate with a number from 0 to 4 the intensity of the attribute from the descriptive list.

Sensory profiles

In the table 4.7 is presented the list of sensory descriptors of white and red wines and their relevant definitions. On the base of selected attributes the organoleptic evaluation of white and red wines with different alcohol content in comparison with initial wine are presented in fig.4.1 and 4.2.

Figure 4.1 reports the sensory profile of white wine Chardonnay before and after dealcoholization process. According to the obtained results it can be concluded that elimination of different amount of alcohol from wines influences in various extents on organoleptic properties of obtained wines.

Table 4.7. Sensory descriptors of white and red wines and their relevant definitions

Nr.	Descriptor	Definition
1	Flowers	Aromatic wine with developed aroma of different flowers by means of the sense of smell
2	Fruits	Characteristic odor of a combination of blueberry, raspberry, and blackberry perceived by means of the sense of smell (orthonasal perception)
3	Bitter	One of the basic tastes, caused by alcohol perceived in the oral cavity
4	Acid	Wines with high acidity (tart and zesty)
5	Astringency	Mouth dryness caused by tannins and perceived in the oral cavity
6	Persistence	Duration of aroma and taste maintenance perceived in the oral cavity
7	Balanced	Relation between all the components (flavor and taste)
8	Olfactory preference	Intensity and balance of main volatile wine components by means of the sense of smell
9	Taste preference	Balance of the main wine components perceived in the oral cavity
10	Cooked	Presence of cooked notes as a result of high temperatures

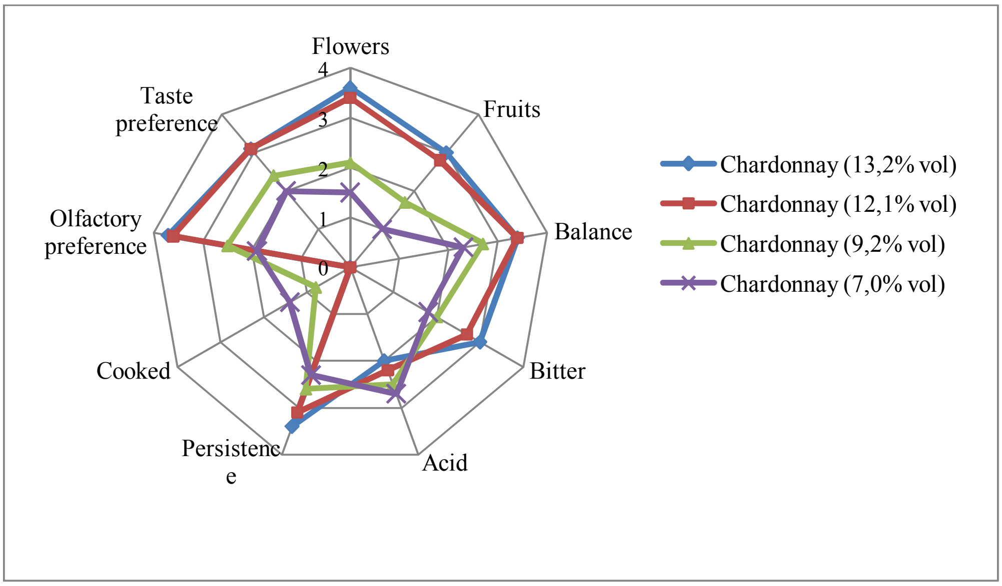

Fig.4.1. Sensory profiles of white wine Chardonnay before and after the dealcoholization process

For white wine the most decreased olfactory attributes were "Flowers" and "Fruits" as a result of elimination of most volatile aromatic compounds responsible for floral and fruit aroma. Besides this, appearance of green notes also known as herbal, herbaceous and leaf-like as a result of removal of esters and higher alcohols leading to increasing of fatty acids concentration in ratio to other aroma compounds was observed. In the process of dealcoholization light cooked notes appeared (Chardonnay 7,0% vol). Acidity of obtained dealcoholized wines increased in dependence of the eliminated amount of alcohol and probably a part of water leading to disrupting the balance of wine significantly affecting the taste and olfactory preference. According to obtained results presented in fig. 4.1 in wine with 12,1% alcoholic content is observed improvement of its quality by reduction of negative effect of alcohol in wines.

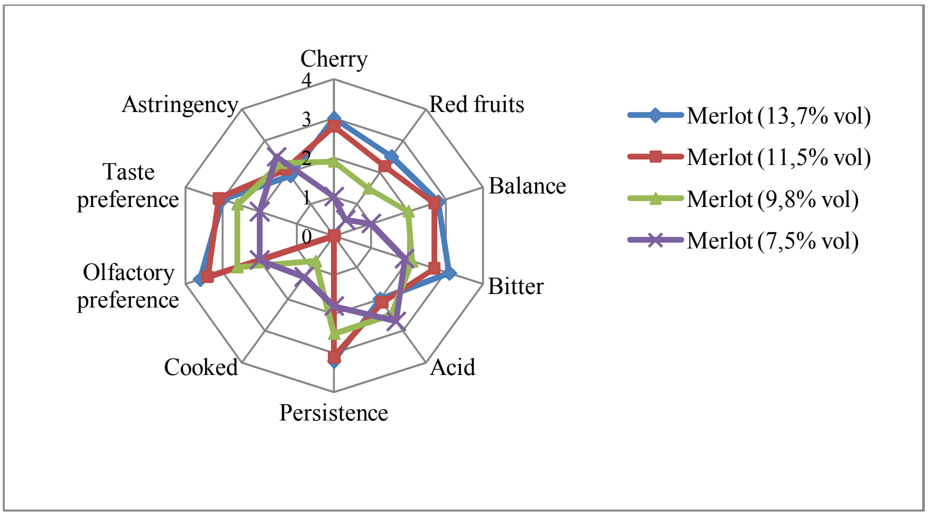

Fig.4.2. Sensory profiles of red wine Merlot before and after partial dealcoholization process

Figure 4.2. reports the sensory profile of red wine Merlot before and after partial dealcoholization process. According to the obtained results of organoleptic evaluation it can be concluded that partial dealcoholization process influences on the organoleptic characteristics of obtained wines in dependence of eliminated alcohol. Therefore, for the red wine the most decreased olfactory attributes were "Cherry" and "Red fruits", as well as decreased Olfactory and Taste Preference as a result of compositional change and concentration of wine. Astringency of obtained wines increased significantly as a result of increased phenolic substances concentration. Olfactory attribute "Bitter" which intensity depends on alcohol content in wines decreases significantly after ethanol removal from wine. Cooked notes appear in wine with increasing of temperature of dealcoholization process conferring the red wines aroma of resin.

In order to evaluate the influence of blending on organoleptic properties of obtained white wines the ranking test was performed and results are presented in fig. 4.3. In the ranking test, 5 white wines with different alcohol content, obtained by blending of dealcoholized wine (9% vol) with untreated wine (control) in different proportions. The tasters were asked to put the wines for some descriptors: Aromatic intensity, Acidity, Bitterness, Olfactory and Taste preference.

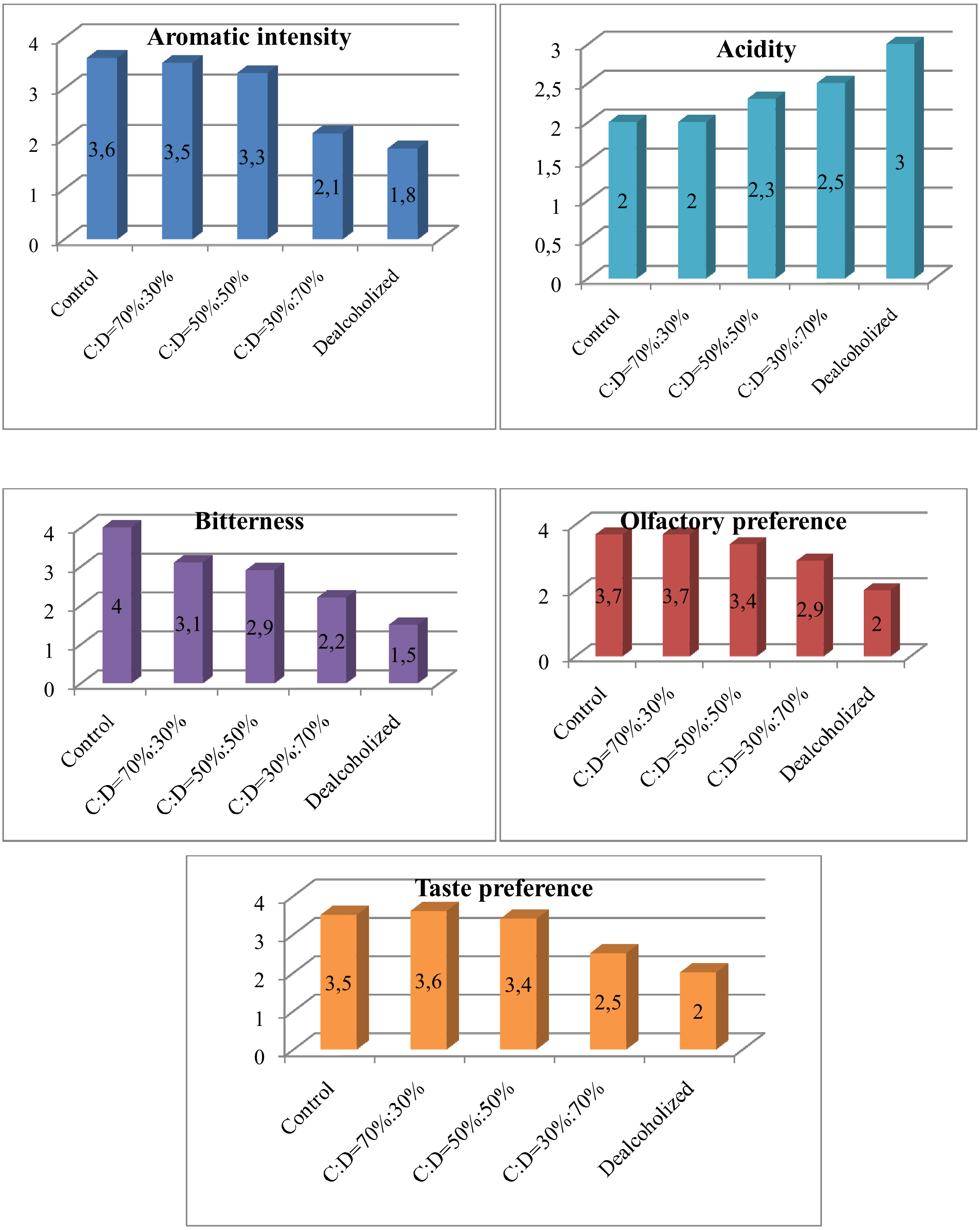

Fig. 4.3. Results of ranking test for white wine Chardonnay with corrected alcoholic content obtained by blending

In figure 4.3 the results of ranking test are presented. According to the obtained results blending of partial dealcoholized wine with initial wine in different proportions can significantly improve the quality of the final product. In partial dealcoholized wine with 9% vol alcohol a decrease in aromatic intensity, bitterness, olfactory and taste preference and increase of acidity is observed.

Blending of wines in ratio 70%:30%, significantly improve the quality of obtained wine making it more balanced due to decreasing of bitterness and increasing of olfactory and taste preference, after ethanol removal only aromatic intensity slightly decreased. Regarding the 50%:50% blending ratio, an insignificant decrease of aromatic intensity and olfactory and taste preference was observed. However, obtained wine is balanced and this blending ratio can be used for wines with decreased alcohol content production. Regarding the wine C:D=30%:70%, according to expectations is better than partial dealcoholized wine for all considered parameters, but inferior to remained samples by decreasing of its aromatic intensity and overall taste and olfactory preference.

In order to evaluate differences and preference between obtained white and red wines with different alcohol content triangle test was performed. Results of sensory evaluation (after the statistical treatment) for white and red wines are presented in table 4.8 and 4.9.

Table 4.8. Results of sensory triangle test for white wine Chardonnay

Nr.	Triangle test	Answers (correct/total)
1	Chardonnay (13,2% vol) *vs* Chardonnay (12,1% vol)	3/11
2	Chardonnay (13,2% vol) *vs* Chardonnay (9,2% vol)	7/11
3	Chardonnay (13,2% vol) *vs* Chardonnay (7,0 % vol)	9/11
4	Chardonnay (9,2% vol) *vs* Chardonnay (7,0% vol)	5/11
5	Chardonnay (9,2% vol) *vs* Chardonnay (12,1% vol)	7/11
6	Chardonnay (12,1% vol) *vs* Chardonnay (7,0% vol)	10/11

Organoleptic evaluation of white partial dealcoholized wines, wines with corrected alcoholic content and correspondent original wine shows the influence of dealcoholization process on quality of obtained product in dependence of the quantity of removed alcohol. According to the obtained results wine with alcoholic content of 12,1% practically doesn't differ from initial wine only 3 from 11 wine professionals perceived the difference. Both wines Chardonnay with alcoholic content of 9,2% vol. and 7,0% vol. differ significantly from initial wine and wine with 12,1% vol.

According to the results of triangle test for red wine Merlot with different alcohol content, can be concluded that wine with 11,5% vol. alcoholic content possesses very slight differences, practically not perceived by the wine-tasters in comparison to initial wine.

Table 4.9. Results of sensory triangle test for red wine Merlot

Nr.	Triangle test	Answers (correct/total)
1	Merlot (13,7% vol) *vs* Merlot (11,5% vol)	3/11
2	Merlot (13,7% vol) *vs* Merlot (9,8% vol)	6/11
3	Merlot (13,7% vol) *vs* Merlot (7,5% vol)	9/11
4	Merlot (11,5% vol) *vs* Merlot (9,8% vol)	6/11
5	Merlot (11,5% vol) *vs* Merlot (7,5% vol)	9/11
6	Merlot (9,8% vol) *vs* Merlot (7,5% vol)	6/11

Merlot with 7,5% vol. differs significantly from the standard one, due to a loss of aromatic compounds of wine in the process of dealcoholization.

Thus, process of ethanol removal influences the organoleptic properties of obtained white and red wines. Correction of wine alcohol content by 20% reduction of alcoholic strength leads to improvement of the organoleptic properties of wine without negative consequences on wine quality. However, further alcohol content reduction lead to negative influence on wine quality as well as on organoleptic properties. Blending of dealcholized base (9% vol.) with initial wine in ratio of 30%:70% contribute to improvement of wine quality.

4.4. Production testing and implementation of improved technology for correction of alcoholic content in wines using vacuum distillation method

On the base of elaborated in the laboratory conditions optimal technological regimes for ethanol removal from wines, the technological scheme was elaborated and implemented in production on the winery "Nectar S" LTD (Annex 3). In production conditions installation for correction of alcoholic content in white and red wines "Tetra Therm Aceptic Drink" of "Alfa Laval" (Sweden) was used. The operation principle of the equipment includes the following stages: heating of wine to desired temperature by heat-exchange unit, after this the heated wine is fed to evaporation unit, where it gets to heated plate. In the evaporation unit a vacuum is created and ethanol vapors under the vacuum are condensed at the top of the unit. The top of the column is cooled and vapors after condensation are removed from installation.

On the first stage white wine Aligote and red wine Merlot with high alcoholic content was selected in order to be used in the process of ethanol correction. It is worth emphasizing, that selected wines to be dealcoholized are stable to crystal, protein and colloidal hazes and without any organoleptic defects. The correction of alcoholic content was conducted according to the

OIV Resolution, with removal of 20% of the total alcoholic content. The main physical-chemical indices was determined and presented in the table 4.10.

Table 4.10. Physical-chemical indices of initial white and red wines

Nr.	Wine	Alcohol content,% vol.	Mass concentration of, g/dm³			pH	SO_2 total/free, mg/dm³	Sensory evaluation, points
			Titratable acids	Volatile acids	Residual sugars			
1	Aligote	13,9±0,1	5,50±0,08	0,36±0,03	1,0±0,5	3,07±0,01	120/31	7,9±0,01
2	Merlot	14,1±0,1	5,1±0,1	0,39±0,03	1,2±0,5	3,24±0,01	103/22	7,9±0,01

According to obtained results presented in table 4.10 initial wines distinguish by high alcoholic content equal to 13,9% vol. in white wine and 14,1% vol. for red wines. Initial wines are of high quality without any defects as well as stable against crystal, protein hazes. According to OIV recommendations estimated alcohol level content should not exceed 11,0% vol. for white wine and 11,4% vol. for red wine. Sensory evaluation demonstrated high quality of initial white and red wines which was appreciated with high notes of 7,9 points (Annexes 4, 5).

The process of ethanol removal was carried out by vacuum distillation installation using elaborated technological regimes presented in table 4.11.

Table. 4.11. Operating conditions of the industrial plant for ethanol removal from white and red wines

Nr	Wine	Temperature	Pressure	Volume
1	Aligote	(30±1)°C	4 kPa	1000 dal
2	Merlot	(30±1)°C	4 kPa	1000 dal

Process of ethanol removal was carried out at the temperature which varies in a very close limits from 29ºC to 30ºC with constant pressure of the process (4 kPa). The initial volume is equal to 1000 dal for both wines. After the process of alcohol level reduction the wine was sent to the rest for 10 days in order to recover its balance. In the obtained production batches of white and red wines the main physical-chemical indices and stability of obtained wines was determined. The results are presented in tables 4.12 and 4.13.

Physical-chemical analysis of wines after alcohol strength correction has shown insignificant influence of the process on wine composition except for alcohol. Reduction of alcohol in white wines constitutes 2,4% vol. and for red wines 2,1% vol. Concentration of titratable acids varies from 5,5 g/dm³ to 5,7 g/dm³ for Aligote and from 5,1 g/dm³ to 5,4 g/dm³ for Merlot as a result of volume decrease.

Table 4.12. Physical-chemical indices of obtained wines with reduced alcohol content after dealcoholization process

Nr.	Wine	Alcohol content,% vol.	Mass concentration of, g/dm³			pH	SO_2 total/free, mg/dm³	Sensory evaluation, points
			Titratable acids	Volatile acids	Residual sugars			
1	Aligote	11,5±0,1	5,7±0,08	0,33±0,03	1,2±0,5	3,05±0,01	110/21	8,0±0,01
2	Merlot	12,0±0,1	5,4±0,1	0,37±0,03	1,5±0,5	3,20±0,01	91/12	8,0±0,01

Volume decrease is related to quantity of removed ethanol. Slight reduction of volatile acidity occurs as a consequence of some acetic acid molecules losses during distillation. Regarding the concentration of residual sugars an increase from 1,0 g/dm³ to 1,2 g/dm³ for white wine and from 1,2 g/dm³ to 1,5 g/dm³ for red wine was determined. Organoleptic evaluation of obtained wines with reduced alcohol content demonstrates the positive effect of dealcoholization process on wine quality. Obtained white and red wines were appreciated with 8,0 points (Annex 5).

Table 4.13.Influence of process of alcoholic content correction on stability of white and red wine

Parameter	Initial wine Aligote	Aligote	Initial wine Merlot	Merlot
Alcohol content, % vol	13,9±0,1	11,5±0,1	14,1±0,1	12,0±0,1
Potassium, mg/dm³	526	534	619	623
Tartaric acid, g/dm³	1,9	1,9	1,6	1,6
Stability:				
-Bio-chemical	+	+	+	+
-protein haze	+	+	+	+
-colloidal	+	+	+	+
-crystal haze	+	+	+	+
-microbiological	+	+	+	+

Legend: +-stable
-unstable

According to obtained results presented in table 4.13 process of ethanol removal of white and red wines have no influence on its stability. Stable to different hazes initial wines remain stable and after process of alcoholic strength correction.

On the base of organoleptic evaluation of obtained samples of white and red wines performed by the taste panel, the sensory profiles of initial wines and corresponding wines with reduced alcohol content are presented in the fig.4.4 and 4.5.

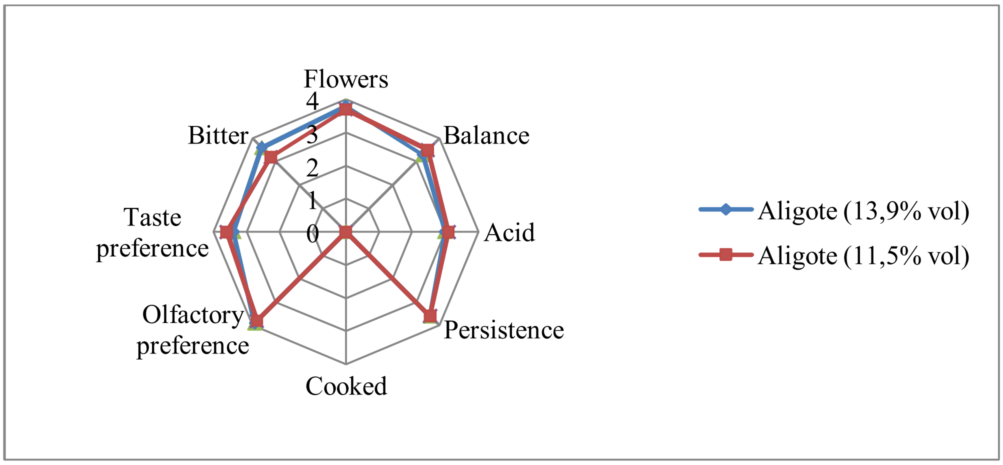

Fig. 4.4. Sensory profiles of white wine Aligote before and after the correction of alcoholic content in production conditions

Fig. 4.4 demonstrates that alcohol correction of white wines contributes to improvement of wine quality and balance of its components. The attribute “Flowers” decreased insignificantly as a result of compounds responsible for floral aroma removal. However, ethanol level reduction contributed the improvement of “Balance” and “Taste preference” of obtained wines by reduction of “Bitterness” caused by excess of alcohol.

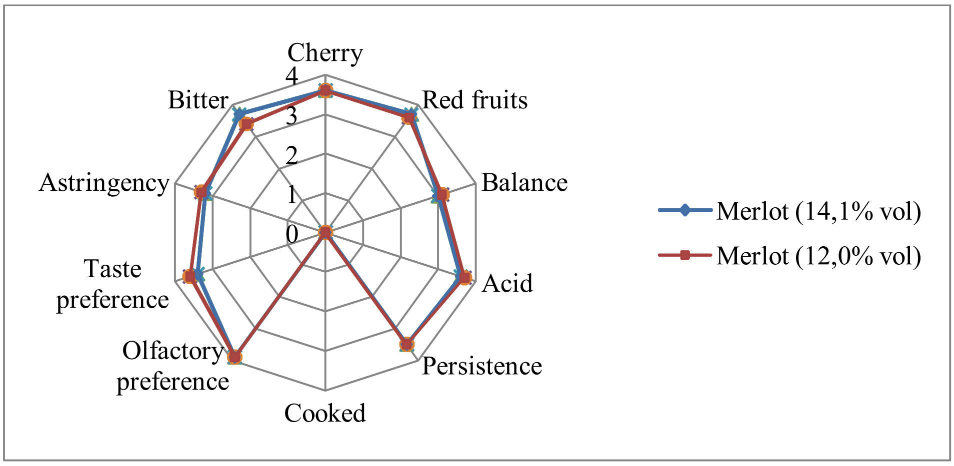

Fig. 4.5. Sensory profiles of red wine Merlot before and after the correction of alcoholic content in production conditions

Comparable situation is observed in the case of red wine Merlot after the correction of alcoholic content. A reduction of “Fruit” aroma is perceived and consequently “Olfactory preference” decreased. Perception of Bitterness decreased because of ethanol removal what leads to increasing of “Balance” and “Taste preference” of wine with reduced alcohol content in comparison to initial wine.

On the base of obtained results regarding the implementation of elaborated technological regimes in production conditions can be concluded that correction of alcoholic strength of white and red wines by vacuum distillation process has shown the effectiveness and beneficial effect on quality of obtained wines. Reduction of alcoholic content to 20% leads to insignificant change of physical-chemical composition of wines as well as improvement of organoleptic characteristics of obtained wines.

Scientific results obtained within the thesis were focused on elaboration of optimal technological regimes for correction of alcoholic content in wines. Elaborated technological regimes contributed the development of technological scheme for correction of alcoholic levels in wine. Technological schemes based on the research findings are presented in the fig. 4.6 and 4.7.

The scheme (fig. 4.6) includes the following technological operations:

- Initial wine directed to ethanol removal should be without any organoleptic defects;
- Correction of alcoholic content in wine using vacuum distillation technique is carried out at the temperature of (30±1)°C and pressure from 10 to 4 kPa with alcohol removal to 20% of initial alcoholic strength;
- A rest of wine during 10 days after alcohol correction is necessary;
- Stabilization of obtained wine with corrected alcoholic content. In case of necessity a correction of wine composition by adding of sulphur dioxide or reduction of titratable acidity etc.
- Sterile filtration of wine;
- Wine storage at the temperature of 14-16°C.

Process of production of wines with corrected alcoholic content (fig. 4.7) includes the following technological operations:

- Initial wine directed to ethanol removal should be without any organoleptic defects;
- Reduction of alcoholic content in wine using vacuum distillation technique is carried out at the temperature of (30±1)°C and pressure from 10 to 4 kPa with alcoholic concentration no less than 9,0% vol;
- Blending of initial wine[1] (wine before the dealcoholization) with obtained partial dealcoholized wine[2] (wine after the dealcoholization process) in proportions 1:2=50%:50% or 1:2=70%:30%;
- A rest of wine during 10 days after alcohol correction is necessary;
- Wine stabilization and in case of necessity a correction of wine composition by adding of sulphur dioxide or reduction of titratable acidity etc.
- Filtration of wine;

- Wine storage at the temperature of 14-16°C.

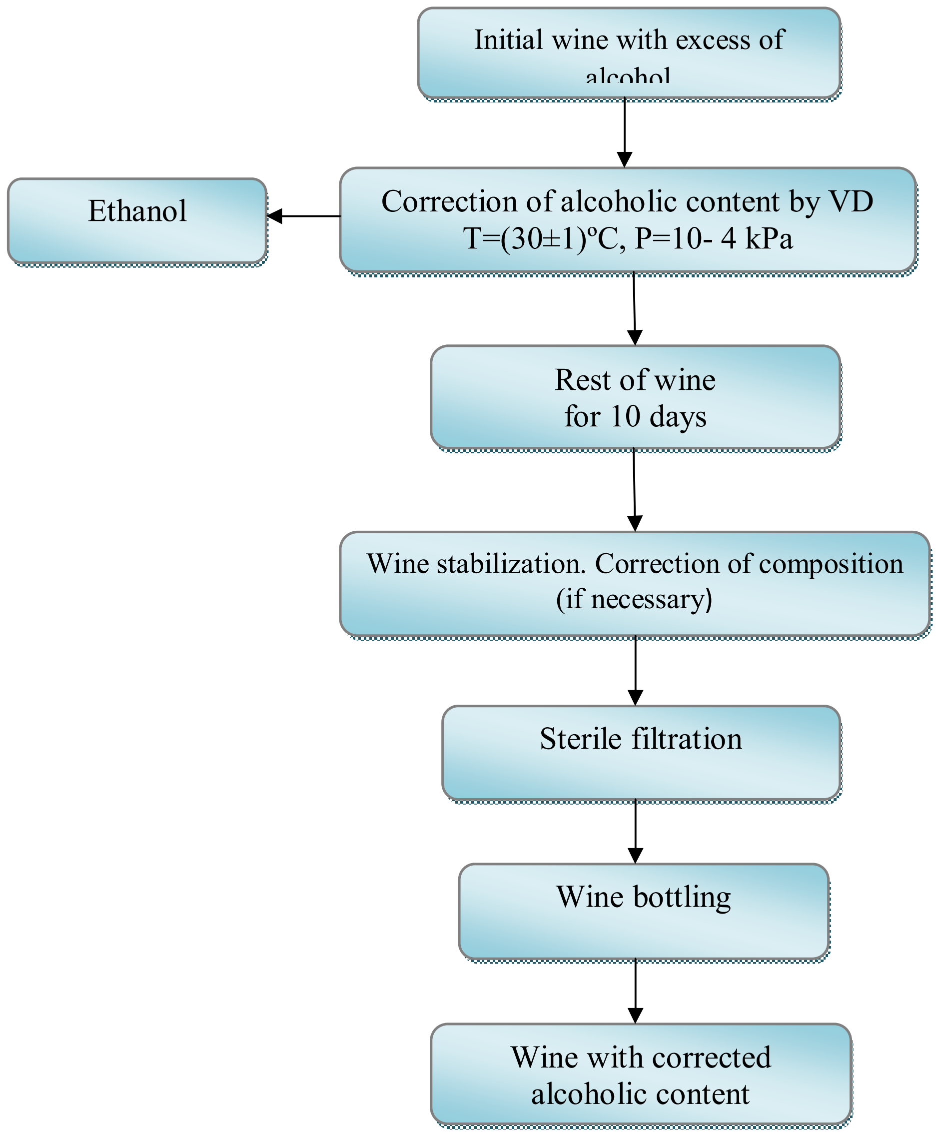

Fig.4.6. Technological scheme of alcoholic strength correction in dry wines

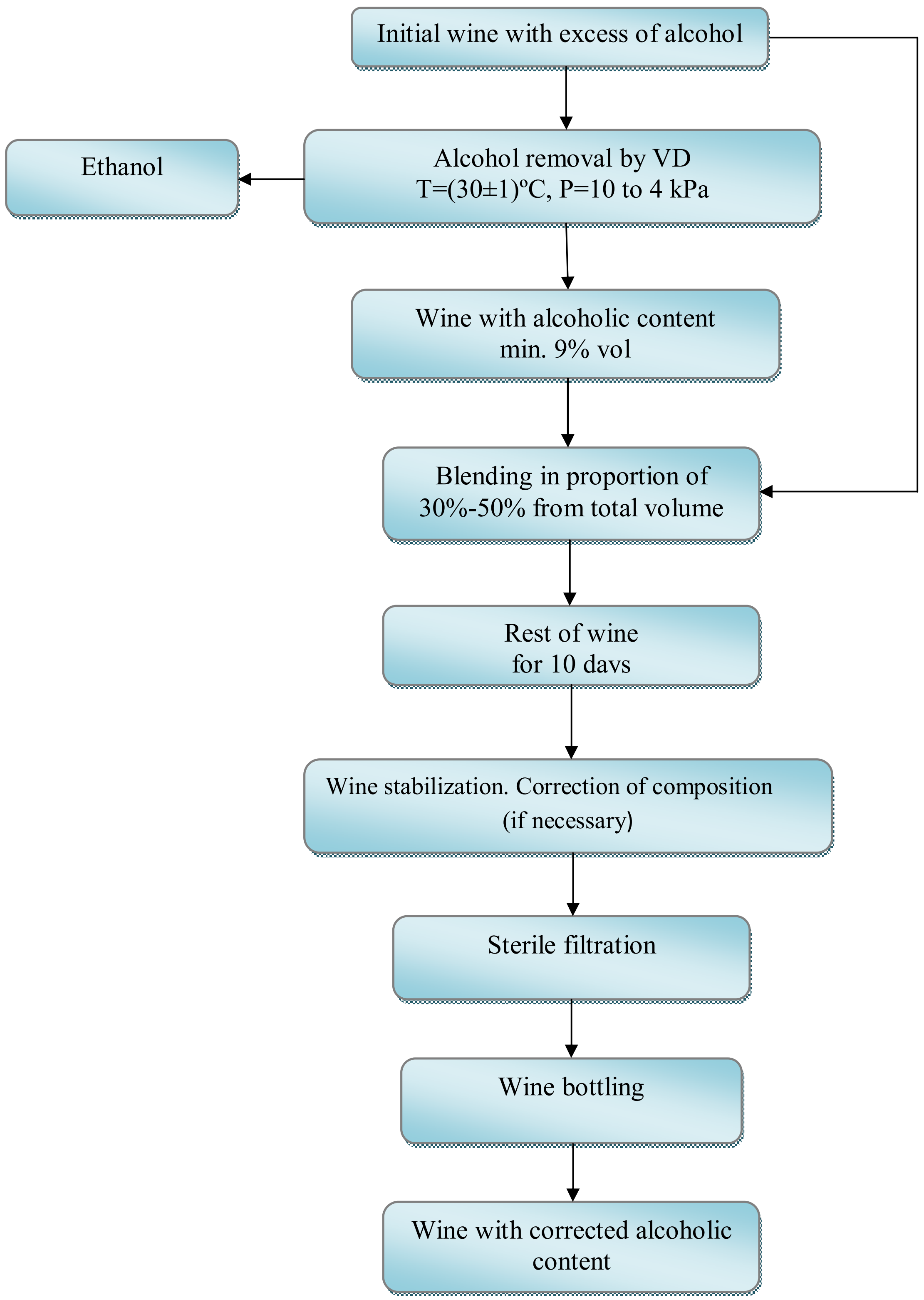

Fig. 4.7. Technological scheme for production of wines with corrected alcoholic content

4.5. Conclusions to the chapter 4

In the chapter 4 in order to improve the technological regimes for correction of alcoholic content in wines the influence of ethanol removal process on stability of wines as well as on organoleptic properties were studied. Beside this, the optimal conditions for ethanol removal were established.

It was established on base of experimental data that process of ethanol removal from wines should be carried out after the complete alcoholic fermentation because of removal of alcohol from fermenting wort leads to significant depletion of white wine aroma as a result of reduction of higher alcohols from 179 mg/dm^3 to 100 mg/dm^3, esters from 59 mg/dm^3 to 25 mg/dm^3, volatile acids varies from 218 mg/dm^3 to 103 mg/dm^3 and aldehydes and ketones concentration from 32 mg/dm^3 to 18 mg/dm^3.

Blending method for obtaining of wines with corrected alcoholic content has some advantages as restitution of the volatile complex of wine or possibility of adjusting the chemical composition of wine without the use of artificial additives.

Results regarding the influence of process of ethanol removal on stability of white and red wines demonstrate, that whether initial wine is stable to hazes the subsequent alcohol removal don't influence the wine stability except for white and red wine with 5% vol and 5,1% vol. alcoholic content respectively.

Process of ethanol removal influences the organoleptic properties of obtained white and red wines in dependence of extent of ethanol removal. Correction of wine alcohol content by 20% reduction of alcoholic strength leads to improvement of the organoleptic properties of white and red wines without negative consequences on wine quality. However, further alcohol content reduction lead to decrease of "Flower" and "Red fruit" attributes as a result of aroma compounds losses. Blending of dealcoholized wine (9% vol.) with initial wine in ratio of 30%:70% and 50%:50% contribute to improvement of wine organoleptic properties.

GENERAL CONCLUSIONS AND RECOMMENDATIONS

Generalizing obtained scientific and practical results of research, presented in the thesis the following conclusions and recommendations can be made:

1. For the first time the correlation between parameters of technological process of wine dealcoholization and final alcoholic content in wines with corrected alcoholic contentration was elaborated and argumented.
2. Optimal technological regimes for correction of alcoholic content in white and red wines using vacuum distillation method was scientifically substantiated: temperature (30±1)°C, pressure from 10 to 4 kPa and processing time in dependence of initial wine volume and quantity of alcohol eliminated from wine.
3. It was determined, that increasing of dealcoholization temperature from 20 ºC to 40 ºC the significant losses of volatile complex are observed: higher alcohols from 8,3% to 86,1%, esters from 19,4% to 90,4%, acids from 6,6% to 30,7% □i aldehydes, ketones from 9,1% to 60,6% in dependence of process temperature.
4. Pressure reduction in the process of dealcoholization from 40 kPa to 4 kPa leads to moderate losses of volatile compounds: higher alcohols from 0,1% to 18,3%, esters from 0,2% to 35,6%, acids from 0,2% to 8,5%, aldehydes, ketones from 1,6% to 17,3% in dependence of the process pressure.
5. In dependence of dealcoholization processing time the reduction of higher alcohols constitutes from 8,2% to 90,7%, esters from 22,3% to 99,9%, acids from 7,1% to 31,3% and aldehydes, ketones from 12,9% to 70,8%.
6. On the base of undertaken study in laboratory conditions an adequate mathematical model, reflecting the influence of physical factors of dealcoholization process on alcohol removal was obtained. It was established that Temperature and Pressure are the main technological factors influencing the process of ethanol removal.
7. According to obtained results, blending of initial wine with partial dealcoholized wine in proportions 50%:50% and 70%:30% contributes the improvement of the effectiveness of dealcoholization process, leads to substantial reduction of operating time and amelioration of quality for wines with reduced alcoholic content. Novelty of elaborated technology is confirmed by Utility patent application "Method for obtaining of natural wines" Nr: s 2015 0056 from 2015.04.17

8. It was demonstrated that reduction of alcoholic concentration to 8,5% vol leads to microbiological instability, but reduction of alcoholic content to 5,0% vol influences total destabilization of wines.
9. It was found, that sensory characteristics of wines obtained by dealcoholization using vacuum distillation method, depend on ethanol removal rate. Reduction of initial alcoholic content to 20% contributes improvement the sensory characteristics of obtained white and red wines in comparison with initial wine.
10. Elaborated technological regimes of white and red wines with corrected alcoholic content was successfully tested in production conditions at wine factory at "Nectar S" LTD and are recommended for implementation. Total volume of implementation of improved technology for white and red wines with corrected alcoholic content production constituted 2000 dal.

RECOMMENDATIONS

On the base of obtained results it is recommended:

- Vacuum distillation method is recommended for correction of alcoholic content in wines in limits proposed by OIV (reduction of alcoholic content constitutes 20%).
- Conduction of the process of ethanol removal from wine using elaborated technological regimes T=(30±1)ºC, pressure from 10 to 4 kPa;
- Using for the process of ethanol removal a wine without any defects;
- Partial dealcoholization of wine to 9% vol with subsequent blending with initial wine in proportion 30%:70% and 50%:50%.

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ANNEXES

Annex 1. Concentration of volatile compounds in white wine Chardonnay in dependence of technological factors

Table A1.1. Influence of temperature of ethanol removal process on volatile complex of white dry wine Chardonnay, mg/dm^3

Parameter	**Initial wine**	**Temperature**		
		20ºC	**30ºC**	**40ºC**
Alcoholic content, % vol.	13,5	13,2	9,8	4,7
Higher alcohols				
1-propanol	13,8	12,7	8,7	-
2-propanol	0,27	0,23	0,17	-
buthanol	1,3	1,0	0,92	-
isobutanol	20,8	20,5	19,1	7,4
Isoamyl alcohol	92,5	81,4	70,5	10,1
1-hexanol	0,87	0,73	0,66	-
2-phenylethanol	20,23	20,01	19,11	2,34
2,3-butylene glycol	20,57	19,8	18,94	3,25
1,2-propilene glycol	8,6	8,4	8,61	1,74
Σ Higher alcohols	**178,94**	**164,17**	**146,71**	**24,83**
Losses, %	**-**	**8,3**	**18,0**	**86,1**
Esters				
methylacetate	0,46	0,38	0,29	-
ethylacetate	53,2	42,4	34,1	5,4
ethylbytirate	2,2	2,01	1,44	0,06
ethylcaprilate	0,32	0,25	0,1	-
ethylcaprinate	0,83	0,77	0,61	0,01
ethyldecanoate	0,07	0,02	-	-
2-phenylacetate	2,4	2,1	1,83	0,17
Σesters	**59,48**	**47,93**	**38,37**	**5,64**
Losses,%	**-**	**19,4**	**35,5**	**90,5**
Fatty acids				
Acetic	215,33	200,9	197,88	150,04
Propionic	0,74	0,73	0,68	0,21
Bytiric	0,61	0,57	0,54	0,18
Isobytiric	0,28	0,27	0,25	0,1
Valeric	0,06	0,05	0,048	0,02
Capronic	1,34	1,32	1,30	0,85
Σ Acids	**218,36**	**203,84**	**200,69**	**151,4**
Losses, %	**-**	**6,6**	**8,0**	**30,7**
Aldehydes, ketones, terpens				
acetaldehyde	23,5	20,0	18,7	9,3
furaldehyde	0,01	0,01	-	-
acetoin	7,7	7,5	7,2	1,4
β-ionon	0,09	0,08	0,06	-
limonen	0,58	0,52	0,4	-
Σ Aldehydes, ketones, terpens	**31,88**	**28,11**	**26,36**	**10,7**
Losses, %	**-**	**11,8**	**17,3**	**66,4**
Σtotal	**488,66**	**444,05**	**412,13**	**192,57**
	-	**9,1**	**15,7**	**60,6**

Table A1.3. Influence of operating time on volatile complex of white dry wine Chardonnay, mg/dm^3

Parameter	Initial wine	Time, min				
		15	**30**	**60**	**90**	**120**
Alcoholic content, % vol.	13,5	11,4	10,1	8,3	7,9	4,1
Higher alcohols						
1-propanol	13,8	11,1	8,9	6,1	5,4	-
2-propanol	0,27	0,19	0,17	0,07	-	-
buthanol	1,3	1,002	0,92	0,53	0,32	-
isobutanol	20,8	19,3	19,1	8,7	8,3	6,2
Isoamyl alcohol	92,5	83,4	78,3	42,4	34,5	5,1
1-hexanol	0,87	0,805	0,72	0,21	0,18	-
2-phenylethanol	20,23	19,73	19,3	9,2	8,73	1,96
2,3-butylene glycol	20,57	20,33	19,12	8,58	7,29	2,51
1,2-propilene glycol	8,6	8,342	8,2	2,1	1,3	0,87
Σ Higher alcohols	**178,94**	**164,2**	**154,73**	**77,89**	**66,02**	**16,64**
Losses, %	**-**	**8,2**	**13,5**	**56,5**	**63,1**	**90,7**
Esters						
methylacetate	0,46	0,32	0,305	0,07	0,03	-
ethylacetate	53,2	41,22	35,18	15,2	7,9	-
ethylbytirate	2,2	1,738	1,52	0,53	0,45	-
ethylcaprilate	0,32	0,211	0,13	0,08	-	-
ethylcaprinate	0,83	0,71	0,65	0,21	0,05	-
ethyldecanoate	0,07	-	-	-	-	-
2-phenylacetate	2,4	2,04	1,78	0,71	0,44	0,03
Σesters	**59,48**	**46,23**	**39,56**	**16,8**	**8,87**	**0,03**
Losses,%	**-**	**22,3**	**33,5**	**71,8**	**85,0**	**99,9**
Fatty acids						
Acetic	215,33	200,1	197,8	181,3	178,5	148,7
Propionic	0,74	0,703	0,68	0,22	0,18	0,15
Bytiric	0,61	0,59	0,54	0,112	0,11	0,11
Isobytiric	0,28	0,27	0,253	0,03	-	0,08
Valeric	0,06	0,05	0,05	0,02	-	-
Capronic	1,34	1,3	1,305	1,13	1,07	0,76
Σ Acids	**218,36**	**203,01**	**200,62**	**182,81**	**179,86**	**149,8**
Losses, %	**-**	**7,0**	**8,1**	**16,2**	**17,6**	**31,3**
Aldehydes, ketones, terpens						
acetaldehyde	23,5	19,74	18,9	9,4	8,7	8,1
furaldehyde	0,01	-	-	-	-	-
acetoin	7,7	7,521	7,23	2,11	1,93	1,2
β-ionon	0,09	0,064	0,061	-	-	-
limonen	0,58	0,42	0,41	0,103	0,02	-
Σ Aldehydes, ketones, terpens	**31,88**	**27,74**	**26,6**	**11,61**	**10,65**	**9,3**
Losses, %	**-**	**12,9**	**16,6**	**63,5**	**66,5**	**70,8**
Σtotal	488,66	441,18	421,15	289,11	265,4	175,7
	-	9,7	13,8	40,8	45,6	64,0

Table A1.2. Influence of pressure of ethanol removal process on volatile complex of white dry wine Chardonnay, mg/dm^3

Parameter	**Initial wine**	**Pressure, kPa**				
		40	**30**	**20**	**10**	**4**
Содержание спирта, % об.	13,5	13,5	13,2	12,5	10,2	9,8
Higher alcohols						
1-propanol	13,8	13,8	13,5	12,0	8,9	8,8
2-propanol	0,27	0,27	0,26	0,23	0,19	0,17
buthanol	1,3	1,3	1,3	1,2	1,06	0,92
isobutanol	20,8	20,8	20,7	20,0	19,4	19,1
Isoamyl alcohol	92,5	92,4	92,0	87,2	78,3	70,5
1-hexanol	0,87	0,87	0,86	0,79	0,72	0,66
2-phenylethanol	20,23	20,2	20,01	19,9	19,3	19,11
2,3-butylene glycol	20,57	20,54	20,5	19,7	19,12	18,94
1,2-propilene glycol	8,6	8,6	8,5	8,31	8,2	8,01
** Higher alcohols**	**178,94**	**178,78**	**177,63**	**169,33**	**155,19**	**146,21**
Losses, %	**-**	**0,1**	**0,7**	**5,4**	**13,3**	**18,3**
Esters						
methylacetate	0,46	0,45	0,443	0,37	0,305	0,29
ethylacetate	53,2	53,1	50,04	41,24	35,18	34,1
ethylbytirate	2,2	2,2	2,04	1,72	1,52	1,44
ethylcaprilate	0,32	0,32	0,30	0,24	0,13	0,10
ethylcaprinate	0,83	0,83	0,80	0,71	0,65	0,61
ethyldecanoate	0,07	0,07	0,02	-	-	-
2-phenylacetate	2,4	2,4	2,21	1,96	1,78	1,72
esters	**59,48**	**59,37**	**55,85**	**46,24**	**39,56**	**38,26**
Losses,%	**-**	**0,2**	**6,1**	**22,2**	**33,4**	**35,6**
Fatty acids						
Acetic	215,33	215,0	210,0	200,0	197,8	197,01
Propionic	0,74	0,74	0,74	0,70	0,68	0,68
Bytiric	0,61	0,61	0,61	0,57	0,54	0,54
Isobytiric	0,28	0,28	0,28	0,26	0,253	0,25
Valeric	0,06	0,06	0,06	0,052	0,05	0,048
Capronic	1,34	1,34	1,33	1,31	1,305	1,30
** Acids**	**218,36**	**218,03**	**213,02**	**202,89**	**200,62**	**199,82**
Losses, %	**-**	**0,2**	**2,4**	**7,1**	**8,1**	**8,5**
Aldehydes, ketones, terpens						
acetaldehyde	23,5	23,0	22,8	19,4	18,9	18,7
furaldehyde	0,01	0,01	0,01	-	-	-
acetoin	7,7	7,7	7,64	7,4	7,23	7,2
β-ionon	0,09	0,09	0,09	0,072	0,061	0,06
limonen	0,58	0,58	0,56	0,49	0,41	0,4
** Aldehydes, ketones, terpens**	**31,88**	**31,38**	**31,1**	**27,36**	**26,6**	**26,36**
Losses, %	**-**	**1,6**	**2,4**	**14,2**	**16,6**	**17,3**
total	488,66	487,56	477,6	445,82	421,97	410,65
	-	0,22	2,26	8,76	13,64	15,96

Table A1.4. Influence of initial volume of white dry wine Chardonnay wine for ethanol removal process on volatile complex, mg/dm^3

Parameter	**Initial wine**	**Volume, dm^3**			
		0,25	**0,50**	**0,75**	**1,0**
Alcoholic content, % vol.	13,5	8,9	9,8	11,9	13,1
Higher alcohols					
1-propanol	13,8	6,2	8,8	11,4	13,4
2-propanol	0,27	0,11	0,17	0,19	0,26
buthanol	1,3	0,6	0,92	1,05	1,28
isobutanol	20,8	9,4	19,1	19,8	20,6
Isoamyl alcohol	92,5	50,1	70,5	81,9	90,1
1-hexanol	0,87	0,31	0,66	0,71	0,84
2-phenylethanol	20,23	9,42	19,11	19,5	20,0
2,3-butylene glycol	20,57	10,15	18,94	19,38	20,44
1,2-propilene glycol	8,6	3,1	8,01	8,22	8,52
Σ Higher alcohols	**178,94**	**89,39**	**146,21**	**162,15**	**175,44**
Losses, %	**-**	**50,0**	**18,2**	**9,4**	**1,9**
Esters					
methylacetate	0,46	0,13	0,29	0,33	0,44
ethylacetate	53,2	21,4	34,1	38,1	49,84
ethylbytirate	2,2	0,99	1,14	1,54	2,03
ethylcaprilate	0,32	0,17	0,1	0,20	0,28
ethylcaprinate	0,83	0,30	0,61	0,63	0,78
ethyldecanoate	0,07	-	-	0,01	0,02
2-phenylacetate	2,4	1,03	1,72	1,81	2,38
Σesters	**59,48**	**24,02**	**37,96**	**42,62**	**55,77**
Losses,%	**-**	**59,6**	**36,1**	**28,3**	**6,2**
Fatty acids					
Acetic	215,33	183,1	197,01	199,0	209,3
Propionic	0,74	0,31	0,68	0,69	0,73
Bytiric	0,61	0,24	0,54	0,55	0,61
Isobytiric	0,28	0,11	0,25	0,26	0,28
Valeric	0,06	0,02	0,048	0,049	0,054
Capronic	1,34	0,71	1,30	1,30	1,33
ΣAacids	**218,36**	**184,49**	**199,82**	**201,84**	**212,30**
Losses, %	**-**	**15,5**	**8,5**	**7,6**	**2,8**
Aldehydes, ketones, terpens					
acetaldehyde	23,5	10,9	18,7	18,9	22,3
furaldehyde	0,01	-	-	-	0,01
acetoin	7,7	2,6	7,2	7,31	7,60
β-ionon	0,09	0,01	0,06	0,066	0,09
limonen	0,58	0,2	0,4	0,43	0,55
Σ Aldehydes, ketones, terpens	**31,88**	**13,71**	**26,36**	**26,70**	**30,55**
Losses, %	**-**	**56,9**	**17,3**	**16,2**	**4,2**
Σtotal	**488,66**	**311,6**	**410,35**	**433,31**	**474,06**
	-	**36,2**	**16,0**	**11,3**	**2,9**

Annex 2. Sensory evaluation protocol of white and red wines obtained in laboratory conditions

APROB
Director general IȘPHTA,
_________C. Dadu
"24" aprilie _________2015

Proces verbal

№ 1 din 21.04.2015 a Comisiei extinse de degustare a laboratorului "Biotehnologii și Microbiologia Vinului" a IȘPHTA

mun. Chișinău 21.04.2015

Președintele comisiei: **Taran Nicolae** – dr.hab., prof.univ., șef laborator "Biotehnologii și Microbiologia Vinului" a IȘPHTA

Membrii comisiei: **Soldatenco Eugenia** - dr.hab., cercetător științific coordonator, lab. "Biotehnologii și Microbiologia Vinului" a IȘPHTA

Adajuc Victoria – dr.în tehnică, cercetător științific coordonator, lab. "Biotehnologii și Microbiologia Vinului" a IȘPHTA

Antohi Maria – dr.în tehnică, șef laborator "Standardizare și Expertiză" a IȘPHTA

Ponomariov Irina - dr.în tehnică, cercetător științific coordonator, lab. "Standardizare și Expertiză" a IȘPHTA

Degteari Natalia – dr.în tehnică, cercetător științific coordonator al laboratorului "Verificarea calității producției alcoolice"

Morari Boris – cercetător științific al laboratorului "Biotehnologii și Microbiologia Vinului" a IȘPHTA

Barsova Oxana – cercetător științific al laboratorului "Biotehnologii și Microbiologia Vinului" a IȘPHTA

Stoleicova Svetlana – cercetător științific al laboratorului "Biotehnologii și Microbiologia Vinului" a IȘPHTA

Scopul: 1. Aprecierea calității vinurilor naturale albe și roșii cu un conținut redus de alcool obținute cu utilizarea regimurilor tehnologice optimale de dealcoolizare prin metoda distilării sub vid.

2. Aprecierea calității vinurilor albe și roșii cu un conținut redus de alcool obținute prin metoda cupajării.

1. Vin alb Chardonnay (1) (control, concentrația alcoolică 13,5% vol.) – limpede, culoare pai deschis, aroma curată, florală, tipică de soi. Gust curat, plin, amarui. Nota medie – 7,9 puncte.

2. Vin alb Chardonnay (2) cu conținut redus de alcool (concentrația alcolică 9,0% vol) – limpede, culoare pai-deschis, aroma simplă, slabă. Gust simplu, acidulat, puțin dezechilibrat. Nota medie – 7,7 puncte.

3. Vin alb Chardonnay reducere de alcool 20% (concentrația alcoolică 11,5% vol) – limpede, culoare pai deschis. Aroma curătă, florală. Gust plin, curat, armonios, extractiv. Nota medie – 7,9 puncte.

4. Vin alb Chardonnay cu conținut redus de alcool obținut prin cupajare 1:2=50%:50% (concentrația alcoolică 11,3% vol) – limpede, culoare pai-deschis, aroma curată, puțin florală. Gust curat, proaspăt, plin. Nota medie – 7,9 puncte.

5. Vin alb Chardonnay cu conținut redus de alcool obținut prin cupajare 1:2=70%:30% (concentrația alcoolică 12,2% vol) – limpede, culoare pai-deschis, aroma curată, florală, tipică. Gust plin, armonios, curat. Nota medie – 8,0 puncte.

6. Vin roșu Merlot (1) (control, concentrația alcoolică 13,5% vol.) – limpede, culoare roșu, aroma bogată, de fructe, de soi. Gust curat, puțin astringent, plin, amarui. Nota medie – 7,9 puncte.

7. Vin roșu Merlot (2) cu conținut redus de alcool (concentrația alcoolică 8,7% vol.) – limpede, culoare roșu intens, aroma curată, simplă, fără nuanțe străine. Gust curat, proaspăt, puțin simplu. Nota medie – 7,7 puncte.

8. Vin roșu Merlot reducere de alcool 20% (concentrația alcoolică 11,0% vol) – limpede, culoare roșu, aroma curată, de fructe, de soi. Gust curat, tipic, plin, armonios. Nota medie – 7,9 puncte.

9. Vin roșu Merlot cu conținut redus de alcool obținut prin cupajare 1:2=50%:50% (concentrația alcoolică 11,1% vol) – limpede, culoare roșu, aroma curată, puțin tipică, slabe nuanțe de fructe roșii. Gust curat, astringent, proaspăt. Nota medie – 7,9 puncte.

10. Vin roșu Merlot cu conținut redus de alcool obținut prin cupajare 1:2=70%:30% (concentrația alcoolică 12,1% vol) – limpede, culoare roșu, aroma curată, tipică, de fructe roșii. Gust plin, armonios, curat, echilibrat. Nota medie – 8,0 puncte.

Concluzii: În urma aprecierii organoleptice a vinurilor albe și roșii cu un conținut redus de alcool obținute prin metoda distilării sub vid cu utilizarea regimurilor tehnologice optimale (T=30°C, P=0,04 bar) se evidențiază mostrele Nr. 3 Chardonnay (concentrația alcoolică 11,5% vol) și Nr.8 Merlot (concentrația alcoolică 11,0% vol) apreciate cu notă 7,9 puncte.

În urma aprecierii organoleptice a vinurilor albe și roșii cu un conținut redus de alcool se evidențiază mostrele Nr. 5 și 10 obținute în baza cupajării vinului inițial cu vinul dealcoolizat în proporție 1:2=70%:30%, obținînd note de 8,0 puncte.

Președintele Comisiei de Degustare N.Taran

Secretarul Comisiei de Degustare O.Barsova

Annex 3. Report of implementation of scientific and technical production

APROB

Director general ÎM "Nectar S" SRL

_________ P.Andreanov

"10" martie 2015

ACT DE IMPLEMENTARE

a producției tehnico-științifice

Comisia în componența:

Coceban Vladimir - Tehnolog principal, ÎM "Nectar S" SRL

Calmîș Elena- Șef laborator, ÎM "Nectar S" SRL

Taran Nicolae – șef laborator "Biotehnologii și Microbiologia Vinului", IȘPHTA

Soldatenco Eugenia – cerc. coord., laboratorului "Biotehnologii și Microbiologia Vinului", IȘPHTA

Stoleicova Svetlana- cerc. științ., laboratorului "Biotehnologii și Microbiologia Vinului", IȘPHTA, au întocmit acest act pentru confirmarea obținerii, în condițiile de producere la ÎM "Nectar S" SRL în a. 2015 a partidelor experimentale de vinuri albe și roșii cu conținut redus de alcool prin metoda distilării în vid.

Cercetările au fost efectuate în scopul elaborării și implementării în producere a noii tehnologii de obținere vinurilor cu conținut redus de alcool prin utilizarea metodei de distilare în vid. În rezultatul implementării noii tehnologii, elaborate în laboratorul Biotehnologii și Microbiologia Vinului a IȘPHTA, la fabrica ÎM "Nectar S" SRL au fost obținute 2000 dal de vinuri albe și roșii cu un conținut redus de alcool. Implementarea a noii tehnologii permite obținerea vinurilor cu un conținut de alcool de înaltă calitate.

Coceban Vladimir

Calmîș Elena

Taran Nicolae

Soldatenco Eugenia

Stoleicova Svetlana

PROCES VERBAL

al testării a tehnologiei de producere a vinurilor albe □i ro□ii seci cu un con□inut redus de alcool prin metoda distilării sub vid la fabrica de vinuri ÎM "Nectar S" SRL, Republica Moldova

Comisia în componen□a:

Pre□edinte:

Coceban Vladimir - Tehnolog principal, ÎM "Nectar S" SRL

Membrii comisiei:

Calmî□ Elena- Şef laborator, ÎM "Nectar S" SRL

Taran Nicolae – şef laborator "Biotehnologii şi Microbiologia Vinului", IŞPHTA

Soldatenco Eugenia – cerc. coord., laboratorului "Biotehnologii şi Microbiologia Vinului", IŞPHTA

Stoleicova Svetlana - cerc. ştiinț., laboratorului "Biotehnologii şi Microbiologia Vinului", IŞPHTA

A efectuat testările în producere a noii tehnologii de ob□inere a vinurilor albe □i ro□ii cu un con□inut redus de alcool. În rezultatul testării în producere a noii tehnologii comisia a stabilit următoarele:

1. Controlul tehnologiei experimentale în producere.

Pentru testările în producere a fost prezentată o nouă tehnologie de ob□inere vinurilor albe □i ro□ii seci cu un con□inut redus de alcool prin metoda distilării sub vid. Aceasta tehnologie include următoarele etape: selectarea vinurilor materie primă cu o concentra□ia alcoolică sporită, stabile la casările cristalice, coloidale □i proteice, fără difecte organoleptice; corectarea con□inutului de alcool (max 20%) prin metoda distilării sub vid cu utilizarea regimurilor tehnologice elaborate; păstrarea vinului ob□inut cu un con□inut redus de alcool timp de 10 zile; filtrarea sterilă a vinului ob□inut cu utilizarea filtrului cu mărimea porilor de 0,4 µm; îmbutilierea sau păstrarea vinului ob□inut la temperature de 14-16ºC.

Pentru efectuarea testărilor în producere au fost selectate vinuri materie primă albe □i ro□ii seci, destinate producerii vinurilor cu con□inut redus de alcool, cu următoarele con□inuturi de alcool: Aligote (a.r.2014) cu concentra□ia alcoolică 13,9% vol. □i Merlot (a.r. 2014) cu concentra□ia alcoolică 14,1% vol. Vinurile selectate au fost tipice, cu nuan□e de soi □i fără difecte organoleptice. Asigurarea procesului tehnologic cu energie electric, apă, material auxiliare □i altele necesare a fost efectuată fără probleme.

Determinarea indicilor fizico-chimici ai vinurilor a fost efectuată de colaboratorii laboratorului de producere a fabricii ÎM “Nectar S” SRL □i Institutului □tiin□ifico-Practic de Horticultură □i Tehnologii Alimentare. Indicii fizico-chimici principali în vinurilor ini□iale □i ob□inute după diminuarea con□inutului de alcool au fost determina□i conform metodelor utilizate în practica vinicolă.

2. Aprecierea generală a procesului tehnologic de diminuare a con□inutului de alcool în vinurile prin utilizarea metodei de distilare sub vid.

În procesul testărilor a noii tehnologii de producere vinurilor albe □i ro□ii seci cu un con□inut redus de alcool au fost utilizate următoarele vinuri materie primă: Aligote (a.r. 2014) □i Merlot (a.r. 2014) cu indicii fizico-chimici prezenta□i în tabelul 1. Deasemenea, vinurile selectate au fost testate la predispozi□ia la diferite tipuri de tulburări. Rezultatele studiului stabilită□ii vinurilor la diferite tipuri de tulburări sunt prezentate în tabelul 2.

Tabelul 1. Indicii fizico-chimici a vinurilor albe □i ro□ii selectate pentru diminuarea con□inutului de alcool

Nr.	Denumirea	Concentra□ia alcoolică,% vol.	Concentra□ia în masă a, g/dm³			pH	SO_2 total/lib, mg/dm³	Nota organoleptică, puncte
			Acidită□ii titrabile	Acidită□ii volatile	Zaharului rezidual			
1	Aligote	13,9±0,1	5,5±0,08	0,36±0,03	1,6±0,5	3,18±0,01	120/31	7,9±0,01
2	Merlot	14,1±0,1	5,1±0,1	0,39±0,03	2,2±0,5	3,25±0,01	103/22	7,9±0,01

Tabelul 2. Rezultatele stabilită□ii vinurilor materie primă, prelevate pentru testări în producere, către diferite tipuri de tulburări

Tulburări	Aligote	Merlot
Concentra□ia alcoolică, % vol.	13,9	14,1
Biochimice	+	+
Proteice	+	+
Coloidale	+	+

Cristalice	+	+
Microbiologice	+	+

Legenda: + stabil

- nestabil

Conform rezultatelor ob□inute vinurile selectate pentru diminuarea con□inutului de alcool corespund cerin□elor tehnologice în vigoare: nu au difecte organoleptice □i sunt stabile la diferite tipuri de tulburări.

Procesul de diminuare a con□inutului de alcool din vinurile selectate în volum de 1000 dal de vin alb □i 1000 dal de vin ro□u a fost efectuat la instala□ia existentă la fabrica ÎM "Nectar S" SRL pentru distilare a vinurilor sub vid. Procesul de dealcoolizare a vinurilor a fost controlat prin determinarea concentra□iei alcoolice în vinurile supuse eliminării alcoolului etilic.

Parametrii tehnologici ai procesului de reducere a concentra□iei alcoolice în vinurile albe □i ro□ii sunt prezentate în tabelul 3.

Tabelul 3. Regimurile tehnologice a procesului de reducerea concentra□iei alcoolice în vinurile albe □i ro□ii

Nr	**Denumirea**	**Temperatura**	**Presiune**	**Volumul vinului**
1	Aligote	(30±1)°C	4 kPa	1000 dal
2	Merlot	(30±1)°C	4 kPa	1000 dal

Din tabelul 3 rezultă, că în procesul testărilor în producere a noii tehnologii de reducere concentra□iei alcoolice prin metoda distilării sub vid au fost utilizate 2000 dal de vinuri albe □i ro□ii seci. Procesul de eliminare alcoolului a fost efectuat la temperature de (30±1)ºC □i presiunea de 0,4 bar. Vinurile ob□inute după dealcoolizare au fost supuse analizelor fizico-chimice, precum □i a fost determinată stabilitatea vinurilor către diferite tipuri de tulburări, iar rezultatele ob□inute sunt prezentate în tabelul 4, 5.

Tabelul 4. Indicii fizico-chimici ai vinurilor albe □i ro□ii seci ob□inute după procesul de dealcoolizare

Nr.	Denumirea	Concentra□ia alcoolică,% vol.	Concentra□ia în masă a, g/dm³			pH	SO_2 total/lib, mg/dm³	Nota organoleptică, puncte
			Acidită□ii titrabile	Acidită□ii volatile	Zaharului rezidual			

1	Aligote	11,5±0,1	5,7±0,08	0,33±0,03	1,8±0,5	3,12±0,01	110/21	8,0±0,01
2	Merlot	12,0±0,1	5,4±0,1	0,37±0,03	2,5±0,5	3,20±0,01	91/12	8,0±0,01

Tabelul 5. Stabilitatea a vinurilor obţinute după reducerea concentraţiei alcoolice către diferite tipuri de tulburări

Tulburări	**Aligote**	**Merlot**
Concentraţia alcoolică, % vol.	11,5	12,0
Biochimice	+	+
Proteice	+	+
Coloidale	+	+
Cristalice	+	+
Microbiologice	+	+

Legenda: + stabil

- nestabil

Din rezultatele obţinute după testările în condiţii de producere se observă, că concentraţia alcoolică în vinurile dealcoolizate a scăzut de la 13,9 % vol pînă la 11,5% vol pentru vinul Aligote şi de la 14,1% vol pînă la 12,0% vol. pentru vinul Merlot, ceea ce corespunde cerinţelor recomandate de OIV. Deasemenea, în vinurile dealcoolizate se observă o majorare a concentraţiei în masă a acidităţii titrabile (cu 0,3-0,4 g/dm^3) şi zaharului rezidual (cu 0,2-0,3 g/dm^3). Concomitent are loc o micşorarea neesenţială a indicelui pH, concentraţiei bioxidului de sulf precum şi concentraţiei în masă a acidităţii volatile, în urma proceselor de concentrare, care au loc după dealcoolizarea vinurilor.

În aşa fel, în urma testării noii tehnologii de producere a vinurilor albe şi roşii seci cu un conţinut redus de alcool prin metoda distilării sub vid în condiţii de producere, se poate concluziona, că eliminarea parţială a alcoolului etilic nu influenţează asupra stabilităţii vinurilor obţinute, precum şi a fost demonstrate, că diminuarea conţinutului de alcool în limitele studiate (circa 20%) influenţează pozitiv asupra notei organoleptice. Mostrele de vinuri dealcoolizate albe şi roşii seci au fost apreciate cu note organoleptice înalte.

3. Neajunsurile tehnologice și de exploatare a procesului tehnologic.

Pe parcursul testării în producere a noii tehnologii de producere a vinurilor albe și roșii seci cu un conținut redus de alcool prin metoda distilării sub vid neajunsuri nu au fost depistate.

4. Concluzii și recomandări

1. Pe parcursul testării în producere la fabrica ÎM “Nectar S” SRL a noii tehnologii de producere vinurilor cu un conținut redus de alcool au fost obținute 2000 dal albe și roșii seci. Aprecierea organoleptică a vinurilor parțial dealcoolizate a demonstrat că tehnologia elaborată permite obținerea vinurilor cu note organoleptice înalte.
2. Diminuarea parțială a concentrației alcoolice prin metoda distilării sub vid realizată conform tehnologiei elaborate la IȘPHTA permite eliminarea efectivă a alcoolului etilic din vinurile pînă la limita recomandată de OIV.
3. Noua tehnologie de reducere parțială a concentrației alcoolice prin metoda distilării sub vid se recomandă pentru implementare în industria vinicolă.

Președintele comisiei: Coceban V.

Membrii comisiei: Taran N.

Calmîș E.

Soldatenco E.

Stoleicova S.

APROB

Director general ÎM "Nectar S" SRL

_____________ P.Andreanov

"__" ____________2015

ACT DE PRELEVARE

a probelor de vinuri albe şi roşii, obţinute prin utilizarea noii tehnologii de obţinere a vinurilor cu un conţinut redus de alcool în a. 2015 la ÎM "Nectar S" SRL

Comisia în componenţa:

Coceban Vladimir - Tehnolog principal, ÎM "Nectar S" SRL

Calmîş Elena- Şef laborator, ÎM "Nectar S" SRL

Taran Nicolae – şef laborator "Biotehnologii şi Microbiologia Vinului", IŞPHTA

Soldatenco Eugenia – cerc. coord., laboratorului "Biotehnologii şi Microbiologia Vinului", IŞPHTA

Stoleicova Svetlana- cerc. ştiinţ., laboratorului "Biotehnologii şi Microbiologia Vinului", IŞPHTA, a efectuat prelevarea probelor de vinuri albe şi roşii obţinute în urma procesului de eliminare excesului de alcool prin utilizarea metodei distilării sub vid.

Prelevarea probelor a fost efectuată pentru îndeplinirea următoarelor cercetări:

-efectuarea analizei comparative a indicilor fizico-chimici în vinurile obţinute;

-aprecierea proprietăţilor organoleptice a vinurilor obţinute.

Reeşind din sarcinile propuse, au fost prelevate următoarele mostre de vinuri albe şi roşii, obţinute prin utilizarea a noii tehnologii, care sunt prezentate în table

№	Denumirea	Volumul, dal	Indicii fizico-chimici					
			Concentraţia alcoolică, % vol	Concentraţia în masă a, g/dm^3			pH
				Zaharului rezidual	Acidităţii titrabile	Acidităţii volatile	
1	Aligote iniţial	-	13,9	1,6	5,5	0,36	3,18
2	Aligote	1000	11,5	1,8	5,7	0,33	3,12
3	Merlot iniţial	-	14,1	2,2	5,1	0,39	3,25
4	Merlot	1000	12,0	2,5	5,4	0,37	3,20

Volumul total a partidelor experimentale de vinuri albe şi roşii cu conţinut redus de alcool obţinute la fabrica ÎM "Nectar S" SRL în a. 2015 constiuie 2000 dal.

Semnăturile membrilor comisiei:

Coceban Vladimir

Calmîş Elena

Taran Nicolae

Soldatenco Eugenia

Stoleicova Svetlana

Annex 5. Sensory analysis report of white and red wines obtained in production conditions

APROB

Director general ÎM "Nectar S" SRL

P.Andreanov

„10" martie 2015

Proces verbal

de degustare a mostrelor experimentale de vinuri albe şi roşii cu un conţinut redus de alcool obţinute la fabrica de vinuri ÎM "Nectar S" SRL prin metoda distilării sub vid

Preşedintele comisiei:

Coceban Vladimir - Tehnolog principal, ÎM "Nectar S" SRL

Membrii comisiei:

Calmîş Elena- Şef laborator, ÎM "Nectar S" SRL

Taran Nicolae – şef laborator "Biotehnologii şi Microbiologia Vinului", IŞPHTA

Soldatenco Eugenia – cerc. coord., laboratorului "Biotehnologii şi Microbiologia Vinului", IŞPHTA

Stoleicova Svetlana- cerc. ştiinţ., laboratorului "Biotehnologii şi Microbiologia Vinului", IŞPHTA

Scopul degustaţiei constă în determinarea influenţei procesului de eliminare a excesului de alcool din vinurile albe şi roşii obţinute în cadrul testării în producere a noii tehnologii asupra indicilor organoleptici în comparaţie cu vinurile iniţiale.

Aprecierea organoleptică a vinurilor este prezentată mai jos:

Vinul Aligote iniţial (a.r. 2014). Vin cu o culoare pai-deschis, aromă complexă, cu nuanţe florale, gust curat, plin, amarui, tipic. Nota 7,9 puncte

Vinul Aligote cu conţinut redus de alcool (a.r. 2014). Vin cu o culoare pai-deschis, aromă complexă, cu nuanţe florale,de soi, gust curat, plin, armonios, tipic. Nota 8,0 puncte

Vinul Merlot iniţial (a.r. 2014). Vin cu o culoare roşie, aromă complexă, cu nuanţe de fructe roşii, gust curat, plin, amarui, astringent. Nota 7,9 puncte

Vinul Merlot cu conţinut redus de alcool (a.r. 2014). Vin cu o culoare pai-deschis, aromă complexă, de fructe, gust curat, plin, catifelat, tipic. Nota 8,0 puncte.

Concluzia comisiei: Eliminarea excesului de alcool din vinurile albe şi roşii prin metoda distilării sub vid cu utilizarea regimurilor tehnologice elaborate la IŞPHTA permite obţinerea vinurilor cu un conţinut redus de alcool de înaltă calitate.

Comisia de degustare:

Coceban Vladimir
Calmîş Elena
Taran Nicolae
Soldatenco Eugenia
Stoleicova Svetlana

Annex 6. Application form for invention

F-01-BI-002-E-01-0210

Referinţa solicitantului/reprezentantului	Se completează de către AGEPI	
	Registratura AGEPI intrare:	Registrul naţional de cereri de brevet de invenţie de scurtă durată
Nr.	Nr. 1318	(21) Nr. depozit S2015 0056
Data	Data 2015 APR. 17	(22) Data depozit 2015 04. 17.

Către **AGENŢIA DE STAT PENTRU PROPRIETATEA INTELECTUALĂ A REPUBLICII MOLDOVA**

Str. Andrei Doga nr. 24, bloc 1, MD-2024, Chişinău, Republica Moldova, tel.: (37322) 40-05-05, fax: 43-85-08

C E R E R E
DE BREVET DE INVENŢIE DE SCURTĂ DURATĂ

Cererea se va completa în 3 exemplare dactilografiate sau imprimate

I. (71) SOLICITANT (nume, prenume sau denumire completă, adresă, telefon şi fax cu prefixul zonei)

Instituţia Publică "Institutul Ştiinţifico-Practic de Horticultură şi Tehnologii alimentare", mun. Chişinău, str. Vierul, 59, MD-2070, fax (37322) 285025, tel. (37322) 285431

Numărul de identificare de stat unic (IDNO/IDNP) 1008600056226

Cod ţară conform normei ST. 3 OMPI

MD

II. (74) REPREZENTANT (nume, prenume sau denumire completă, adresă, telefon şi fax cu prefixul zonei)

Adajuc Victoria, Instituţia Publică "Institutul Ştiinţifico-Practic de Horticultură şi Tehnologii Alimentare", mun. Chişinău, str. Vierul, 59, MD-2070, fax (37322) 285025 tel. (37322) 285018

☐ mandatar autorizat ☐ reprezentant ☐ reprezentant comun al solicitanţilor

☐ procură ×

III. ADRESA PENTRU CORESPONDENŢĂ (nume, prenume, adresă, telefon şi fax cu prefixul zonei)

Adajuc Victoria, Instituţia Publică "Institutul Ştiinţifico-Practic de Horticultură şi Tehnologii Alimentare", mun. Chişinău, str. Vierul, 59, MD-2070, fax (37322) 285025 tel. (37322) 285018

IV. SOLICIT(ĂM) în baza Legii nr. 50/2008 privind protecţia invenţiilor (Lege) acordarea unui brevet de invenţie de scurtă durată pentru invenţia cu

(54) TITLUL:

Procedeu de obţinere vinurilor naturale cu un conţinut redus de alcool

Solicitantului îi aparţine dreptul la brevet în baza × **art. 14 alin. 1,** ☒ art. 15 alin. 2, ×**art. 15 alin. 3,** ×**art. 15 alin. 4** din Lege sau

☐ în baza unui acord încheiat la data de ……………………

VIII. DECLAR(ĂM) că **INVENTATORUL(II)** este (sunt):

☐ acelaşi (aceiaşi) cu **SOLICITANTUL(ŢII)**

×**persoana(ele) menţionată(e) mai jos**

DECLARAREA INVENTATORILOR:

(72) Numele şi prenumele, cod ţară conform normei ST. 3 OMPI	Adresa completă, numărul de identificare de stat unic (INDP)	Locul de muncă şi funcţia la data creării invenţiei

S2015 0056 F-01-BI-002-E-01-0210

Taran Nicolae, MD	str. Grenoble 130/2, ap 6, Mun. Chişinău, MD-2019, 0961201549094	Institutul Ştiinţifico-Practic de Horticultură şi Tehnologii Alimentare, Şef laborator
Stoleicova Svetlana, MD	r-nul Taraclia, s. Corten, str. Miciurin, 19, MD-7421, 2001046202052	Institutul Ştiinţifico-Practic de Horticultură şi Tehnologii Alimentare, cercetător ştiinţific
Soldatenco Eugenia, MD	str. Alexandru cel Bun, 2/1, ap. 45, MD-6800, Ialoveni, 0972810442335	Institutul Ştiinţifico-Practic de Horticultură şi Tehnologii Alimentare, cercetător ştiinţific coordonator

IX. DOCUMENTE DEPUSE:

	Nr. file	Nr. ex.	se anexează:	Nr. file	Nr. ex.
■ **în limba moldovenească** □ **altă limbă**					
■ - formular-tip de cerere	2	3	□ - declaraţie privind divulgarea invenţiei, conform art. 9 din Legea nr. 50/2008		
■ - descriere	3	3	**Alte documente:**		
■ - revendicări	1	3	□ - traducerea materialelor cererii:		
□ - desene			□ - descriere		
■ - rezumat	1	3	□ - revendicări		
□ - act de prioritate			□ - rezumat		
□ - procură			□ - desene		
□ - copie/traducere a cererii anterioare de la rubrica VI			□ - act de prioritate		
□ - document referitor la plata taxelor			■ - Referinţe bibliografice	18	1
□ - act privind acordarea reducerii la plata taxelor			■ - Lista bibliografică................	1	3

X. Semnătura solicitantului(lor)/reprezentantului (numele în clar): Adajuc Victoria, conform procurei 17.04.15 Data	**XI.** a) **Persoana** care a prezentat cererea, alta decât solicitantul/reprezentantul (numele complet, actul de identitate): b) Semnătura persoanei care a recepţionat cererea la AGEPI (numele în clar): AGEPI **XII. Registratura** AGEPI ieşire: Nr. 1967 Data 2015 05. 11

Annex 7. Scholarship granted by World Federation of Scientists

WORLD FEDERATION OF SCIENTISTS
Founded in Erice
Beijing Geneva Moscow New York

WORLD FEDERATION OF SCIENTISTS

THE PRESIDENT

Ms. Svetlana Stoleicova
Academy of Sciences of Moldova
Institute of Horticulture and Food Technology
Chisinau
Republic of Moldova

Geneva, 2nd September 2013

Concerns: Moldovan Scholarship Programme

Dear Ms. Stoleicova,

Following the recommendation made by Academician Gheorghe Duca, National Representative of the World Federation of Scientists in Moldova, I have the pleasure of granting you a one-year scholarship to conduct research under the direct supervision of Professor Nicolae Taran at the Institute of Horticulture and Food Technology, Chisinau. The topic of your research, related to the WFS Planetary Emergency "Food", will be "*Influence of the process of dealcoholisation on the quality of white and red wines*".

The scholarship will amount to 150 Swiss Francs per month and will be paid to you every 2 months against receipt. Please note that we must receive the following for the continuation of the scholarship:

1) A copy of this letter signed for acceptance by return mail.
2) The delivery of an interim report after six months, and a final report at the end of the scholarship.
3) Signed receipts every two months.

Wishing you success with your research work, I remain,

Yours sincerely

Professor Antonino Zichichi
President

Enclosures: Basic Rules & Guidelines and Receipt Form

Main centres:
OPERATIONAL CENTRE – 1211 Geneva – Switzerland – C/o CERN, LAA Building #29 - Tel: +41/227679957 - Fax: +41/227679965 - E-mail: info@worldlab.ch
ESTONIA - EE0010 TALLIN - 10 Rävala Boulevard - Tel: +372/2/441304 - Fax: +372/2/440640 - E-mail: rebanek@park.tartu.ee
GEORGIA - 300008 TBILISI - 52 Rustaveli Avenue - Tel: +995/32/998891 - Fax: +995/32/998823 - Telex: 212133 ECO SU - E-mail: lado@acad.acnet.ge
LITHUANIA - 232600 VILNIUS - 3 Gediminio Avenue - Tel: +3/702/613651 - Fax: +3/702/618464 - Telex: 261141 LMA SU - E-mail: tmkc.plls@wllb.lt
MEDITERRANEAN area - CCSEM, I 91016 ERICE - 26 Via Guarnotta - Tel: +39/923/869133 - Fax: +39/923/869226 - E-mail: hq@emcsc.ccsem.infn.it
PEOPLE'S REPUBLIC OF CHINA - BEIJING - 52 Sanlihe Road - Tel: +86/1/8597701 - Fax: +86/1/8511095 - Telex: 22474 ASCHI CN
UKRAINE - 252054 KIEV - 32-A Str. Turguenevskaya - Tel: +380/44/2167012 - Fax: +380/44/2167012 - Telex: 131376 IDEA SU
USA - Colombia University in the City of New York, NY 10027 NEW YORK - 538 West 120th Street - Tel: +1/212/8543339 - Fax: +1/212/9323169
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Annex 8. Certificate of registration of scientific results on the project for young scientists

AGENŢIA DE STAT
PENTRU PROPRIETATEA INTELECTUALĂ
A REPUBLICII MOLDOVA
Str. Andrei Doga nr. 24/1, MD-2024, Chişinău, Republica Moldova
Tel.: +(373 22)40-05-00, +(373 22)44-32-53, fax: +(373 22)44-01-19
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www.agepi.gov.md, e-mail: office@agepi.gov.md

ADEVERINŢĂ

de înregistrare a rezultatelor activităţii de cercetare ştiinţifică
nr. 1122 din 12.02.2015

Prezenta Adeverinţă confirmă înregistrarea în Baza de Date „Rezultate ştiinţifice" a rezultatelor activităţii de cercetare ştiinţifică obţinute, urmare a realizării proiectului:

Studiul şi influenţa procesului de dezalcoolizare a vinurilor albe asupra parametrilor de calitate a produsului finit

Codul (cifrul) proiectului	**13.819.14.11A**
Numărul şi data înregistrării de stat	**455IND / 02.01.2013**
Direcţia strategică	**18.05 Biotehnologie**
Denumirea programului de stat	**(Lipseste)**
Organizaţia-executor	**Institutul Ştiinţifico-Practic de Horticultură şi Tehnologii Alimentare**
Conducătorul (-ii) proiectului	**Adajuc Victoria (Doctor)**
Tipul raportului (final/intermediar)	**final**
Numărul înregistrării în Baza de Date	**911/1212**
Data înregistrării în Baza de Date	**11.02.2015**

Raportul privind rezultatele activităţii de cercetare ştiinţifică înregistrate în Baza de Date se anexează pe 2 file.

Dr. BOLOCAN Lilia,
Director General
L.Ş.

The 5th International Conference on Food Chemistry, Engineering & Technology"

Banat's University of Agricultural Sciences and Veterinary Medicine
"King Michael I of Romania" from Timişoara, Romania
Faculty of Food Processing Technology

The 5th International Conference on Food Chemistry, Engineering & Technology"

Certificate of Attendance

to **Nicolae Taran, Svetlana Stoleicova, Olga Soldatenco, Boris Morari**

"The influence of pressure on chemical and physical parametres of white and red wines obtained by dealcoholization method"

Prof. Dr. Ing. Adrian RIVIŞ
Dean of the Faculty of Food Processing Technology

May 29-30, 2014, Timişoara, Romania

Ministry of Education of
Republic of Moldova
Technical University of Moldova

MTFI
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IN THE FOOD INDUSTRY

Excellence diploma

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Languages: Romanian C1, Russian C1, Bulgarian C1, English B1

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