Hungarian University of Agriculture and Life Sciences

Options for Reducing the Alcohol Content of Wines in the Context of Wine Quality

Theses of the doctoral thesis

Szabina Steckl

Budapest

2026

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1. INTRODUCTION AND AIMS OF THE STUDY

Consumer preferences have changed in recent years, with health-conscious nutrition and, along with it, conscious wine consumption coming to the front. Recently, there has been a growing trend for consumers to increasingly consume beverages with reduced alcohol content (in a broader sense, those with an ethanol content of 9-13% v/v) and low-alcohol wines (0.5-2% v/v) (Jordão et al., 2015; Bucher et al., 2018). Growing health and safety awareness and global initiatives to reduce alcohol consumption are the reasons why lower-alcohol wines that are attractive to wine consumers are being produced (Saliba et al., 2013).

These consumers perceive low-alcohol beverages as a response to the increased incidence of nutrition-related diseases (WHO, 2003) and the increased health awareness of consumers and society as a whole (Jones and Bellis, 2012). Low-alcohol beverages may therefore be perceived as a healthier alternative to traditional beverages by consumers who aim to maintain a healthier diet and lifestyle.

At the same time, there are consumer groups who identified taste as a reason for avoiding low-alcohol beverages. Lack of taste is a significant disadvantage of low-alcohol beverages (Chrysochou, 2014), and it can be assumed that it influences people's assessment of the quality of a given low-alcohol beverage. Some previous research has shown that "light" products are generally perceived as less palatable (Kähkönen et al., 1999; Solheim and Lawless, 1996; Stubenitsky et al., 1999), and similar observations have been made for low-alcohol beverages (Porretta and Donadini, 2012).

Over the past two decades, the ethanol content of wines has increased noticeably in some regions, by 0.1-1% per year (Godden et al., 2015; Alston et al., 2015), as warmer climates lead to higher sugar content in grapes at harvest time, resulting in higher alcohol content in wine (van Leeuwen and Darriet, 2016).

The aim of my doctoral thesis was to examine how the alcohol content of wines can be reduced by 1% to a maximum of 2% v/v.

My research focused on the use of an experimental yeast strain that does not carry out alcoholic fermentation in the usual way, but instead produces other components instead of alcohol. Thanks to the cooperation between a company producing winemaking additives and the Department of Oenology, I was able to participate in the experiment.

In my doctoral thesis, I sought answers to the following questions:

- Is the new yeast strain I used actually suitable for reducing the alcohol content of wines by 1-1.5 or 2 v/v%? If so, to what extent and how did the fine-analytical parameters of the wines change?
- Does the special yeast affect the glycerol concentration of alcohol-reduced wines?
- Did the alcohol reduction actually shift the lactic acid concentration upward?
- Do the titratable acid content, pH value, malic acid, tartaric acid, and citric acid content change? I examined how the treatment affects the concentration of other important organic acids, such as fumaric acid, shikimic acid, and succinic acid.

- Does the special yeast strain affect the polyphenol composition? Do the concentrations of total polyphenols, leucoanthocyanins, and catechins change?
- I examined the biogenic amino acid composition of the wines to determine whether the yeast strain I used influenced the quantity and composition of biogenic amino acids, and if so, in what way. I paid particular attention to changes in the concentrations of histamine, tyramine, and serotonin, which were the focus of my research.
- To what extent does the composition and quantity of higher alcohols change in the experimental samples?

- What sensory characteristics do wines with reduced alcohol content have, to what extent do lactic acid and glycerol concentration appear as a sensation of fullness in these wines, and did the 1-1.5% v/v alcohol reduction make the wines more harmonious compared to the control wines?
- To what extent and how does the vintage effect manifest itself during alcohol reduction, i.e., to what extent does it influence the analytical and fine-analytical composition of wines with reduced alcohol content?
- Based on analytical and sensory evaluations, which yeast strain dosage produces the most balanced wine (with the best sensory properties)?

In a separate chapter, I examined wines with reduced alcohol content, where the reduction was achieved by physical methods after alcoholic fermentation.

In these cases, I sought answers to the following questions:

- Is it possible to achieve a partial reduction in alcohol content using this process?
- Apart from the basic analytical parameters, how does the physical method affect the composition of the fine analytical parameters?
- Does the process affect the glycerol content of wines?
- Does it influence the formation of nitrogen-containing compounds?
- Does the composition of phenolic compounds change, and if so, how?

2. MATERIALS AND METHODS

2.1. Measurement methods used

The reference measurements of the basic analysis parameters include the following tests:

- Determination of titratable acidity by acid-base titration, expressed as tartaric acid equivalent (OIV-MA-AS313-01)
- pH measurement by potentiometric titration, using a Radelkis pH/ION ANALYSER automatic benchtop pH meter (OIV-MA-AS313-15)
- Determination of reducing sugar content by Schoorl titration (OIV-MA-AS311-01A)
- Determination of alcohol content after distillation using a hydrostatic weighing scale (OIV-MA-AS312-01B), Gibertini DEE distiller and Gibertini Densimat & Alcomat hydrostatic weighing scale.
- Determination of extract content (OIV-MA-AS2-03B:R2012)

Enzymatic measurements:

- Determination of L-malic acid content by enzymatic method (OIV-MA-AS313-11), L-malic acid Assay Kit (Megazyme Inc., USA)
- Enzymatic determination of glycerol content (OIV-MA-AS312-05), Glycerol Assay Kit (Megazyme Inc., USA), Dynamica
- Enzymatic determination of lactic acid content (OIV-MA-AS313-07), D-Lactic Acid Assay Kit (Megazyme Inc., USA)

Spectrophotometric measurement:

- Determination of tartaric acid content (OIV-MA-AS313-05B)
- Determination of total polyphenol content (MSZ-9474-80)
- Leucoanthocyanin determination (Flanzy, 1970 modified)
- Catechin content determination (Rebelein, 1965)
- Yeast Assimilable Nitrogén (YAN) determination
- Proline determination

HPLC measurements:

- *Determination of organic acids – succinic acid, citric acid, fumaric acid, shikimic acid* (OIV-MA-AS313-04)
- *Determination of biogenic amines* (Kállay, Sárdy, 2003)

Gas chromatography measurement:

- Determination of higher alcohols (OIV-MA-BS-14:R2009)

2.2. Experimental methodology

I used grape must made from Generosa grapes to set up the experiment. The experiment was set up at the MATE Badacsony Research Institute in three different years (2021, 2022, 2023). The musts fermented under operating conditions in 100-liter small tanks that could be heated and cooled individually, with a constant temperature of 16-17°C maintained in the tanks. The musts received different treatments. In addition to the two controls (spontaneous fermentation and commercially available *Saccharomyces cerevisiae* yeast), I used a yeast with special properties at doses of 20 g/hl and 40 g/hl, depending on the time.

2.3 Applied special yeast

The yeast with special properties that I used is a pure strain of *Lachancea thermotolerans* (formerly *Kluyveromyces theromolerans*). The non-*Saccharomyces* yeast used in my doctoral thesis experiment has an alcohol-reducing effect, as it does not convert all of the sugar present during fermentation into alcohol, but rather produces more secondary fermentation by-products, which are also formed from sugars during fermentation. Its properties include the ability to increase the acidity and flavor complexity of white and rosé wines. As a result of lactic acid release, the final alcohol content of these wines can be reduced.

2.4. Alcohol reduction by physical methods

Szürkebarát wines with reduced alcohol content by physical methods were produced under operating conditions, which I had the opportunity to examine in cooperation with the Törley Sparkling Wine Cellars. Basic and fine analytical measurements were performed on the wines made available to us. Given the quantity of wine received, it was not possible to perform sensory evaluation. My goal within the collaboration with the company was to examine changes in total polyphenol content.

Membrane separation (Juclas MMR50)

MASTERMIND® REMOVE is an innovative alcohol removal technology that can reduce the alcohol content of wines to perfectly comply with both laws and regulations and the structure, color, and aroma of the wine. Viticultural and winegrowing decisions, as well as recent harvests characterised by significant climatic changes, have often led to the production of wines with high alcohol content. The latest market trends are leaning towards balanced, distinctive wines. The polymer forming the membrane has no electrical charge, and this process does not affect the original color or structure of the wine, as the membrane does not interact with the colloidal system. The wine obtained in this way retains its aroma. (https://www.juclas.it/index.cfm/en/products/mastermind-remove/)

The results show 3 sampling times:

- sampling at 0.5% v/v alcohol reduction
- sampling at 1.0% v/v alcohol reduction
- sampling at 1.5% v/v alcohol reduction

2.5. Applied statistics

I performed statistical analyses using IBM SPSS Statistics (version: 29.0.1.0). I used one-way analysis of variance (ANOVA) to analyze annual data and sensory evaluation data.

Prior to the analysis, I checked the conditions required for the use of ANOVA. I tested normality using the Shapiro–Wilk test and checked the homogeneity of variances using the Levene test. In the case of a significant effect, I performed pairwise comparisons using a post hoc test (Tukey/Games–Howell).

I used two-way analysis of variance (MANOVA) to analyze the three different years. Due to a violation of the normality assumption (outliers), I applied data transformation (Box–Cox transformation). I used the transformed variables in further analyses. To accurately determine the differences between groups, I used Tukey's post hoc tests (Box and Cox, 1964).

3. RESULTS AND DISCUSSION

3.1. Comparison and evaluation of the three growing seasons

3.1.1. Evaluation of alcohol content development

In terms of the development of the alcohol content of the wines, it can be observed that in each year, the treated samples differed significantly from the control wines (Sp, HD A54). However, in 2022, the difference was only statistically significant. It can be concluded that in 2021 and 2023, the sample treated on day 1 (Oc20) and day 2 (Oc20+2d) did not differ from the control wines among the 20 g/hl treatments. In the same two years, it was observed that among the 40 g/hl treatments, the samples inoculated on the third day (Oc40+3d) and those fermented only with non-Saccharomyces yeast differed significantly not only from the control wines but also from the other treated samples. Furthermore, a vintage effect was also observed between the three years studied.

3.1.2. Evaluation of glycerol content development

The highest glycerol concentration values were measured in 2021. In 2021, only the treatments differed significantly from spontaneous fermentation, while among the 20 g/hl treatments inoculated with yeast (HD A54), only the treatment inoculated on day 3 (Oc20+3d) and only the sample fermented with non-*Saccharomyces* yeast (Oc20+4d), as well as the 40 g/hl treatments on the 2nd day (Oc40+2d). In 2022, all wines differed from the two controls, except for the sample inoculated on the third day (Oc40+3d) among the 40 g/hl treatments. In 2023, all treated samples differed significantly from the two controls. In addition to the treatments, the effect of the vintage was also observed, with differences between the three vintages in the effect of each treatment.

3.1.3. Evaluation of lactic acid content development

In all three years, each treatment differed significantly from the two controls (spontaneous, HD A54). In 2021 and 2023, not only were there significant differences compared to the controls, but there were also differences between the 20 g/hl and 40 g/hl doses. The vintage also had an effect on the development of lactic acid concentration.

3.1.4. Evaluation of polyphenol composition development

3.1.4.1. Evaluation of total polyphenol content development

In terms of polyphenol composition, no significant effect was detected between treatments in 2021, while in 2022, only spontaneous fermentation differed significantly from the treatments. Higher total polyphenol values were measured in the 2022 and 2023 vintages.

3.1.4.2. Evaluation of leucoanthocyanin content development

From a technological point of view, there was no significant difference in the 2021 year. In the case of 2022, a significant difference was only detected in comparison with spontaneous fermentation. In 2023, a significant difference was only observed in the 40 g/hl treatment sample compared to inoculation with yeast (HD A54). The effect of the vintage was also evident in the leucoanthocyanin concentration of the wines. The highest leucoanthocyanin concentration was detected in 2021, while the values measured in the wines of 2022 and 2023 were lower.

3.1.4.3. Evaluation of catechin content development

The catechin concentration was highest in 2021, while lower values were detected in 2022 and 2023. In 2021, a significant difference was only detected in the treated samples compared to spontaneous (Sp) fermentation, except for the two 40 g/hl treatments, the sample inoculated on day 3 (Oc40+3d) and the sample fermented with non-Saccharomyces yeast (Oc40+4d). The measured values for the 2022 vintage did not differ significantly from each other. In 2023, the sample fermented with non-*Saccharomyces* yeast (Oc20+4d) and treated with 20 g/hl differed from the 40 g/hl treatments, except for the racking on day 2 (Oc40+2d).

3.1.5. Evaluation of the biogenic amine composition of wines

3.1.5.1. Evaluation of histamine concentration

With regard to histamine concentration, it can be seen that while in 2021, species yeast inoculation (HD A54) produced the lowest amount of histamine, in 2022 and 2023, the lowest concentration among the 20 g/hl doses was measured in the sample fermented with non-*Saccharomyces* yeast (Oc20+4d). The difference between vintages can also be observed here.

3.1.5.2. Evaluation of serotonin concentration

With regard to the serotonin concentration of wines, it can be observed that, compared to the yeast inoculation, the 20 g/hl and 40 g/hl treatments also differed in 2021. In 2022, all treated samples differed significantly from the species yeast inoculation, except for the 20 g/hl treatments with racking on day 2 (Oc20+2d). Of the 20 g/hl treatments, only the re-inoculation on day 2 (Oc20+2d) differed from spontaneous fermentation (Sp), while of the 40 g/hl treatments, the re-inoculations on day 1 (Oc40), day 2 (Oc40+2d) and day 3 (Oc40+3d). In 2023, all samples deviated significantly from spontaneous fermentation, and among the 40 g/hl treatments, the wines fermented with species yeast inoculation (HD A54) on day 3 (Oc40+3d) and only with non-*Saccharomyces* yeast (Oc40+4d) differed. The effect of the vintage was also evident in the serotonin concentration.

3.1.5.3. Evaluation of tyramine concentration

With regard to the tyramine concentration of the wines, it can be said that in 2021, there was a significant difference compared to spontaneous fermentation (Sp) as a result of the treatments, while in 2022, the treated samples differed from both controls (Sp, HD A54), while in 2023, there was a difference compared to species yeast inoculation (HD A54) in the case of wines treated with 40 g/hl on day 3 (Oc40+3d) and fermented with non-*Saccharomyces* yeast (Oc40+4d). The effect of the vintage was also evident here.

3.2. Analytical evaluation of wines with reduced alcohol content using physical methods

The reduction in alcohol content was clearly evident when comparing the control with the wines that had undergone reduction. Examination of the basic analytical parameters clearly showed a reduction in *extract content*, even if minimal, in the alcohol-reduced wines compared to the control. There was no difference in *residual sugar content*, although we did not expect such an effect, similar to the *titratable acid content*, where no significant effect was detected either. The *pH value* of each wine was around the critical pH of 3.5, but this value alone is not sufficient to draw far-reaching conclusions.

The measurement results show that a significant decrease in *n-propanol* was detected in the third sample. A significant difference can be seen between the control and the third sample.

There was a significant difference in *the i-butanol content* of the wines between the control and the wines with 0.5% v/v and 1% v/v reduced alcohol content, a trend that can also be seen in the concentration of *i-amyl alcohol*, while the concentration of *2-methyl-1-butanol* differed from the control only in the case of a 0.5% v/v reduction in alcohol content. With regard to *acetaldehyde*, there was a significant difference between the control and the third sampling results, i.e., the 1.5% v/v alcohol content reduction caused a slight decrease in acetaldehyde. Among the measurement results, the continuous decrease in *ethyl acetate* was the most significant. A significant difference was detected compared to the control, with a decrease from 49.7 mg/l to 21.83 mg/l following the alcohol reduction process.

As a result of the alcohol reduction, glycerol also decreased from 6.2 g/l to 5.8 g/l. Thus, under the present conditions, a 1.5% v/v reduction in alcohol results in a reduction of approximately 0.5 g of glycerol. *Succinic acid* also showed a significant effect in alcohol-reduced wines compared to the control.

In the case of nitrogen-containing compounds, there was no significant effect on *proline* concentration, while in the case of *YAN*, there was a significant effect between the control and the 0.5% v/v alcohol reduction.

In the case of *total polyphenol content*, a difference was observed between the control and wines with a 1% v/v alcohol reduction, but this did not affect the total polyphenol content. Based on my measurement results, it can be concluded that the alcohol reduction process has no effect on total polyphenol content.

4. CONCLUSIONS AND SUGGESTIONS

Based on my studies, it can be stated that the reduction in alcohol content was successful, with a decrease of ~1.5% v/v achieved in 2021, from 14.71% v/v (Sp) to 13.31% v/v (Oc40+3d).

The reduction in alcohol content was not as spectacular in 2022, with no significant difference detectable in this case. In 2023, the alcohol content was reduced by approximately 1% v/v, from 13.16% v/v (Sp) to 12.15% v/v (Oc40+4d). In terms of alcohol content, it can be concluded that this yeast strain is suitable for reducing alcohol by 1-1.5% v/v. It can also be used in cases where climate change would cause the alcohol content to become disharmonious in the wine. This means that it is possible to wait until full ripeness at harvest time without fear of excessively high alcohol content. Furthermore, statistical evaluation shows that the dose of the special yeast strain used (20 g/hl or 40 g/hl) and the number of days between inoculations also have an effect on the degree of alcohol reduction.

In both 2021 and 2023, the 40 g/hl treatments proved to be more effective, while in the case of 20 g/hl treatments, the inoculations on the first (Oc20) and second (Oc20+2d) days did not differ significantly from the control wines, as in these cases the special yeast strain did not have enough time to exert its effect. It can be concluded that a dose of 40 g/hl should be used to ensure that the alcohol reduction is successful. Ivić et al. (2024) reported that wines produced using sequential inoculation with *Lachancea thermotolerans* and *Saccharomyces cerevisiae* yeasts had a lower alcohol content than the control. According to Morata et al. (2019), the lower alcohol content can be attributed to lactic acid synthesis from sugars in the metabolism of *Lachancea thermotolerans*.

The concentration of glycerol in 2021 and in 2023 was higher than in the case of spontaneous fermentation. Overall, glycerol formation had a positive effect on the fullness of the wines, and another positive outcome of the experiment was that the yeast strain enhanced glycerol formation.

The yeast strain I used produces more lactic acid during alcoholic fermentation. In all three vintages, it is clear that the maximum concentration of lactic acid in the control wines was approximately 1.2 g/l, while the treatments resulted in an increase in lactic acid concentration in all three vintages. Similarly to the alcohol content, a significant difference was observed between the two doses in 2021 and 2023. From this, it can be concluded that during alcohol fermentation, part of the pyruvic acid was not decarboxylated but converted directly into lactic acid. In drier, more drought-prone vintages, acids become oxidized. In lighter vintages, the positive effect of the yeast strain is that it can increase the acid content without the need for additional acidification. Su et al. (2024) also used *Lachancea thermotolerans* and *Saccharomyces cerveisiea* yeasts in sequential inoculation. Consistent with my results, late inoculation (72 hours later) of *Saccharomyces cerevisiea* effectively increased lactic acid production, which in turn increased the total acidity of the wine.

A significant increase in the titratable acid content of wines was observed in 2021 compared to the controls, and a significant difference was also found between the 20 g/hl and 40 g/hl treatments. However, this cannot be said about the values for 2022 and 2023.

The tartaric acid and malic acid content of the wines in 2021 showed higher tartaric acid values than malic acid in all cases except for the two control wines (Sp, HD A54) and the wine treated on day

1 (Oc20). However, this changed in 2022, with the exception of Oc40 and Oc40+4d, where malic acid was detected in higher concentrations. In 2023, malic acid was detected in higher concentrations than tartaric acid in all cases. The imbalance in the ratio of tartaric acid to malic acid can be linked to climate change.

In addition to being one of the starting compounds for polyphenol synthesis, shikimic acid is known for its positive physiological effects. In terms of shikimic acid, all three vintages showed a decrease in concentration in the treated samples compared to the control wines (Sp, HD A54).

Succinic acid is produced during alcoholic fermentation as a secondary fermentation by-product and is responsible for the complex bitter-salty-sour taste that characterizes wine. Its quantity may exceed 2.0 g/l in some cases. In 2021, higher concentrations were detected in 20 g/hl treatments than in 40 g/hl treatments. In 2022, much lower values were measured, except for the treatments on day 1 (Oc20) and day 2 (Oc20+2d), where the values were around 2 g/l. In 2023, again among the 20 g/hl treatments, the racking on day 1 (Oc20), the inoculation on day 2 (Oc20+2d), and the treatments fermented with non-*Saccharomyces* yeast only (Oc20+4d) showed higher succinic acid concentrations. Izquierdo-Cañas et al. (2025) found that the use of *Lachancea thermotolerans* in sequential inoculation at a dose of 20 g/hl resulted in higher succinic acid concentrations compared to the control.

Fumaric acid is also known for its positive physiological effects, promoting the secretion of digestive juices. Overall, the average fumaric acid concentration of 2023 is the highest of the three vintages. However, no uniform conclusion can be drawn about the above-mentioned organic acids (shikimic acid, fumaric acid, succinic acid), as their quantity may be influenced by the variety used, the processing method, and the fermentation conditions. Further studies are definitely needed in order to draw the appropriate conclusions.

Polyphenols are primarily known for their antioxidant and positive physiological effects, but they are also responsible for the sensory properties of wines. There was no significant difference in the total polyphenol concentration of wines in 2021, but in all three vintages, lower values were measured in the treated sample compared to spontaneous fermentation. The 2022 and 2023 vintages were richer in polyphenols than the 2021 vintage.

Catechins and leucoanthocyanins are responsible for the bitter and astringent taste. In 2021, the catechin concentration was significantly higher than in the other two vintages. In terms of leucoanthocyanin content, there was a decrease in 2022 and 2023 compared to the 2021 results. Overall, it can be said that the yeast strain used also plays a significant role in the development of the polyphenol composition, which explains the significant difference, and the vintage also plays a role. The yeast-polyphenol interaction is a scientifically proven fact, and the yeast strain I studied clearly had a positive effect on the polyphenol composition of the wines. The effect of yeast on the phenolic composition and quality of wine has also been studied by Morata et al. (2016), among others.

Zhang et al. (2023) found that *L. thermotolerans* CVE-LT1 has good potential for use under operating conditions to improve the acidity, color index, aroma, and phenolic compounds of Cabernet Sauvignon when combined with *S. cerevisiae*.

Biogenic amines are also known for their physiological effects. In my thesis, I focused on three biogenic amines that were

selected for their effects on the human body. Among the biogenic amines examined, histamine is the most significant, as it is considered the most allergenic. In 2021, the sample inoculated with species yeast had the lowest concentration. However, in 2022 and 2023, among the 20 g/hl treatments, the lowest amount was measured in wines fermented with non-*Saccharomyces* yeast. Despite the varying values, the concentration remained within the permissible limit.
Serotonin is characterized by its positive physiological effects, also known as the happiness hormone, and is known to relieve tension and aid digestion. In all three vintages, the highest concentration was detected in the 20 g/hl treatments with racking on day 2 (Oc20+2d). Tyramine has a blood pressure-raising effect. In terms of tyramine concentration in wines, the lowest measured values were found in wines inoculated with yeast (HD A54), while in 2023, it was lowest in the 40 g/hl treatments with inoculation on the third day (Oc40+3d). Benito et al. (2015) demonstrated that *L. thermotolerans* does not produce more biogenic amines than S. cerevisiae. Overall, the samples treated with special yeast are safe to consume because the biogenic amine concentration in the wines did not reach critical levels. From a food hygiene perspective, the yeast strain proved to be suitable for winemaking in practice.

Higher alcohols were also detected in wines from the 2023 vintage. In addition to being formed from sugars, higher alcohols play a role in the formation of wine aromas. N-propanol, i-butanol, i-amyl alcohol, and 2-methyl-1-butanol were formed in higher concentrations as a result of the treatments than in the two controls. It is well known that non-*Saccharomyces* yeasts and *Saccharomyces* yeasts have different abilities to produce volatile compounds. According to Wang et al. (2023), *Metschnikowia pulcherrima* and

Lachancea thermotolerans stand out in the production of higher alcohol compounds. Higher alcohols can form fruit esters with acetic acid, thereby enhancing the fruity character of wines.

Based on sensory evaluations, it can be stated that the samples inoculated with species yeast achieved the best results, while the wines treated with special yeast were less characterized by floral aromas and fruity varietal characteristics, and a lactic acid aroma was noticeable, but the alcoholic aroma was less noticeable.

In the case of wines with reduced alcohol content obtained by physical methods, alcohol reduction was also achieved compared to the initial (control) wine. The membrane separation technique also proved to be suitable for partially reducing the alcohol content of wines. However, the measurement results clearly show that even a 1.5% v/v reduction in alcohol significantly removed the higher alcohols that play an important role in the formation of fruit esters, thereby enabling the development of wine character. Nevertheless, it is important to note that among the higher alcohols, the concentrations of i-amyl alcohol and i-butanol cannot be reduced as much by the technology used as the concentrations of n-propanol and 2-methyl-1-butanol. Liguori et al. (2019) also reported a decrease in the concentration of higher alcohols during alcohol reduction. At the same time, with partial alcohol reduction, wines are able to retain their phenolic and volatile compounds as well as their sensory properties (Kumar et al., 2024). Furthermore, a minimal decrease in the glycerol and extract content of wines was observed, which may affect the sensory evaluation of wines, as a decrease in glycerol concentration may also affect the fullness of wines.

In a recent study, Italiano et al. (2025) observed that the glycerol content of alcohol-free white wine produced by vacuum distillation increased. In contrast, membrane-based technologies such as osmotic distillation and reverse osmosis produced alcohol-free wines with reduced glycerol content, probably due to the passage through the membrane.

In the case of nitrogen-containing compounds, although the statistics showed a significant difference in the YAN concentration of the wines, from a technological point of view, the result cannot be considered significant. No significant effect was observed in the proline concentration of the wines; the process has no effect on the amount of proline. It can also be stated that the treatment did not affect the polyphenol composition of the wines. An et al. (2025) showed that a process such as osmotic distillation proved promising in terms of preserving phenolic composition. It is important to note that wine is an aqueous-alcoholic mixture, and the compounds dissolved in it are in balance. If this physicochemical balance is disturbed, it may also affect the sensory composition. Due to the limited quantity of wine available, it was not possible to perform a sensory evaluation, but I believe it would be worthwhile to examine wines with reduced alcohol content using this process in the future to determine the extent to which the reduction in glycerol concentration affects the fullness and body of the wines.

In conclusion, based on both analytical and sensory characteristics, the results obtained with yeast with special properties proved promising for samples treated with a dose of 40 g/hl. The effect of the vintage was significantly evident in the parameters examined. In my doctoral thesis, I had the opportunity to perform experiments on a variety originating from a single wine region. However, I consider it important to examine the suitability of other wine regions and varieties.

With regard to alcohol reduction based on membrane separation, I consider it important to extend future studies to include the measurement of leucoanthocyanin, catechin, and biogenic amine composition, as well as sensory evaluation.

I consider it worthwhile to continue my measurements and research.

5. NEW SCIENTIFIC RESULTS

1) I was the first in Hungary to examine a yeast strain with special properties in the experimental phase under operating conditions, seeking to answer the question of whether the yeast is suitable for reducing alcohol content and whether it affects the glycerol concentration of wines. *Based on my results, it can be stated that the yeast strain is suitable for reducing alcohol content by 1-1.5% v/v under operating conditions, and that the yeast also had a positive effect on the glycerol concentration of wines, thereby increasing their fullness.*

2) I determined the acid composition and D-lactic acid concentration of the experimental samples. *In terms of acid composition, it can be concluded that the D-lactic acid concentration of the wines increased compared to the control wines, therefore, in vintages with milder acidity, acid harmony can be achieved without the need for additional dosage of acid. The ratio of tartaric acid and malic acid concentrations has changed, which can be linked to climate change. Furthermore, the yeast strain used also has a positive effect on the development of succinic acid concentration, which contributes to the sensory properties of the wines.*

3) *In terms of polyphenol composition, the new yeast strain and sequential inoculation are suitable for producing quality wines with reduced alcohol content in terms of catechin, leucoanthocyanin, and total polyphenol content. From a food hygiene perspective, the yeast has also proven to be suitable*

for winemaking in practice. Higher concentrations of higher alcohols were detected in the treated samples, contributing positively to the sensory properties of the wines.

4) *Based on my research, it can be stated that, based on their analytical, fine analytical, and sensory properties, the samples treated with 40 g/hl are suitable for the production of quality wines with reduced alcohol content.*

5) *The physical method of reducing alcohol content also results in a decrease in glycerol concentration. A 1.5% v/v reduction in alcohol content resulted in a 0.5 g/l decrease in glycerol.*

6) *Based on my results, it can be concluded that the physical method of reducing alcohol content has no effect on the total polyphenol content. However, higher alcohols showed a decrease as a result of a 1.5% v/v reduction in alcohol content. The process reduces higher alcohols, which are responsible for the development of wine character (fruit esters).*

7) I also examined the development of nitrogen-containing compounds in wines that had undergone alcohol reduction, *which showed that there was no change in proline concentration, while in the case of YAN, there was a significant effect between the control and the alcohol content reduced by 0.5% v/v.*

6. PUBLICATIONS

Basic requirements
Scientific publications with impact factor

1) Nyitrainé Sárdy, Diána Ágnes ; Bodor-Pesti, Péter ; **Steckl, Szabina**
   Assessing the Applicability of a Partial Alcohol Reduction Method to the Fine Wine Analytical Composition of Pinot Gris
   FOODS 14 : 15 Paper: 2738 , 13 p. (2025)
   DOI WoS Scopus Egyéb URL
   Tudományos
   Folyóirat szakterülete: Scopus - Health Professions (miscellaneous) SJR indikátor: D1
   Folyóirat szakterülete: Scopus - Food Science SJR indikátor: Q1
   Folyóirat szakterülete: Scopus - Health (social science) SJR indikátor: Q1
   Folyóirat szakterülete: Scopus - Plant Science SJR indikátor: Q1
   Folyóirat szakterülete: Scopus - Microbiology SJR indikátor: Q2

2) Jahnke, Gizella ✉ ; Szőke, Barna Árpád ; **Steckl, Szabina** ; Szövényi, Áron Pál ; Knolmajerné Szigeti, Gyöngyi ; Németh, Csaba ; Jenei, Botond Gyula ; Nyitrainé Sárdy, Diána Ágnes
   Delay in the Ripening of Wine Grapes: Effects of Specific Phytotechnical Methods on Harvest Parameters
   AGRONOMY (BASEL) 13 : 8 Paper: 1963, 20 p. (2023)
   DOI WoS Scopus Egyéb URL
   Központi kezelésű Tudományos
   Nyilvános idéző összesen: 4 | Független: 3 | Függő: 0 | Nem jelölt: 1 | Scopus jelölt: 1 | WoS/Scopus jelölt: 1 | DOI jelölt: 1
   Folyóirat szakterülete: Scopus - Agronomy and Crop Science SJR indikátor: Q1

Refereed scientific publications without impact factors

3) **Steckl, Szabina** ; Sólyom-Leskó, Annamária ; Nagy, Balázs ; Szőke, Barna
Alkoholtartalom csökkentése speciális élesztőtörzsekkel
BORÁSZATI FÜZETEK 32 : 2 pp. 35-39. , 5 p. (2022)
Tudományos
IV. Agrártudományok Osztálya IVAO A

Further scientific publications

1) Nyitrainé, Dr. Sárdy Diána ; Dr. Sólyom-Leskó, Annamária ; Dr. Nagy, Balázs ; **Steckl, Szabina**
Különböző élesztőtörzsek egyszerű fenol- és biogénamin-termelése közötti összefüggések vizsgálata
BORÁSZATI FÜZETEK 35 : 2 pp. 36-39. , 4 p. (2025)
Tudományos
IV. Agrártudományok Osztálya IVAO A

2) Nyitrainé, Sárdy Diána ; Antal, Eszter ; Nagy, Balázs ; **Steckl, Szabina**
Csökkentett alkoholtartalmú borok finomanalitikai vizsgálata
BORÁSZATI FÜZETEK 34 : 4 pp. 35-39. , 5 p. (2024)
Tudományos
IV. Agrártudományok Osztálya IVAO A

3) **Steckl, Szabina** ; Sólyom-Leskó, Annamária ; Nagy, Balázs ; Nyitrainé, Sárdy Diána
A speciális tulajdonságú élesztők szerepe a borok aromaképzésében különös tekintettel a borok magasabb rendű alkoholkomponenseire
BORÁSZATI FÜZETEK 33 : 5 pp. 31-35. , 5 p. (2024)
Tudományos
IV. Agrártudományok Osztálya IVAO A

4) Bolbás, Ildikó ; Nagy, Balázs ; Nyitrainé, Sárdy Diána ; Sólyom-Leskó, Annmária ; **Steckl, Szabina**
Biogénamin-koncentráció a csökkentett alkoholtartalmú borokban
BORÁSZATI FÜZETEK 33 : 4 pp. 36-41. , 6 p. (2023)
Tudományos
IV. Agrártudományok Osztálya IVAO A

5) **Steckl, Szabina** ; Sólyom-Leskó, Annamária ; Nagy, Balázs ; Szőke, Barna
Alkoholtartalom csökkentése speciális élesztőtörzsekkel
BORÁSZATI FÜZETEK 32 : 2 pp. 35-39. , 5 p. (2022)
Tudományos
IV. Agrártudományok Osztálya IVAO A

Conference proceedings („abstract")

1) Nyitrainé, Sárdy Diána ; **Steckl, Szabina**
A magasabb rendű alkoholok az alkoholcsökkentett és alkoholmentesített borokban
In: Nyitrainé, Sárdy Diána Ágnes; Kókai, Zoltán; Bodor-Pesti, Péter; Deák, Tamás (szerk.) A 2025. évi Lippay János – Ormos Imre – Vas Károly (LOV) Tudományos Ülés összefoglalói
Budapest, Magyarország : Magyar Agrár- és Élettudományi Egyetem, Budai Campus (2025) 87 p. p. 45
Tudományos
ISBN 978-615-7048-00-3

2) **Steckl, Szabina** ; Szövényi, Áron ; Nagy, Balázs ; Nyitrainé, Sárdy Diána Ágnes
A speciális tulajdonságú élesztők szerepe a borok aromaképzésében különös tekintettel a borok magasabb rendű alkohol komponenseire
In: Varga, Zsuzsanna; Oláh, Róbert; Nyitrainé Sárdy, Diána (szerk.) A VI. Országos Szőlész – Borász Konferencia összefoglalói : A konferencián bemutatott tudományos poszterek összefoglalói
(2024) p. 12
ISBN 978-615-6448-53-8

3) **Steckl, Szabina** ; Nyitrainé, Sárdy Diána
Borok alkoholtartalmának csökkentési lehetőségei a borminőség tükrében
In: Fodor, Marietta; Bodor-Pesti, Péter; Deák, Tamás (szerk.) A 2023. évi Lippay János – Ormos Imre – Vas Károly (LOV) Tudományos Ülésszak összefoglalói Abstracts of János

Lippay – Imre Ormos – Károly Vas (LOV) Scientific
Meeting, 2023
Budapest, Magyarország : Magyar Agrár- és Élettudományi
Egyetem, Budai Campus (2024) 149 p. p. 128
Tudományos
ISBN 978-615-02-0252-5