

EXAMINATION OF WINES FROM THE CSONGRÁD WINE REGION AND MONITORING OF FERMENTATION

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ABSTRACT

The focus of our research was on two different grape and wine varieties from the Csongrád Wine Region. In the first part of our research, we examined wines of various strains and vintages made using oxidative and reductive techniques. Based on our results, differences in content were identifiable between vintages and between oxidative and reductive techniques, even samples were from the same cultivation site. In the second part of our research, we monitored the fermentation of wines in progress, applying various examination methods. The aim of our research was to gather information on the changes occurring during the fermentation. As the fermentation period progressed, the value of the dielectric constant continuously increased, which was related to the change in alcohol content. Based on our findings, fermentation monitoring based on the dielectric constant could be a well-applicable, chemical-free, and quickly executable method. Keywords: wine, fermentation, dielectric constant, alcohol content

1. INTRODUCTION

In Hungary, viticulture and winemaking have a long history and are an important part of the country's cultural heritage. Hungary's viticultural tradition has been closely intertwined with Hungarian society and way of life for centuries. The consumption of wine is part of many cultural and social events, be it family celebrations or gatherings of friends. Nowadays, there is also a growing tradition of wine tastings and wine festivals, where several renowned wineries present their more and more special wines.

Science has long been concerned with the physiological effects of wine beyond its pleasure value. Among its physiological properties, antioxidant compounds have long been recognised. Such antioxidant compounds are found in greater quantities in red wines, although they are also present in white wines. The source of antioxidants in wine comes mainly from the grapes used as raw material. The beneficial physiological effects of wine are mainly due to its antioxidant content, which can help reduce the risk of heart disease by reducing the potential for inflammation and improving vascular function. Scientific research on bioactive compounds has shown the effects of a plant-based diet on cardiovascular disease (CVD) and cancer. Scientific research in the field of disease prevention has shown that plant-based foods contain a number of compounds that are effective in enhancing the antioxidant defence potential of the human body [1]. Plants contain a wide variety of bioactive compounds, phytochemicals, which have positive physiological and pharmacological effects. They can be classified into different groups according to their chemical structure and functional properties. The main groups are: carotenoids, phytosterols, glucosinolates, flavonoids, phenolic acids, protein inhibitors, monoterpenes, phytoestrogens, sulphur compounds. These compounds vary greatly in chemical structure and function [2]

The main components of wine, apart from water, are alcohols (mainly ethanol) and acids. These components have a significant influence on the organoleptic properties [3] and some of them also have the antioxidant properties discussed above. Of the acids, tartaric acid is the most important, but several other carboxylic acids and sulphuric acids are also used in wine-making technology. There are many methods for detecting alcohol and acids, and standards have been developed as officially accepted procedures in Hungary and many other countries, including the EU. Rapid methods that do not require large quantities of chemicals are becoming increasingly important for the analysis of various substances, including foodstuffs. Such techniques include various dielectric measurement methods. The dielectric behaviour of different materials,

i.e. the interaction between the electromagnetic field and the material, is determined by their electrodynamic properties and influenced by several factors. These factors include, for example, the physical and chemical properties of the material, its structure and temperature, but also the frequency (ω) and field strength (E) of the applied electromagnetic field [4].

2. MATERIALS AND METHODS

2.1. Materials

During our work we performed 2 major analysis processes and for both of them we used samples from the Újvári Winery, located in Csongrád-Csanád County (Csongrád Wine Region).

Materials for the study of vintage differences:

Samples:

Rhine Riesling (white)

1.2021 vintage reductive vinification technology

2.2021 vintage oxidative vinification technology

3.2022 vintage reductive vinification technology

Blue Franc (red)

1.2021 vintage

We examined the differences between wine samples in terms of vintage, ageing technology and grape variety.



Figure 1. Materials for the study of vintage

Materials for fermentation testing:

In our research, we followed the fermentation of two types of grape wine using different analytical methods, which provided information on how the alcohol concentration and acidity of the must varies. The tests were carried out on several types of wine, as we wanted to see how the same tests would give different results on different types of wine.

The samples:

- Blue Franc for rosé

- Rhine Riesling - white wine

To monitoring fermentation, at the suggestion of the winemaker, samples were taken every 3 days from harvest to fermentation, resulting in 6 samples per grape variety. The samples were stored frozen at -20°C until the laboratory tests were carried out. It is important to stress that both the results obtained from the determination of the relative density of the distillates and the dielectric properties can be easily influenced by temperature, therefore we performed the measurements at a uniform temperature of 20°C .

2.2. Methods

All the measurements were carried out using the same method, both to investigate differences in vintage and to monitor fermentation unless stated otherwise.

2.2.1. Dielectric properties testing:

For the determination of dielectric parameters, we used a DAK 3.5 (Speag, Switzerland) open-ended dielectric measuring sensor connected to a ZVL-3 (Rhode&Schwarz, Germany) vector network analyser with a 50 ohm coaxial power supply. The test was carried out at a frequency range of 200-2400 MHz, as other studies have shown this to be appropriate for measuring similar systems. It was important during the test that the must sample filled into the beaker did not contain any gas bubbles as this would have affected the dielectric parameters.

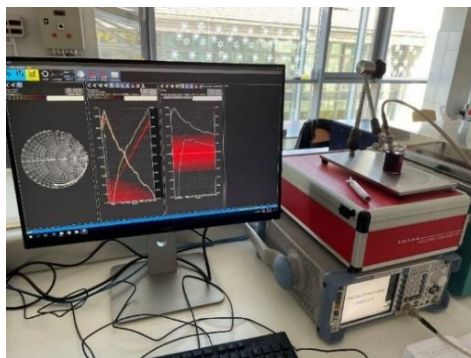


Figure 2. Dielectric properties

2.2.2. Testing the measurement of alcohol content:

The alcohol content was measured using the standard distillation method (MSZ 9458). I measured 100 cm³ of sample into a 500 cm³ flask, connected to the distillation apparatus (Figure 3). At the end of this operation, we obtained an extract and a distillate sample, to which we added 100 cm³ of distilled water. The density of each must sample, the extract, the distillate and the sample itself was measured with a pycnometer and the alcohol content of the samples was determined using this data.



Figure 3. Testing the measurement of alcohol content

2.2.3. Determination of acidity:

As for the determination of the alcohol content, the acidity was determined according to the relevant standard (MSZ 9472). 10 cm³ of the samples were weighed into an Erlenmeyer flask, heated to boiling and allowed to cool to 20 °C. After cooling, 3-4 drops of bromothymol blue indicator were dropped in and titrated with sodium hydroxide to a greenish blue colour and the weight loss was recorded. From the results obtained, the acidity was expressed as tartaric acid equivalent.

3. RESULTS AND DISCUSSION

The aim of our study was to gather information about the transformations that take place during the fermentation of must and the quantitative parameters that characterise these transformations. We also aimed to find correlations between vintages and ageing techniques for different types of wine.

3.1. Vintage differences:

Dielectric constant test:

The values of the dielectric constant (ϵ') are shown in the Figure 4, where it is clear that there are differences at lower frequency bands for different wines. The differences start to disappear significantly above 600 MHz and above 1000 MHz there is practically no difference between the dielectric constants of the different samples. In most cases the values decrease with increasing frequency. The only sample that shows a different trend is the Blue Franc sample, as the dielectric constant increases between 200 and 400 MHz and only starts to decrease at higher frequency values. The 2021 oxidative Rhine Riesling shows a steady increase, while the reductive wines show a break when the measuring frequency is increased from 300 MHz to 400 MHz. Our results show that there are clear differences between the dielectric constants of wines produced with different technologies measured at lower frequency intervals (200-600 MHz).

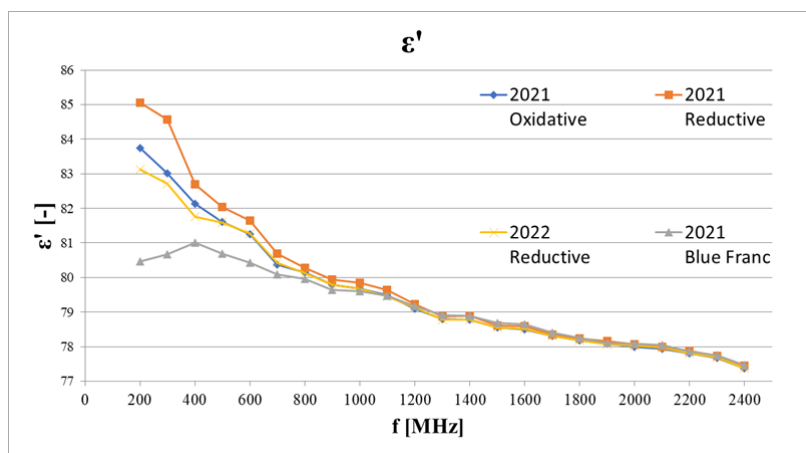


Figure 4. Dielectric constant

Alcohol content:

When tested for alcohol content, the values were between 10.7 and 12.6. The lowest value was obtained for Blue Franc, with an alcohol content of 10.7%. Among the white wines, the 2021 oxidative and 2022 reductive wines did not differ significantly, with alcohol levels of 11.48 and 11.64% respectively. The 2021 reductive Rhine Riesling had a significantly higher value compared to the other samples. When the standard deviation is taken into account, there is a significant difference in alcohol content between white wines from the same

vintage (2021). As the wine was produced from the same raw material, the only difference between them was the oxidative or reductive character of the wine, so it can be assumed that the difference is due to the microbial activities present in the oxidative technique.

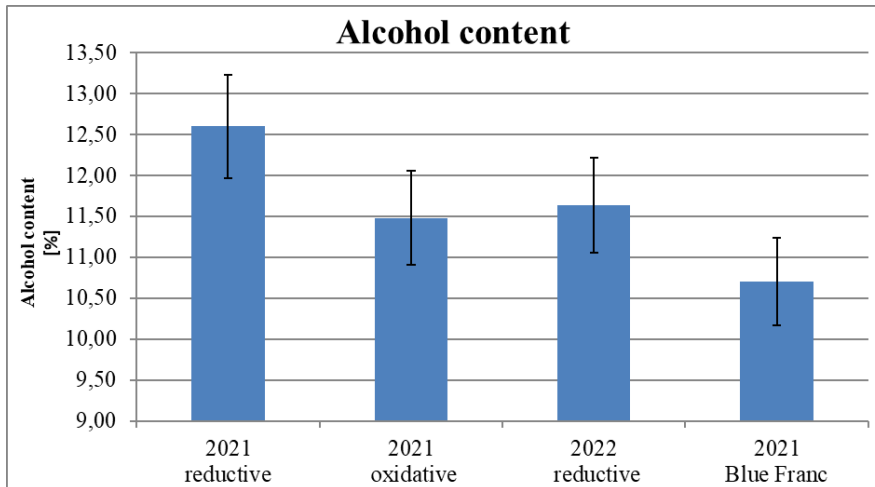


Figure 5. Alcohol content

Acid content:

The acidity values measured in the samples vary widely. The lowest acidity value was found in the red wine, while the highest value was found in the 2021 oxidative Rhine Riesling. When comparing the two reductive Rhine Rieslings, it can be seen that the vintage also has a significant influence on the acidity. The acidity of the 2022 wine was nearly 1.4 times that of the 2021 wine, with a value of 5.8 gL⁻¹. Furthermore, it can be seen that in the case of Rhine Riesling from the same vintage (2021), produced with different ageing techniques, higher acidity values were measured for the oxidative one.

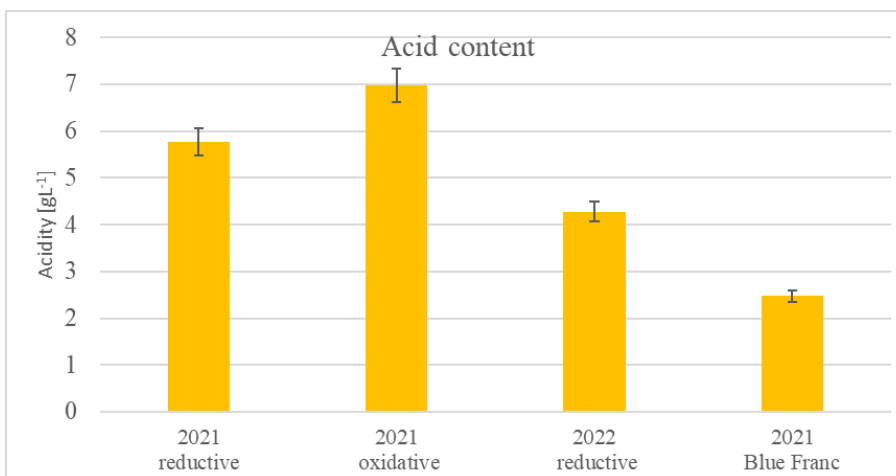


Figure 6. Acid content

3.2. Fermentation monitoring results and their evaluation:

Evolution of dielectric parameters:

In our work we mainly investigated the evolution of the dielectric constant and alcohol content. When we look at the content of must, we can see that it contains the largest amount of water and sugars, and during fermentation these sugars are converted into alcohol. We investigated when this happens in our samples. The dielectric constant of sugar solutions and alcohol is lower than that of water in the frequency range we tested, so if the system runs out of sugar, the dielectric constant will show an increasing trend. This is clearly illustrated by the results shown in Figure 7, i.e. the dielectric constant increased more intensively on day 9 with respect to the higher sugar content, and then the rate of increase showed a slowing down after day 9. On sampling days 12 and 15, the dielectric constants were almost identical, which leads me to conclude that the fermentation must have been completed, presumably all fermentable sugars in the system were used up, and the dielectric constant did not change. It is also noticeable that the decrease in the concentration of sugar is likely to have affected the change in the dielectric constant more than the appearance of alcohol in the system, since the appearance of the latter would reduce the dielectric constant if a pure water-ethanol biner mixture were tested. At lower frequency bands (200- 600 MHz), more uncertain measurements were observed and the decrease in the dielectric constant was more pronounced than at higher frequency bands. There were differences in the dielectric constants between the two grape varieties at low frequency bands, with Rhine Riesling having a dielectric constant of nearly 98 at the last sampling point and Blue Franc having a dielectric constant of nearly 87. As the fermentation time progressed, the dielectric constant values followed a similar upward trend, except at 1300 MHz. The dielectric constant was chosen at 1300 MHz because it is close to the so-called relaxation frequency (900-1200 MHz), which is typical for aqueous systems, and therefore the differences in the dielectric spectrum were most striking, as confirmed by trends observed in other fermentation studies of higher water content systems.

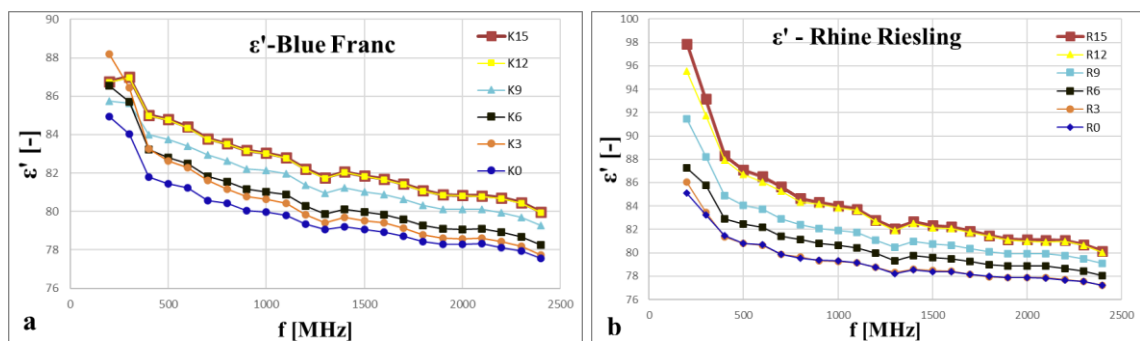


Figure 7. Dielectric constant variation during fermentation for Blue Franc (a) and Rhine Riesling (b)

Evolution of alcohol content during fermentation:

The evolution of alcohol content during fermentation shows an increasing trend for both samples (Figure 8). At the first sampling point, there was no alcohol present in the system, at which point the sugar content of the system was probably very high. The alcohol content of both systems increased intensively after day 3 shows that throughout the fermentation period the Rhine Riesling samples had a lower alcohol content, probably also a lower sugar content. Furthermore, it is likely that the fermentation of the Blue Franc has been completed during the period studied, while that of the Rhine Riesling has not. This can be seen from the graph, since the graph for Rhine Riesling shows an upward trend between days 12 and 15, while for Blue Franc it seems to have stagnated. Overall, both the investigated systems showed a similar upward trend.

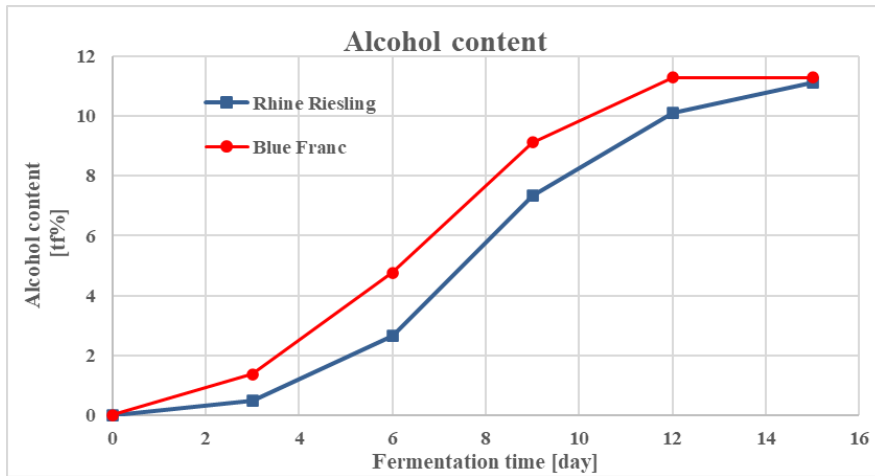


Figure 8. Evolution of alcohol during fermentation

Correlation between dielectric properties and alcohol content:

When comparing the fermentation of Blue Franc and Rhine Riesling, it can be noticed that they are similar in their main trends, but there are minor differences. For both varieties, the evolution of dielectric constant and alcoholic strength show an increasing trend with similar slopes, so that a correlation between the two can be assumed, which may justify the use of the method to monitor the process over time. Figure 9 clearly shows that the curves are similar for both samples, but there are differences in the values of the alcohol content and the dielectric constant. It is likely that Blue Franc has a higher initial sugar content in the system than Rhine Riesling. It is also assumed that the fermentation of the Blue Franc has been completed, since we measured almost identical values at the last two points, both for the alcohol content and the dielectric constant. On the other hand, in the case of Rhine Riesling, I consider it likely that the main fermentation was not completed by day 15, as the measurements show a slight upward trend.

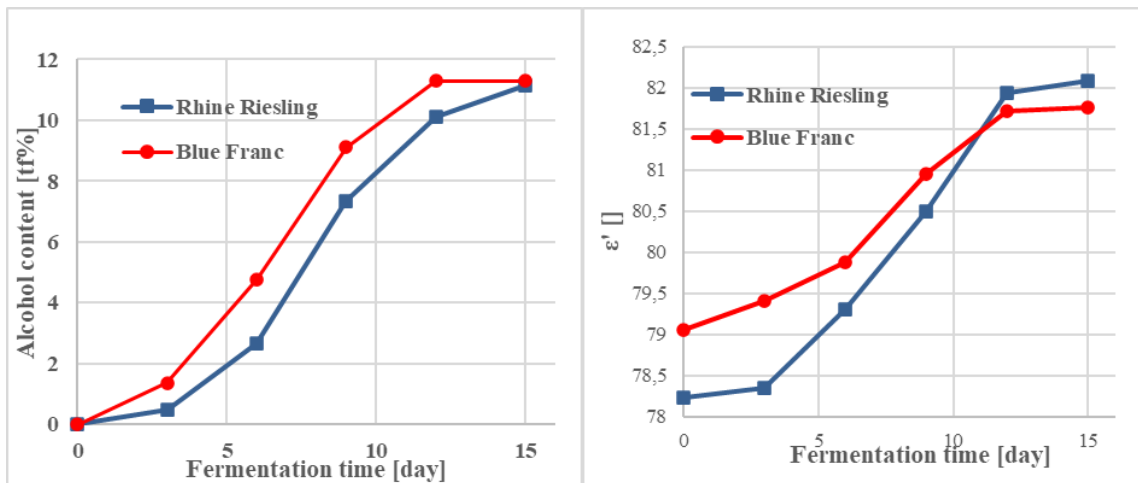


Figure 9. Correlation between dielectric properties and alcohol content

Acidity changes during fermentation:

Examining the acidity, I concluded that the acidity starts to increase when the alcohol content starts to increase, i.e. after the initial adaptation phase, the main fermentation starts (Figure 10). The values show an increase until the sixth day, after which the values become almost constant, so that it can be said that the major changes in acidity occur sooner than in alcohol content.

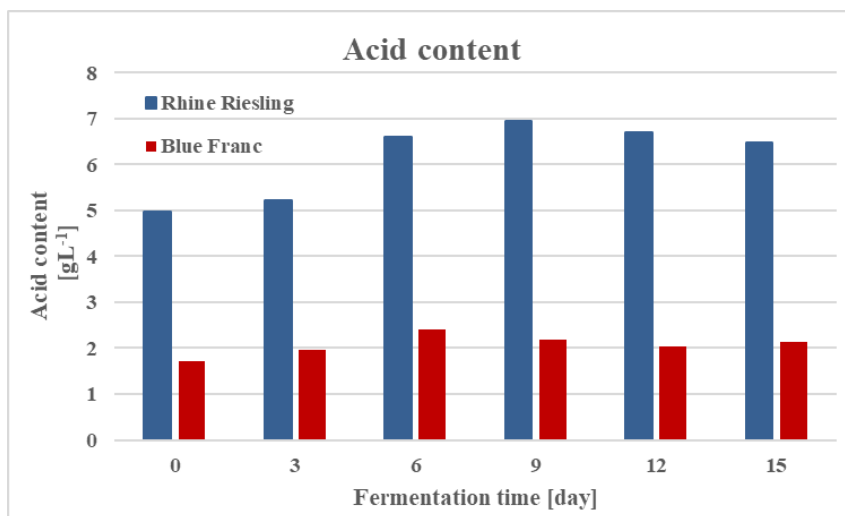


Figure 10. Evolution of acidity during fermentation

4. CONCLUSIONS

Based on the results of our research, it can be concluded that the dielectric constant increased steadily with the fermentation time, but there are differences in the dielectric behaviour of Kékfrankos and Rajnai Riesling. Both types of wine showed higher dielectric constants at lower frequency bands (200–600 MHz). As the fermentation time progressed, a similar trend of decreasing dielectric constant values with increasing frequency was observed for both systems. The variation in alcoholic strength showed a trend well compatible with the classical fermentation processes of the wines, with which the results of the acidity analysis of the samples were also well comparable. For both types of wine, the evolution of the dielectric constant and the alcoholic strength show an increasing trend with similar slopes, so that a correlation between the two can be assumed, which may justify the use of the method for monitoring the process over time.

In the vintage differences study, we analysed four different wines, one Kékfrankos and three Rhine Rieslings. The Rieslings came from two vintages (2021, 2022), were both oxidative and reductive ripening, and the grapes came from the same area. We analysed the alcohol, acidity and dielectric properties of the wines. Our results showed that even with the same variety, the same winemaking technique and the same growing area, differences between wines can be found. In the case of acidity, it was found that the oxidative or reductive character of the wine and the vintage also have a strong influence on acidity. The highest acidity value was found for the wine with oxidative ageing in 2021 (6.98 gL⁻¹). The slopes of the dielectric constant curves were similar as a function of the measurement frequency. A clear difference could be seen between wines made with the same ageing technology but in different years (reductive samples 2021 and 2022). These samples had similar curves, but there were differences in the dielectric constant values. My further aim is to narrow the frequency range, which is likely to give more accurate results on the differences.

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