Analecta Technica Szegedinensia

Vol. 17, No. 3 ISSN 2064-7964 2023

EXAMINATION OF THE COMPOSITION AND DIELECTRIC PROPERTIES OF WINES FROM THE CSONGRÁD WINE REGION

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Received: 31st May; Accepted: 29th June

ABSTRACT

In Hungary, viticulture and winemaking have a very long tradition and culture. Nowadays, more and more consumers are paying attention to the nutritional properties of the food they consume, in addition to their enjoyment value. Wines can have an outstanding antioxidant content. The amount of antioxidants can be influenced by a number of parameters (wine-making technology, grape variety, area under vines, etc.). Antioxidants play an important role in the preservation of health, as well as inhibiting oxidation processes in food. Dielectric material analysis methods are also increasingly used in the food industry. The great advantages of dielectric testing include its chemical-free nature and the speed of the test. In our studies, we have investigated the food properties, i.e. alcohol, acid and antioxidant content and dielectric properties of different wine samples.

Keywords: wine, dielectric, antioxidant

1. INTRODUCTION

Science has long been interested in the physiological effects of wine beyond its pleasure value. Among the physiological properties, antioxidant compounds have been recognised for a long time. Such compounds are found in higher amounts in red wines than in white wines, but white wines also have such compounds. The source of antioxidants in wine comes primarily from the grapes used as the raw material. Scientific research on bioactive compounds has shown the effects of plant-based diets on cardiovascular disease (CVD) and cancer. Scientific research in the field of disease prevention has shown that plant-based foods contain a number of components that effectively enhance the antioxidant defence potential of the human body [1].
A number of different biologically active substances, phytochemicals, are found in plants and have positive physiological and pharmacological effects. They are divided into different groups based on 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 widely in chemical structure and function [2]. Only the groups of compounds that are also found in grapes will be discussed below.
In the case of grapes and wine, mention should be made of phenolic compounds, which have also been studied in cereals, pulses, nuts, olive oil, vegetables, fruits and teas, in addition to grapes and wine [3]. They have a much wider spectrum of activity than other bioactive compounds [4]. Some studies show that flavonoids have beneficial effects on thrombosis and tumourigenesis. Some flavonoids have antioxidant effects, inhibit atherosclerosis and the development of [5]. Various phytoestrogens are present in soy, but also in linseed oil, whole grains, fruits and vegetables and grapes as well. They bind to the same receptors as endogenous oestrogens, but their hormonal effects are significantly smaller. They can positively influence carcinogenesis, cardiovascular disease and osteoporosis. Isoflavonoids are effective in the prevention of viral diseases. Sulphides such as allium compounds have anticarcinogenic, antioxidant and anti-inflammatory effects. Coumarins inhibit blood clotting, inflammatory processes and the development of [6]. In summary, many bioactive compounds of plant origin have beneficial effects on our body and their role in preventive

DOI: https://doi.org/10.14232/analecta.2023.3.33-40

action is undisputed, although their mechanism of action is not fully understood. There is sufficient evidence to recommend the consumption of foods rich in bioactive compounds. In practical terms this means that a diet rich in a variety of fruits, vegetables, whole grains, pulses, oils and nuts is recommended [1]

The main components of wine, apart from water, are alcohols (mainly ethanol) and acids. These components have a significant influence on the organoleptic properties [7], and some of them also have the antioxidant properties discussed above. Among the acids, tartaric acid is the most important, but there are also a number of other carboxylic acids and sulphuric acid used in wine-making technology. There are many methods for the detection of alcohol and acids, and in Hungary and in many other countries, including the EU, standards have been set out as officially accepted procedures [8,9].

Quick methods that do not require large amounts of chemicals are becoming increasingly important in the testing of various materials, including foodstuffs. Such techniques include various dielectric measurement methods [10,11].

The dielectric behaviour of different materials, i.e. the interaction between the electromagnetic field and the material, is defined by their electrodynamic properties and influenced by several factors. These factors include, for example, the physical and chemical properties, structure and temperature of the material, but also the frequency (ω) and field strength (E) of the applied electromagnetic field [12-14].

The absolute permittivity of a material is a constant (ε) characteristic of a material quality, which is the ratio of the electromagnetic field strength (E) to the electric displacement (D). The absolute permittivity (ε) includes all the characteristics that determine the adsorption of electric/electromagnetic energy within the material and the energy loss that occurs after the electromagnetic wave is absorbed within the material. The dielectric constant ε' represents the electrical energy storage capacity of the material, while ε'' represents the total dielectric loss and shows how much of the stored electrical energy is transformed into other forms of energy (e.g. heat or kinetic energy) [15].

The aim of our work was to search for relationships between the properties described above, i.e. antioxidant, acid and alcohol content, and dielectric properties. We have also investigated the differences between wines made from similar grape type harvested in the same field.

2. MATERIALS AND METHODS

2.1. Wine samples

Our wine samples are obtained from a producer in the Csongrád wine region. Three white wine samples and one red wine sample were used in our tests. The grapes for the Riesling white wines were from the same area, with vintage and technique (oxidative/reductive) differences. Table 1. represents the samples of our study. The wines were filled into 0.5 litre PET bottles at the time of purchase and kept at 4 °C until the tests.

Table 1. Wine types of the study

Wine type	Vintage	Technique	Nomination
Rhine Riesling	2021	oxidative	A
Rhine Riesling	2021	reductive	B
Rhine Riesling	2022	reductive	C
Blue Franc	2021	oxidative	D

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2.2 Dielectric properties

Dielectric properties i.e., dielectric constant (ε') and dielectric loss factor (ε'') was measured by a Dielectric Assessment Kit (SPEAG, Switzerland) (Fig. 1.). The kit used in this study contains an open-ended coaxial dielectric probe (DAK 3.5), connected to a vector network analyser (ZVL-3, Rhode&Swarz, Germany). Dielectric measurements were carried out in the frequency range of 200MHz-2.4GHz at constant temperature of 20°C. The data from the network analyser was processed by specific computer software of DAK and exported to MS Excel for further study. Every date presented in this study is the average value of 30 sequential measurements.

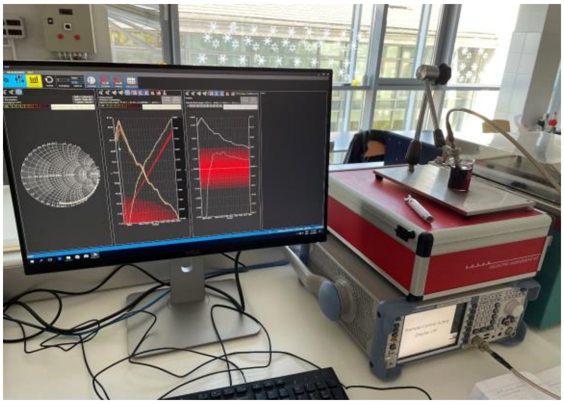

Figure 1. The DAK measuring system and the specific DAK software

2.3. Alcohol and acid content

The alcohol content was determined according to MSZ 9458 standard [8]. 100cm^3 of wine sample was poured into a round-bottomed flask and distilled to produce 75-80 cm^3 of distillate (fig 2.). The distillate was made up to 100cm^3 with distilled water and the relative density of the diluted distillate was determined at the temperature of 20°C using a pycnometer. Knowing the relative density, the alcohol content can be determined from a table. results are expressed as a percentage by volume.

Figure 2. Alcohol content determination

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The determination of the acidity was also carried out using a standard method (MSZ 9472) [9]. A 0.1 M solution of Na hydroxide was used to titrate the wine sample to neutral (7.0) pH using a pH meter. The carbon dioxide content was removed from the wine before the measurement. After titration, the acidity was determined using Eq. 1.

$$A = \frac{V_{NaOH} \cdot f}{V_w} \tag{1}$$

Where A is the acidity of the sample in tartaric acid equivalent [gL^{-1}], V_{NaOH} is the rate of consumption of a 0,1M NaOH solution [cm^3], f is the acidity corresponding to the consumption of 1 cm^3 of the measuring solution [gL^{-1}] and Vw is the volume of the volume of the titrated wine sample [cm^3].

The free radical scavenging activity of the wines was determined using the DPPH (1,1-diphenyl-2-picrylhydrazyl) method. During the reaction, the dark purple stable radical loses its colour when reacting with antioxidants. This method is quick, the measurement is simple, and the radical is commercially available. Its disadvantage is that it uses a stable radical, which does not occur in living organisms, so it is not possible to determine accurately how reactive the antioxidants in the sample are to biological radicals [16]. It is light, oxygen, pH, temperature, and solvent dependent [17].
As a first step, a stock solution was prepared using 39.5mg DPPH reagent and 10cm^3 of 96% ethanol. After complete dissolution, a working solution was prepared by diluting 500cm^3 of 96% ethanol to a final volume of 5cm^3 of stock solution with 96% ethanol. A mixture of 1cm^3 of 96% ethanol and 6cm3 of working solution was used as a control sample, while for the wine samples 1-1cm^3 of wine was pipetted instead of ethanol. After thorough mixing, the samples were kept in the dark for 30min and their absorbance was measured at 517 nm. The calculation of the antioxidant capacity according to DPPH method is presented in Eq 2.

$$DPPH = \frac{A_0 - A_w}{A_0} \cdot 100\% \tag{2}$$

Where A_0 is the absorbance of the control sample [-] and A_s is the absorbance of wine samples [-].

3. RESULTS AND DISCUSSION

The aim of our work was to look for a correlation between the different food properties of wines and their dielectric properties, and to investigate the differences between wines from the same place, from different vintages and produced using different techniques.

3.1. Antioxidant capacity

First, the antioxidant content of the wines was analysed using the DPPH method. During the tests, 5 parallel measurements were performed, the average of which is shown in Fig 3.
The red wine included in the study is not presented in the figure, as this wine (unsurprisingly) had a significantly higher antioxidant content (15.46%) than the white wine. Among the Rhine Rieslings, the highest values were obtained for the 2021 vintage sample (B), which was prepared using the reductive method (1.4%). Lower values were obtained, but not significantly different from this (1.23%), taking into account the standard deviation.

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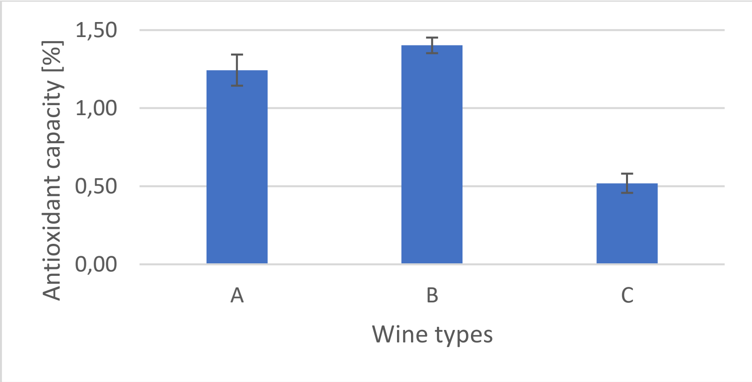

Figure 3. Antioxidant capacity of different Rhone Riesling samples

The 2021 samples contained significantly fewer compounds with antioxidant activity than the 2022 wine (C). Here, the antioxidant capacity was less than half (0.52%) of the previous values. These results suggest that the vintage of the wine, i.e. presumably the composition of the raw material, has a greater influence on the antioxidant activity of the wine than the winemaking technique.

3.2. Alcohol content and acidity

The alcohol content of the wines was examined next. Our results are presented in Fig. 4. The values were between 10,7 and 12,6. The lowest value was obtained in the case of Blue Franc D, with an alcohol content of 10.7%. This is considered significant when the standard deviation is taken into account.

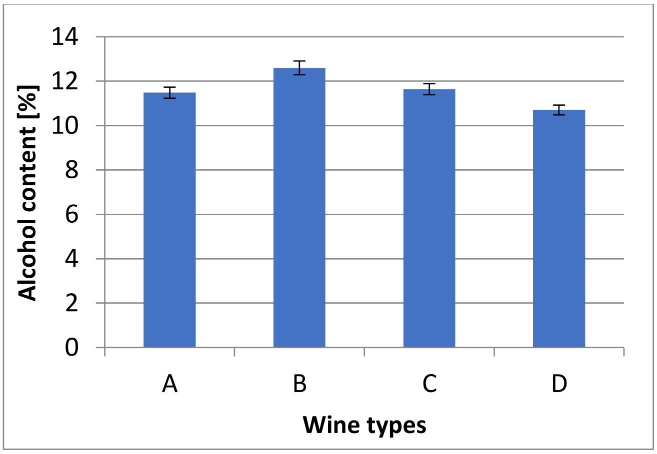

Figure 4. Alcohol content of the wine samples

Among the white wines, the wines labelled A and C did not differ significantly, with alcohol contents of 11.48 and 11.64% respectively. This result can be considered significant in that neither the vintage nor the technique were identical. A significantly higher value than the others was obtained with the 2021 reductive Rhine Riesling marked B.

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As far as acidity is concerned, the values for each wine are significantly different from all the others (Fig. 5.). The lowest value was observed for red wine D. For the differences in oxidative (A) and reductive (B) techniques only, there was a very significant difference of 1.6 times for the same vintage. The oxidative wine had an acidity of almost 7 gL^{-1}, while the reductive wine had an acidity of only 4.3 gL^{-1}. When the two reductive Rhine Rieslings are compared, it can be seen that the vintage also has a significant influence on acidity. The 2022 wine was nearly 1.4 times higher than the 2021 wine, with a value of 5.8 g^{L-1}.

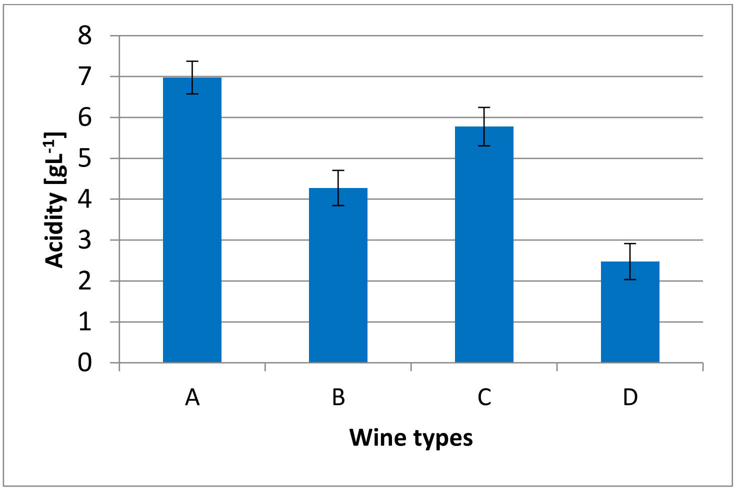

Figure 5. Acidity of the wine samples

3.3. Dielectric properties

Regarding the evolution of the dielectric constant (ε') on Fig. 6, it can be said that a difference is observed at lower frequency values for the different wines. Above 600 MHz the differences start to disappear considerably, and above 1000 MHz there is practically no difference between the dielectric constants of the different samples.

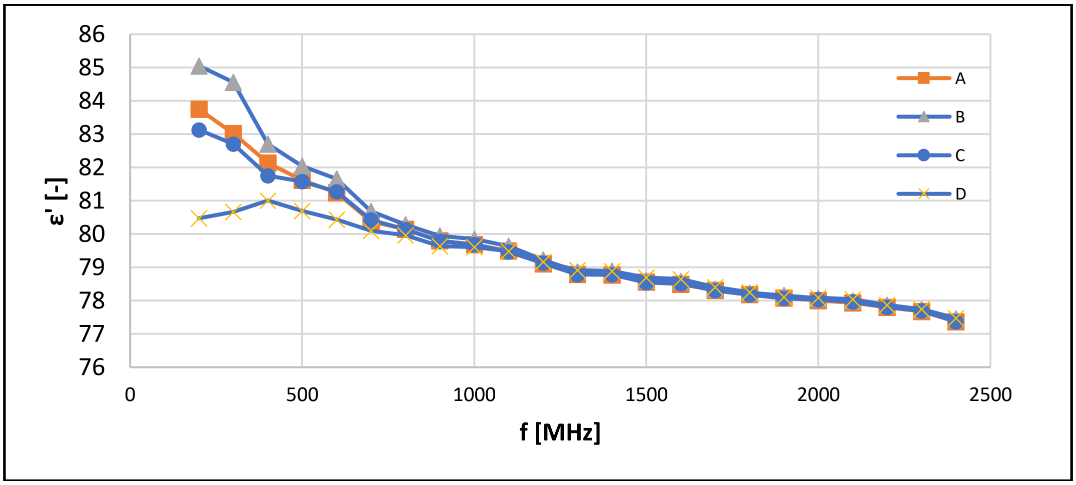

Figure 6. Dielectric constant (ε') in the function of frequency (f)

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In most cases, the values decrease with increasing frequency. The only sample with a different trend is sample D (blue franc): between 200 and 400 MHz the dielectric constant increases and only starts to decrease at higher frequency values. As long as there are noticeable differences between the different wines, it can be said that white wines have a higher dielectric constant. The oxidative Rhine Riesling of 2021 marked A is steady, whereas for the reductive wines a break is seen when the measurement frequency is increased from 300 to 400 MHz. Our results suggest that the dielectric constant value measured at the lower frequency (200-600 MHz) can be used to infer the winemaking technique.
For the loss factor (ε''), an increasing trend is observed for all wine types at increasing measurement frequency (Fig. 7). Primary differences are also observed at lower frequencies, as for the dielectric constant. The values for white wine (A) produced by the oxidative technique start to increase already at low frequencies, whereas for the reductive ones this increase is only observed later. In the case of red wine (D), this increase starts at even higher frequencies, and it can also be said that the ε'' values for this wine are lower, with the difference becoming narrower at higher frequencies. Similar to what was described for the dielectric constant, it can be said that wine making techniques can be concluded from the dielectric loss factor values.

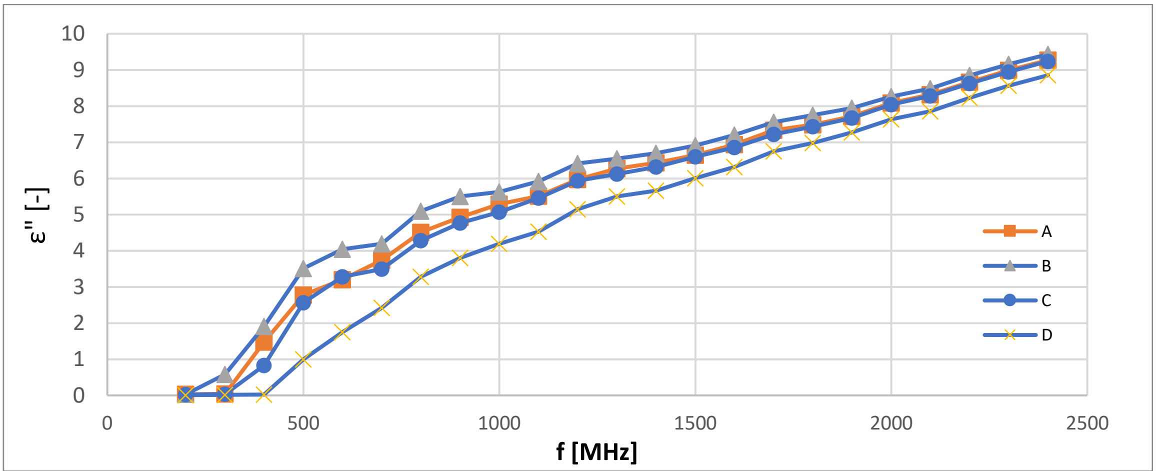

Figure 7. Dielectric loss factor (ε'') in the function of frequency (f)

4. CONCLUSIONS

In the present study, four different wines, a Blue Franc and three Rhone Rieslings, were analysed. The Rieslings were from two vintages, both oxidative and reductive, and the grapes were from the same area. The antioxidant activity, alcohol content, acidity and dielectric properties of the wines were analysed.
Our results showed that, even for the same variety, winemaking technique and growing area, differences between wines can be detected. In terms of free radical scavenging capacity, the influence of the ageing process is greater. For acidity, the oxidative or reductive nature of the wine and the vintage were found to have a strong influence on acidity.
For the dielectric parameters, i.e. dielectric constant and loss factor, it was also found that wine shows more significant differences at lower frequencies. The slope of the dielectric constant curves as a function of the measurement frequency was similar for white wines produced by the reductive method, and thus the method of vinification can be interpreted. Differences were also visible in the dielectric loss factor, with the main differences being found at the critical measurement frequency where the loss factor values increased.

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Our results suggest that the determination of dielectric properties may be a useful tool to determine the differences between wines, and it may be worth extending the tests to more wine samples,

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