THE INFLUENCE OF THE HIGH FREQUENCY ELECTROMAGNETIC FIELD ON THE ORGANOLEPTIC PROPERTIES OF WINE

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Abstract

This paper presents results obtained from processing grapes in high frequency field. For the analysis of the electromagnetic field we used software dedicated to processing in high frequency field. Experimental measurements were performed with an applicator with adjustable power between 100-1000 W.

We processed grapes of the following varieties: Muscat Ottonel, Merlot, Pinot Noir (harvested in the Crişana-Santimreu vineyard, 2014). Wines obtained from the three varieties of grapes (both treated and untreated in high frequency electromagnetic field) were analyzed in terms of the total flavonoid content, antioxidant capacity using the TEAC method and organoleptic properties. The results showed that by using unconventional methods, such as the electromagnetic field, we can obtain a high quality wine, rich in bioactive compounds with antioxidant capacity.

Key words: processing, electromagnetic field, grapes, wine

INTRODUCTION

Grape processing involves the completion of a series of operations in a specific sequence. This ensures that they turn into mash, must, and later wine. The processing technology has to take place on the day of harvesting, in a short time (no more than 4 hours since harvesting). Air and temperature have a negative impact on wine quality (Oprea Ş., et al. 2012).

Finding green products and technologies in order to maintain quality and valorization of useful food compounds has determined the wine industry to shift towards the development of new processes.

Thermal maceration applies to red wines. The extraction of phenols takes place by heating the mash at temperatures close to 70°C for a few minutes followed by the separation and cooling of the colored must.

In the epicarp there is a set of simple phenols – phenolic acids, stilbenes, and polyphenols - tannins, anthocyanins, flavones etc. It has been established by electron microscope that tannins and anthocyanins are located in the epicarp (Amrani J. K., et al. 1996). They can be found in different amounts depending on the location of the cell layers; they gather in the form of small globules outside the large vacuoles, migrate, and condense inside.

These substances are located in the skin of the grape, have antibacterial, antiviral, antioxidant, anti-inflammatory, anticancer properties, and can prevent cardiovascular diseases, thus contributing significantly to the overall impression of the wine product on the consumer.

The skin of the grape or the epicarp, although with a less important proportion, has a substantial contribution to defining the specificity of the types of wine due to its complex chemical composition (Oprea Ş. et al. 2012).

The clusters are rich in phenols. In a kilogram of grapes 20% of the phenols are in the clusters. When wine is prepared from declustered grapes, the phenols determine a lower acidity and a sharper astringency.

In grapes there are substances with varying proportions depending on the state of maturity. Water is the most important component, when the grapes are green it can reach up to 90% of the weight of the clusters, and when overripe and the tissues of the clusters are lignified, it decreases to 30%. Cellulose is a polysaccharide with a high degree of polymerization; it forms the cell walls of the tissues of the clusters, and can be found 5 to 55% depending on the turgidity of the cells. There is no cellulose in the chemical composition of the must, because it remains in the marc (Pomohaci N., 2000).

Cations and anions are minerals which constitute 5-6% of the weight of the clusters, while potassium salts represent more than 50%. Due to the abundance of minerals, organic acids can be found mainly in the form of salts (about 1%). This composition leads to the higher pH of the juice obtained from the clusters (pH - 4).

The purpose of this paper was to evaluate the effect of the high frequency electromagnetic field treatment applied in the first stage of the technological process of obtaining wine on bioactive compounds such as flavonoids and the antioxidant capacity of wines.

MATERIAL AND METHOD

The application of the electromagnetic field on three varieties of grapes

To study the electromagnetic field for the processing in a high frequency field, we start with Maxwell's equations, thus (Metaxas A.C., Meredith R.J., 1983).

$$\mathrm{rot}\mathbf{E} = -\frac{\partial \mathbf{B}}{\partial t}, \mathrm{rot}\mathbf{H} = \mathbf{J} + \frac{\partial \mathbf{D}}{\partial t}, \mathbf{D} = \varepsilon\mathbf{E}, \mathbf{B} = \mu\mathbf{H}, \mathbf{J} = \sigma\mathbf{E} \quad (1)$$

In the case of nonlinear fields J=f(E).

When processing in a high frequency field, the alternating electric field has the form $E_{max}e^{j\omega t}$:

$$\mathrm{rot}\mathbf{H} = \sigma\mathbf{E} + \frac{\partial}{\partial t}\mathbf{D} \quad (2)$$

for the images in complex:

$$\mathrm{rot}\underline{\mathbf{H}} = \underline{\mathbf{J}} + j\omega\varepsilon_0\varepsilon'\underline{\mathbf{E}} \quad (3)$$

If we only take into account the effect of the electrical conduction of free loads under the action of the electric field, and if we assume the dielectric constant to be real, only contributing to energy storage in the system, equation (3) can be written as:

$$\underline{\mathbf{J}} = \sigma \cdot \underline{\mathbf{E}} + j\omega\varepsilon_0\varepsilon'\underline{\mathbf{E}} = (\sigma + j\omega\varepsilon_0\varepsilon') \cdot \underline{\mathbf{E}} \quad (4)$$

In the free space $\sigma = 0$, we obtain:

$$\underline{\mathbf{J}} = j\omega\varepsilon_0\varepsilon'\underline{\mathbf{E}} \quad (5)$$

where:

$$\underline{\varepsilon} = \varepsilon' - \frac{j\sigma}{\omega\varepsilon_0} = \varepsilon' - j\varepsilon'' \quad (6)$$

The dielectric properties of grapes are defined by the dielectric constant (ε') and the loss factor (ε"). The dielectric constant ε' measures the ability of a material to couple with the high frequency energy, while ε" measures the ability of a material to absorb heat through microwave energy. The loss factor refers to the effective loss factor, which includes the effect of conductivity. The power dissipation within a material is proportional to ε" and to the loss tangent ε"/ε', an indicator of the ability of the material to generate heat (Tulasidas T.N., et al., 1995).

We followed two categories of problems:

- the diffusion of the thermal field within the dielectric material processed in high frequency field;
- the propagation and wave reflection at the surface of the dielectric, described by the Dirichlet and Neumann boundary conditions.

Through numerical modeling we obtain precise information about the placement of the dielectric in the applicator, the distribution of the field both in the applicator and the surface of the dielectric. To obtain a uniform electromagnetic field during processing the load has been moved inside the applicator.

The experimental measurements for treating grape mash/pomace were conducted with a processing plant in high frequency field with adjustable power between 100-1000 W. The processed grapes were of the following varieties: Muscat Ottonel, Merlot, Pinot Noir. The three varieties are characterized by different colors and flavors that change very quickly. We aimed to establish effective processing techniques both in terms of energy and to obtain a high quality end product.

Determination of the total flavonoid content in wine

The total flavonoid content was determined using a colorimetric method described by (Vicas et al., 2015). Firstly, 1 ml of wine was mixed with 4 ml of water and introduced in a volumetric flask (10 ml). Then, 3 ml of $NaNO_2$ (5%) solution were added, and after 5 minutes, 0.3 ml of the $AlCl_3$ (10%) solution was added and was left to stand for 6 minutes. Finally, 2 ml of the NaOH (1M) solution was added to the solution, followed by addition of water to the scale, and after 15 minutes the absorbance was recorded at 510 nm, using a spectrophotometer Shimadzu mini UV-Vis. The results were expressed as mg catechin equivalent (CE)/L. The calibration curve was linear for the range of catechin concentrations between 0.1-0.5 mg/ml (Figure 1).

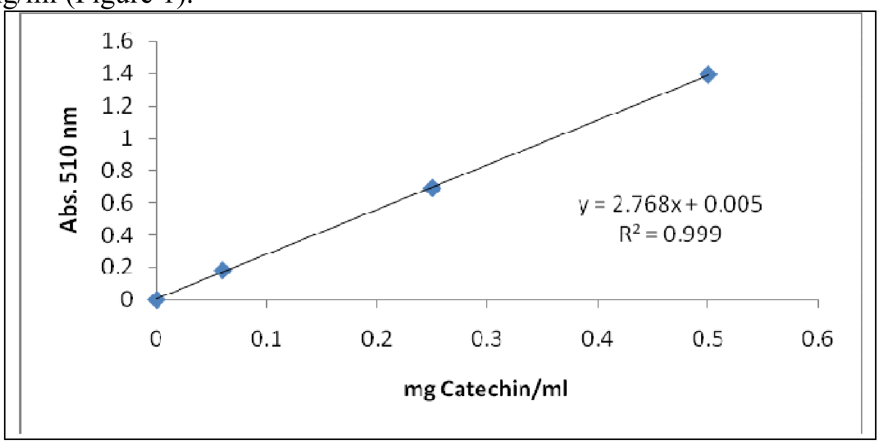

Fig. 1. Calibration curve for the determination of total flavonoid content using catechin as standard

Determination of the antioxidant capacity of wine by ABTS assay

Trolox Equivalents Antioxidant Capacity is a spectrophotometric method, widely used for the assessment of antioxidant activity of various extracts and performed using the method described by of (Vicas et al., 2015). The results are expressed as ABTS radical scavenging activity (%) and ware calculated using the following equation:

$$\text{ABTS radical scavenging activity (\%)} = [1Abs_{734\ nm} - 2Abs_{734\ nm})]/(1Abs_{734\ nm})] \times 100 \qquad (7)$$

where:

$1Abs_{734\ nm}$ is the absorbance of ABTS radical cation; $2Abs_{734\ nm}$ is the absorbance of ABTS radical cation in the presence of wine extract.

Sensorial analysis

Sensorial analysis was made according to the Regulation of the Association of Certified Wine Tasters in Romania and in compliance with the International Office of Vine and Wine. The system uses 100-point grading according to the International Competition System:

1. sight evaluation with the secondary features: clarity and appearance;
2. smell evaluation with the secondary features: nature, intensity, and quality;
3. taste evaluation with the secondary features: nature, intensity, persistence, and quality

Tasting was done by a committee of three members, in laboratory conditions, using tasting glasses. The temperature of the white wines was 16 (^oC) and of the red wines 18 (^oC). The evaluation was divided into the following categories, based on the average points received, obtained by summing the three grades and dividing them by three. The obtained score was classified as follows:

- excellent - between 100 – 90,
- very good - between 89 - 80;
- good - between 79-70;
- satisfactory between 69 – 60.

RESULTS AND DISSCUSIONS

The aim of this experimental study was to obtain a wine that is rich in bioactive compounds, after treating the grape mash (declustered and crushed grapes) in high frequency electromagnetic field. The results regarding the total flavonoid content of the wine samples is shown in Figure 2.

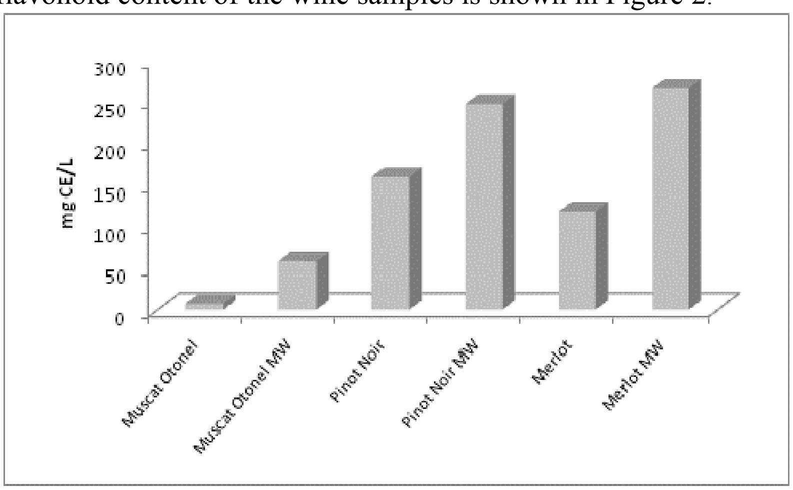

Fig. 2. Total flavonoid content of three different wines obtained from grapes untreated or treated with high electromagnetic field (MW)

Of the three types of wine we studied (untreated samples), the highest amount of flavonoid compounds was obtained in the case of Pinot Noir, followed by Merlot and Muscat Ottonel (160.04 mg CE/L, 118.86 mg CE/L, 7.23 mg CE/L), while for the samples treated with microwaves, the highest amount was obtained in the case of Merlot (266.98 mg CE/L), followed by Pinot Noir and Muscat Ottonel (247.47, 57.80 mg CE/L, respectively). A category of compounds of high interest that are part of the flavonoid class are anthocyanins, which can be found only in rosé (Pinot Noir) and red (Merlot) wine, while in the case of white wine, this category of compounds does not exist. Through the UV-Vis spectra for the three types of wine (Bandici et al., 2015) we noted absorptions that are specific for phenolic acids and flavonoids (280 nm and 340 nm). Rosé and red wines have an absorbance around 500 nm, which is a characteristic domain of antochianins classes.

Specialist literature (Jiang & Zhang, 2012, Lorrain et al., 2013) has proved that these flavonoid compounds have a variety of biological effects, of which the most studied one was antioxidant activity. In this study we used the TEAC method to highlight the ability of both microwave treated and untreated grapes to remove the cation ABTS radical. The results are shown in Figure 3.

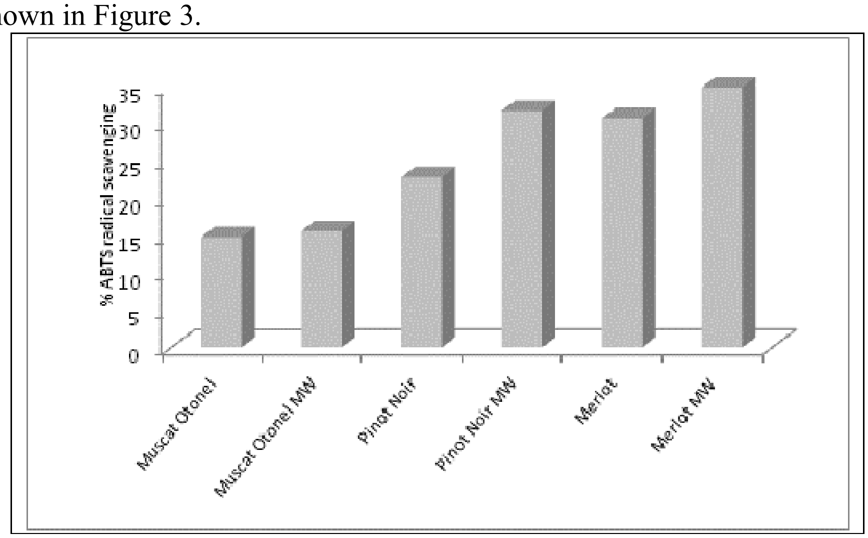

Fig. 3. % ABTS radical scavenging of three different wines obtained from grapes untreated or treated with high frequency electromagnetic field (MW)

The antioxidant capacity of untreated wines, in descending order, was: Merlot, Pinot Noir, and Muscat Ottonel (30.71%, 22.83%, and 14.78%). In the case of MW treated grapes, the antioxidant capacity remains in the same order, but was higher (34.87%, 31.72%, and 15.59%).

The results obtained from organoleptic analyses are shown in Table 1. The first wine we analyzed was untreated Muscat Ottonel, that received 76 points and falls into the category “good”. The comments to this wine are that it has no strong aroma and that it is a short wine without body. Muscat Ottonel processed in high frequency field received 83 points, and ranges at the boundary between “good” and “very good”, it has a much stronger aroma, the only weakness both in smell and taste being the advanced color due to maderisation. Untreated Pinot Noir has an average of 72 points, being almost classified as “good” due to poor color, aggressive acidity, and discrete aroma. Pinot Noir processed in high frequency field obtained an average of 79 points, being almost classified as “very good”, having a much improved color, stronger aroma, and being more full-bodied due to additional transferred tannins which add a little astringency. Untreated Merlot has an average of 82 points, being almost classified as “very good” due to much better aroma, color, and body than Pinot Noir. Merlot processed in high frequency field obtained an average of 88 points, being placed at the top of the category “very good”, because it has more color, aroma, and body due to the transfer of substances through the applied treatment.

Table 1

Results of sensory analysis

Wine	Treatment	Point	Score
Muscat Ottonel (MO)	untreated	76	**Good**
Muscat Ottonel (MO_MW)	treated	83	**Very good**
Pinot Noir (PN)	untreated	72	**Good**
Pinot Noir (PN_MW)	treated	79	**Good**
Merlot (M)	untreated	82	**Very good**
Merlot (M_MW)	treated	88	**Very good**

CONCLUSIONS

Dielectric properties of grapes are influenced by both moisture and temperature. Moisture is an important factor in the variation of dielectric properties due to the change in ionic conductivity and hence in the loss factor. In the case of high moisture contents, the dielectric constant and the loss factor decrease with increasing temperature and they have a tendency to increase with lower moisture contents.

In terms of the flavonoid content and antioxidant capacity of the studied wines we noticed a substantial change in the samples processes in high frequency field. Sensory analysis proves that the processing in high frequency field is beneficial in terms of the transfer of substances from the skin and clusters, adding color and flavor of the wines.

Acknowledgement

This work was performed through the Partnerships Program in priority areas - PN II, developed with the support of MEN - UEFISCDI, project No. 170/2014 “Electromagnetic methods to improve wine processes”.

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