EFFECT OF HEAT TREATMENTS ON COLOR PARAMETERS OF WINE PRODUCTS

Short title: **EFFECT OF HEAT TREATMENT ON WINE COLOR**

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Abstract

In our research we sought to determine whether the treatment of food products in a microwave electromagnetic field is advantageous or disadvantageous compared to conventional technologies. In household practice, microwave energy transfer is used mostly for warming. One of the most important tangible benefits of microwave heat treatment is that, because of its speed, it causes less damage to the nutritional value of the product. Among other generally acknowledged advantages are lower energy consumption, lower operational cost and faster processing times, as well as versatility and lesser spatial requirements, qualities which also potentially make the use of microwave technology attractive for industrial applications. However, despite of the introduction of microwave technology more than 70 years ago, it is still not clear whether its application results in equivalent products in terms of quality and food safety.

In our study, we heat treated wines with microwave energy transmission and with convective heating in a thermostatic water bath. The white, rosé and red wine samples were pasteurized at a temperature of 74±0.5°C. The effect of the heat treatment is examined for color parameters, as controls, untreated wine samples were used.

Keywords: heat treatment, microwave, wine, color parameters

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Introduction

Heat treatment is a common operation in food production because it effectively destroys microorganisms that cause spoilage in food, thereby increasing the shelf-life of products. At the same time, high temperatures may have a negative effect on vitamins and may influence the color and the nutritional content of the product. The goal is to select a technical solution for heat treatment where the advantages dominate.

The applicability of microwave energy transfer in the food industry has been investigated in several domestic and international studies. The foods most frequently used in research are milk and fruit juices which almost always undergo some degree of heat treatment during processing.

The effects of microwave heat treatment on fruit juices have been studied thoroughly, as this process is often part of their production (Jiménez-Sánchez et al., 2015). The qualities of citrus products are determined by the enzyme reactions in the fruit not only in the growth phases but during processing as well. For example, inactivation of methyl-ester-pectinase is especially important to prolong shelf life. Studies have shown that the pasteurization of fruit juices can be performed faster and with a smaller decrease in ascorbic acid content. In the case of citrus juices, the clearly corresponded freshness (Camacho et al., 2009). Microwave heat treatment as a viable alternative in food processing technology significantly decreased the initial bacterial count in fruit (Peremanyer & Grébol, 2010). It has also been proven that mold reduction (*species Aspergillus*) is more substantial using microwave-based heat treatment (Valderrama & Sanches, 2008).

Kapcsándi et al. (2013, 2016), seeking to demonstrate the effect of microwave treatment on grape must fermentation, found that sugar content of the treated samples rapidly decreased compared to the control sample and that fermentation time was 40% shorter.

The possibility of microwave pasteurization also defined nearly 20 years of research conducted by a team at the Szent István University (formerly Gödöllő University of Agricultural Science) Faculty of Mechanical Engineering. We have proved the feasibility of microwave heat treatment as well as its energy-saving and technological advantages. (Garnacho et al., 2012; Géczi et al., 2013a, 2013b, 2013c; Géczi & Sembery, 2010; Sembery & Géczi, 2008; Korzenszky et al., 2013; Korzenszky & Molnár, 2014). Research has covered the heat treatment of fresh milk immediately after milking and influencing the fermentation of fruit juice (apple, orange, grape must) for increasing the shelf-life as well as improving the quality of the liquid product. During our research, we compare microwave and convection heating methods in parallel on liquid food products, and we investigated differences in the physical characteristics, chemical parameters and biological conditions of heat-treated products. Until now we found no significant differences between the parameters we examined in the samples, whether we heated them using the microwave method or in the thermostatic water bath.

Most recently, we have examined heat treatment applied in winemaking technologies. Some biological stabilization effects can be achieved by pasteurization, which prolongs the shelf-life of wine but has considerable influence on the quality, color, alcohol content and other traits of the product. In Hungary, the common practice during heat treatment is to raise the temperature of the wine to 70-80°C and keep it at this temperature for a few seconds, which precipitates harmful heat-sensitive substances from the wine, kills the yeast cells and extends the shelf-life of the heat-treated wine by 6 months (Eperjesi et al., 2010; Farkas, 1988; Margalit, 2012).

We performed comparative examinations in this case as well. We studied whether heat treatments of identical extent (temperature-time) conducted with microwave and thermostatic bath heat treatment methods produce any difference in the color of the wine product.

Material and methods

Wine samples

For our research, we selected the products of Hungarian small-scale producers and wineries that applied no heat treatment after the fermentation of the must and stored their product in an oxygen-free environment until consumption or sale. The characteristics of the examined samples are summarized in Table 1.

Table 1. Characteristics of Wine samples

Code	Wine variety	Wine style	alc. (%v/v)	Vintage Chart	Region
FU-TO-15	Furmint	semi sweet white wine	12	2015	Tokaj
ZA-KU-16	Zalagyöngye	semi dry white wine	8.5	2016	Kunság
CA-MA-16	Cabernet Sauvignon	dry rosé wine	12	2016	Mátra
FA-MA-14	Farkasvér*	dry red wine	12	2014	Mátra
ME-VI-15	Merlot	dry red wine	12.5	2015	Villány

*Blend produced from Zweigelt, Turán, Cabernet Franc

Parallel measurement configuration

The test equipment was assembled by converting a household microwave oven into a flow-through, continuous operating mode device with 900 W output power. Two holes of 7 mm diameter, located 8 cm apart, were made in the oven to introduce and drain the liquid. The microwave equipment, complete with special glass spirals, was connected to a STENNER 85M5 adjustable feed-rate, peristaltic pump (Stenner Pump Company, Jacksonville, FL, USA) (Géczi et al., 2013c; Géczi & Sembery, 2010). Temperatures data were measured and recorded by an ALMEMO 2590-4 temperature measuring instrument (Ahlborn, Holzkirchen, Germany).

Inside the microwave oven, the liquid flowing through the glass spirals can be heated to the desired temperature depending on the length of the spiral and the flow rate of the peristaltic pump. The temperature continuously can be monitored before entering and after exiting the microwave field, allowing the process to be controlled effectively. One of the advantages of this method is the gradual heating and constant output temperature resulting from the use of glass spirals, with which temperature fluctuations characteristic to batch processes operation can be avoided.

To produce a comparative study of heat treatments in which the wine samples are heated in different ways but under identical circumstances (i.e., the final temperature and the treatment time must be identical), a glass spiral instrument was also immersed in a T-PHYWE type water bath (Lauda DR.R. Wobser GmbH, Lauda-Königshofen, Germany). By adjusting the water temperature, we were able to create the same treatment temperature as with the microwave method, using an identical flow rate, resulting in identical treatment time. This parallel process made it possible to compare wine samples treated under identical circumstances but with different heating methods.

For each comparative test, one glass spiral was placed into the Whirlpool AT 314 microwave oven (MW-H), while another one was placed into the *T*-PHYWE thermostatic water bath (TB-H). The temperature was continuously monitored and held constant. During this test, the flow rate was set to $Q=175\ cm^3/min$ and output power was set to $P=900W$, resulting in a wine temperature of $T_{wine}=74\pm0.5°C$. For convective heating at the same flow rate, the water bath temperature was kept at $T_{water}=80\pm0.3°C$. The control wine samples were not heated (NO-H).

Samples of a specific wine variety were heat treated in 3 different days, but at the same temperature every time ($T_{wine}=74\pm0.5°C$). In case of each wine samples, 5 liters were produced from the untreated wine as a control, the wine treated with microwave energy transfer and wine heat treated with the convective method. The large number of samples produced from each wine variety made shelf-life examinations possible. After heat treatment, we repeated color analyses once a month to draw conclusions regarding shelf-life. These long-term results are not presented in this article because examinations are still in progress.

Colour analysis of wine samples

The color of wine is characteristic of the specific variety and is the basis for the wine's evaluation. Evidentially, the color of a wine variety primarily depends on the color of the grape, but several chemical compounds play important roles in color development. Carotenoids are responsible for the green and yellow colors of grapes, while the color of blue grapes and red wines are determined by anthocyanins (Figure 1.). Heat treatment may have a minor effect on the color of the end product – the fact that heat treatment has been applied is generally noticeable to the naked eye – but we can gain precise data by instrumental measurement.

Figure 1. Examined wine varieties
(from left to right FU-TO-15, ZA-KU-16, CA-MA-16, FA-MA-14, ME-VI-15)

The color properties of the wine samples were determined using a ColorLite sph 850 spectrophotometer (ColorLite GmbH, Katlenburg-Lindau, Germany). Test results were obtained as CIE (Commission Internationale de la Éclargie) L*, a*, b* color properties with wavelengths between 400 and 700 nm (Kaszab et al., 2010; 2011). The instrument settings were "2° standard observer" and "standard illuminant D65". Results of each measurement were calculated from the average of three measurements with the ColorLite equipment. There are more than 6 million color codes in the CIE Lab System. The color parameters were the following: lightness - L*, which defines the grades of brightness from black to white; red-green color coordinate - a*; and yellow-blue color coordinate - b*. The color parameters of the wine samples were measured on the day following the treatment and monitored once a month throughout sample storage. This process required a large number of samples, as once the samples were measured, they could not be used again.

Statistical analyses

The measured color properties values were evaluated by R-Studio Version 1.1.414 (R-Studio, 2018). After leaving the outlier data, a normality test (Shapiro-Wilk Test) was run on color test results of the samples from both methods of heat treatment as well as on those of the unheated control samples. ANOVA was used to identify any significant differences between the groups in the case of certain parameters. Where ANOVA indicated TukeyHSD test ($p<0.05$) was used for detecting the significant differences between the groups (Reiczigel et al., 2014).

Results and discussion

The Figure 2 shows the color parameters of the untreated samples using and a*-b* plane. The five examined wine varieties can be separated to “white”, “rozé” and “red” wine (Figure 2.). Furthermore, both of the red wine types showed very similar results, but the values of ZA-KU-16 wine were more scattered. Small difference was found between the values of two white wines as well, but the values of FA-MA-14 sample showed stronger scattering.

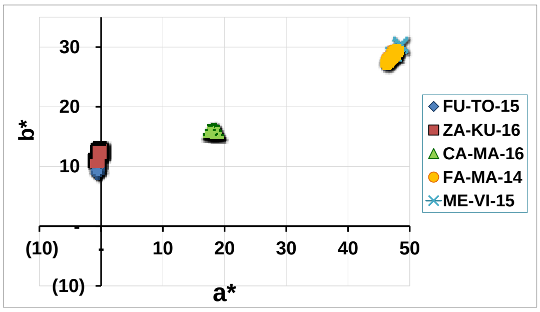

Figure 2. Location on the a*-b* plane of wines examined

On the basis of the above results the analyzed samples were as follows during the heat-treatment experiment: ZA-KU-16 (white), CA-MA-16 (rozé), FA-MA-14 (red) wine.

The Fig. 3. presents the results of lightness coefficient of the microwave handling (MW-H), non-heat-treated (NO-H) and thermostatic bath handling (TB-H). Significant differences were found between the NO-H and the heat-treated samples in case of the white and rozé wines. The MW-H showed the smallest values. However, the MW-H and NO-H of red wine did not separated.

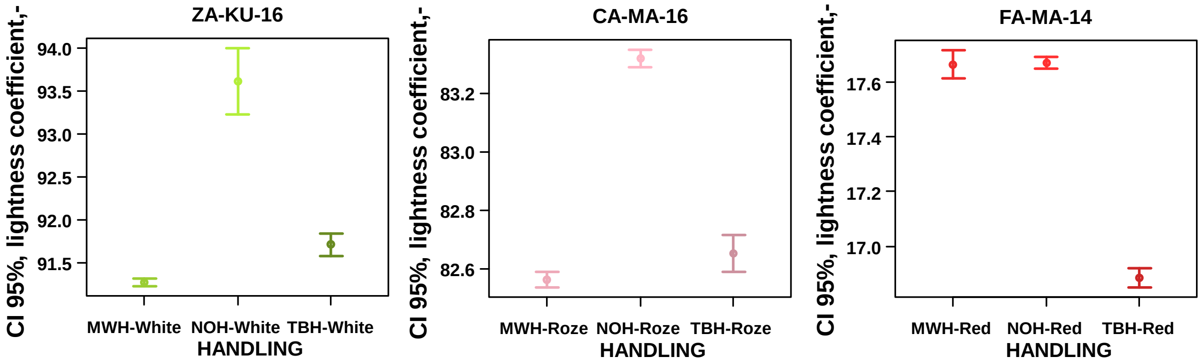

Figure 3. The lightness coefficient (L*) (average and the 95% CI) by the treatment category (from left to right: ZA-KU-16, CA-MA-16, FA-MA-14)

Significant differences were found in the value of a* and b* between the NO-H and the heat-treated samples in case of the white and rozé wine (Figure 4. and 5.). The average values of red wine samples (NO-H and MW-H) were close.

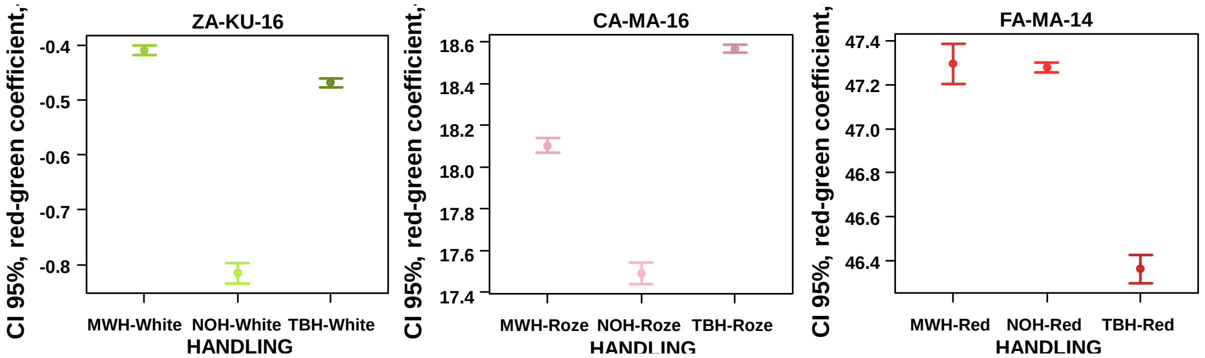

Figure 4. The red-green coefficient (a*) (average and the 95% CI) by treatment category (from left to right: ZA-KU-16, CA-MA-16, FA-MA-14)

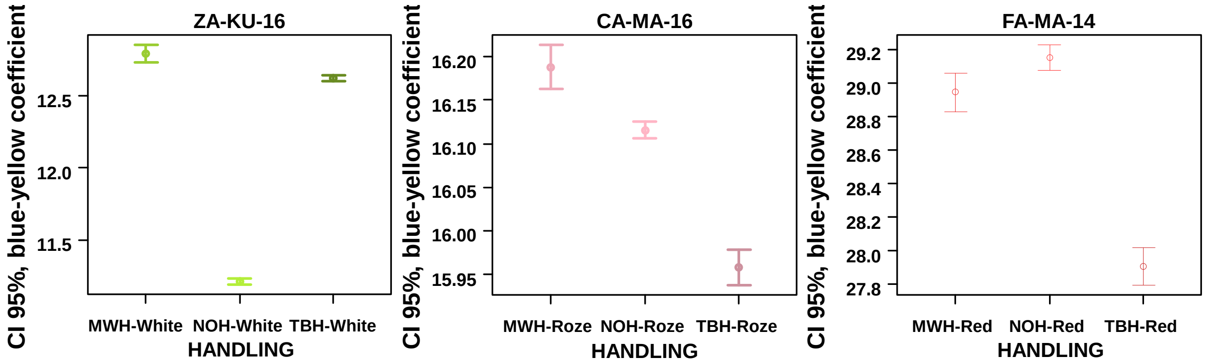

Figure 5. The blue-yellow coefficient (b*) (average and the 95% CI) by treatment category (from left to right: ZA-KU-16, CA-MA-16, FA-MA-14)

Presence of a significant difference was tested between the groups by TukeyHSD test. Based on the results it can be concluded, that the groups significantly separated from each other in case of the measured color parameters (Table 2.). Only in a few cases was no s significant difference found (marked with blue cells in Table 2.).

Table 2. Tukey-test results of the lightness coefficient (L*), red-green coefficient (a*) and blue-yellow coefficient (b*) ($p < 0.05$)

L* - lightness coefficient

	ZA-KU-16			CA-MA-16			FA-MA-14		
	MWH-White	NOH-White	TBH-White	MWH-Rozé	NOH-Rozé	TBH-Rozé	MWH-Red	NOH-Red	TBH-Red
MWH-White									
NOH-White	+								
TBH-White	+	+							
MWH-Rozé	+	+	+						
NOH-Rozé	+	+	+	+					
TBH-Rozé	+	+	+	-	+				
MWH-Red	+	+	+	+	+	+			
NOH-Red	+	+	+	+	+	+	-		
TBH-Red	+	+	+	+	+	+	+	+	

a* - red-green coefficient

	ZA-KU-16			CA-MA-16			FA-MA-14		
	MWH-White	NOH-White	TBH-White	MWH-Rozé	NOH-Rozé	TBH-Rozé	MWH-Red	NOH-Red	TBH-Red
MWH-White									
NOH-White	+								
TBH-White	-	+							
MWH-Rozé	+	+	+						
NOH-Rozé	+	+	+	+					
TBH-Rozé	+	+	+	+	+				
MWH-Red	+	+	+	+	+	+			
NOH-Red	+	+	+	+	+	+	-		
TBH-Red	+	+	+	+	+	+	+	+	

b* - blue-yellow coefficient

	ZA-KU-16			CA-MA-16			FA-MA-14		
	MWH-White	NOH-White	TBH-White	MWH-Rozé	NOH-Rozé	TBH-Rozé	MWH-Red	NOH-Red	TBH-Red
MWH-White									
NOH-White	+								
TBH-White	+	+							
MWH-Rozé	+	+	+						
NOH-Rozé	+	+	+	-					
TBH-Rozé	+	+	+	+	+				
MWH-Red	+	+	+	+	+	+			
NOH-Red	+	+	+	+	+	+	+		
TBH-Red	+	+	+	+	+	+	+	+	

Conclusion

In our research the color parameters of wine were examined using samples heat treated and pasteurized through different methods. In household practice, microwave heating produces uneven heat distribution in the product as a result of the inhomogeneity of the electromagnetic field. In the opinion of our research team, this uneven heat distribution is the reason why there still has been no breakthrough in the application of microwaves on an industrial scale. Research itself is made difficult by the fact that microwave heating operated in intermittent mode cannot be compared with convective heating because of the resulting inhomogeneity. Even heating can be achieved by flowing liquid food products continuously through a glass spiral in a microwave electromagnetic field. The extent of the heating is determined by the length of the glass spiral and the flow speed of the feeding pump. By passing the same food products through a convective water bath with an appropriately selected temperature, we can achieve identical heating parameters using two different heating methods. With this parallel method, we can compare heat treatments based on convection heat transfer and microwave energy transfer by examining the characteristics of the treated food product.

Heat treatment and, within that, pasteurization, applied in winemaking technology, proved to be suitable for the examination of microwave energy utilization. Based on the characteristics we have examined, we can conclude that effects of heat treatment can be observed in changes to color coordinates and luminosity index. In the white, rosé and red wine samples pasteurized at a temperature of 74±0.5°C, we found significant difference between the two heating methods regarding color characteristics.

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References

Camacho, M.M., García, E., García, M., Martinez, N. (2009): Microwave Pasteurization of Grapefruit Juice (in Spanish). *Alimentación Equipos y Tecnología* 244, 34-38.

Eperjesi, I., Horváth, Cs., Sidlovits, D., Pásti, Gy., Zilai, Z. (2010) Borászati technológia. *Mezőgazda Kiadó*

Farkaš, J. (1988): Technology and Biochemistry of Wine volume 2. *Gordon and Breach Science Publishers* 744p.

Garnacho, G., Kaszab, T., Horváth, M., Géczi, G. (2012): Comparative Study of Heat-treated Orange Juice. *Journal of Microbiology, Biotechnology and Food Sciences* 2(3), 446-457.

Géczi, G., Horváth, M., Kaszab, T., Garnacho A.G. (2013): No Major Differences Found between the Effects of Microwave-Based and Conventional Heat Treatment Methods on Two Different Liquid Foods. *Plos One* 8(1) 1-12.

Jiménez-Sánchez, C., Lozano-Sánchez, J., Segura-Carretero, A., Fernández-Gutiérrez, A. (2015): Alternatives to conventional thermal treatments in fruit-juice processing. Part 2: effect on composition, phytochemical content, and physicochemical, rheological, and organoleptic properties of fruit juices. *Critical Reviews in Food Science and Nutrition* 57(3), 637-652.

Kapcsándi, V., Neményi, M., Lakatos, E. (2013): Alacsony teljesítményű mikrohullám hatása a must erjedésére. Review of Faculty of Engineering, *Analecta Technica Szegedinensia* Special Issue, 73-78.

Kapcsándi, V., Kovács, A.J., Neményi, M., Lakatos, E. (2016): Investigation of a non-thermal effect of microwave treatment. *Acta Alimentaria Hungarica* 45(2), 224-232.

Kaszab, T., Kovács, Z., Szöllősi, D., Fekete, A. (2011): Prediction of carrot sensory attributes by mechanical test and electronic tongue. *Acta Alimentaria Hungarica,* 40(SI), 41-58.

Korzenszky, P., Sembery, P., Géczi, G. (2013) Microwave Milk Pasteurization without Food Safety Risk. *Potravinarstvo* 7(1), 45-48.

Korzenszky, P., Molnár, E. (2014): Examination of Heat Treatments at Preservation of Grape Must. *Potravinarstvo* 8, 38-42.

Margalit, Y. (2012): *Concepts in Wine Technology: Small Winery Operations*. 3rd Edition Kindle Edition 312p.

Peremanyer, M., Grèbol, N. (2010): Microwaves in the food industry: Pasteurization of ready-to-serve prepared meals (in Spanish). *Alimentación Equipos y Tecnología* 255, 12-14.

Reiczigel J., Harnos A., Solymosi N. (2014): Biostatisztika nem statisztikusoknak,. 2014, javított utánnyomás, *Pars Kft., Budapest*

Sembery, P., Géczi, G. (2008) Microwave treatment of food. *Hungarian Agricultural Research* 17(2-3), 12-16.

Valderrama, Á.M., Sánchez, R.L. (2008): Use of microwaves in the treatment of mango juice (in Spanish). *Lasallista de Investigación* 5(2), 13-19.