 DOI: 10.1051/metrology/201716001

The contact surface of oak chips / wine determined by image analysis

Igor Chiciuc[1,*] and *Andrei* Chiciuc[1]

[1]Technical University of Moldova, MD-2004 Chisinau, Moldova

Abstract. The study is focused on measuring the oak chips/wine contact surface. Five samples were analysed with the doses used in oenology (2; 3; 4; 5 g.L^{-1}). For example, for the dose of 2 g.L^{-1} there were obtained the surfaces, as follows: XOV US-71 $cm^2.L^{-1}$; XOV Fr-76 $cm^2.L^{-1}$; DS Fr-72 $cm^2.L^{-1}$; OG Md 83 $cm^2.L^{-1}$ and OS Md 154 $cm^2.L^{-1}$. The results were compared with the data known for the barrel, oak chips doses being calculated to have a similar surface, thus obtaining: XOV US-2,57 g; XOV Fr-2,41 g; DS Fr-2,52 g; OG Md-2,19 g; OS Md-1,18 g. Measurements were done with image analysis and this is a first approach to determine this parameter for the wine.

1 Introduction

Wine aging in oak barrels is a widespread practice in wine-making, especially when it comes to obtaining a quality red wine and occurs generally from the end of the alcoholic fermentation till wine bottling. This process allows the wine to develop new organoleptic characteristics (color, aroma, taste), valued by consumers, the wine becoming more stable and more complex [1].

Being quite expensive, wine aging in barrels cannot be used for all wines. Therefore, an alternative technology of wine aging is being used lately, by using oak chips associated with wine micro-oxygenation. This can speed up the aging period and lead to make wines with lower production costs compared to the traditional technique, while still obtaining wines with similar organoleptic characteristics [2].

To better control the process of wine aging on the oak chips, it would be good to know the contact surface between wood and wine so as to approach as much as possible to the conditions in the classical method of maturing wine in barrels, where this parameter is already known. Thus, this study comes to help to know this parameter and have a tool to better manage the aging process of the wine on oak chips.

The objective of this study is to determine the contact surface of oak wood/wine during wine aging when oak chips are used.

1.1 The influence of oak wood on wine quality

There are several parameters that can influence the accumulation of volatile compounds in wine and the color at its interaction with the oak wood during aging that will lead to the change of the wine kept in barrels, compared with the wine that is kept, for instance, in stainless steel tanks. Among these parameters, some of the most important are the geographical origin of the oak wood and the type of wood heating used to produce the barrel.

1.1.1 The influence of the oak wood

The oak tree belongs to the botanical genus Quercus, this genus being represented by over 250 species, and from among these species only three are mainly used in cooperage to manufacture oak barrels.

These species are as follows:

- Quercus petraea and Quercus robur, widespread in Europe, from northern Spain to the Ural Mountains.
- Quercus alba, this species is found in the USA and especially in the eastern part.

The analyses carried out showed that Quercus robur is rich in polyphenolic compounds, tannins and is less aromatic, while Quercus petraea contains less and medium polyphenolic compounds being more aromatic.

The American oak tree Quercus alba contains less phenolic compounds but is rich in aromatic compounds, especially in whiskey lactones. The molecules of whiskey lactones, eugenol and vanillin are the main substances with a strong aroma and are characteristic of the oak wood before it is subjected to heat processing [1].

1.1.2 The influence of heat treatment

When manufacturing the barrel, the oak wood is subjected to a heat treatment process that can be decomposed into two stages [3]:

1. Heat treatment for oak staves bending – it supposes curving the staves that will be used to manufacture the barrel.

* Corresponding author: ichiciuc@gmail.com

Article available at http://cfmetrologie.edpsciences.org or https://doi.org/10.1051/metrology/201716001

2. Heat treatment by burning – it supposes to give the barrel its specific shape. This heating of the barrel leads to changes in the structure and composition of the oak wood. Thermal treatment by burning defines the quality of the barrel and influences the subsequent evolution of the organoleptic characteristics of the wine during aging.

1.2 Image analysis, ImageJ

Image analysis has found utility in various fields of human activity, totally different from each other. Thus, this technique is widely used in the food industry, agriculture, biology, medicine, environment and many other areas of modern activity [4].

Image analysis done with the help of ImageJ software was used in this study for the characterization of the oak chips contact surface during wine aging. This is open-source software developed by Wayne Rasband from the National Institute of Health.

2 Material and methods

2.1 Oak chips

The oak chips used in this study are sold by the companies Martin Vialatte Œnologie (France), Corimpex (Italy) and Oenolab (Moldova). The products from Martin Vialatte Œnologie correspond to a medium heat treatment and are of American and French origin (XOV US – American oak tree, and XOV Fr – French oak tree). The oak chips from Corimpex are of French origin, subjected to a light heat treatment and sold under the name Dessein structure (DS Fr). The oak chips from Oenolab are of Moldovan origin, treated to a medium heat treatment and sold under the name Oenotal Grosier (OG Md) and Oenotal Standard (OS Md) (Figure 1).

Figure 1. Oak chips.

2.2 Characterization of the contact surface

Contact surfaces for barrels and other regular oak shapes (nuggets, staves, ministaves, …) are measurable by the usual measurement means and mathematically computable [2], [5]. Due to the fact that oak chips have irregular forms, this determination is difficult to be done and its surface is little known. Therefore, in this study we tried to determine the contact surface wood/wine using image analysis. In this case, this method is not a very accurate method due to irregularities at the surface of the chips, but it is a method that allows us to get closer to measuring the contact surface wood/wine.

In order to characterize the contact surface, we proceeded the following way:

1. In the first stage oak chips images are obtained. Two methods to obtain the image were used:

1.1. In the first case by using a photo camera - for the all studied oak chips samples (for XOV US and XOV Fr a JVC photo camera, model KV-F50E was used); for DS Fr a NIKON photo camera, model D90 was used and for OG Md and OS Md a Canon EOS photo camera, model 1200D was used. When capturing the image, a light source placed above the area of image capture for a better brightness is used. The analyzed oak chips are placed on the area of image capture, being spread over a white sheet of paper and distributed in a single layer. The oak chips are separated from each other into pieces, so that they are not stuck together and can be clearly distinguished when capturing the image (Figure 2).

Figure 2. Captured image.

1.2. In the second case by using a scanner - only for the oak chips samples OG Md and OS Md, the same samples used for obtain the image by photo camera (1.1). A scanner Canon I-SENSYS MF4450 was used to get image and the analyzed oak chips are placed on the working area of scanner, distributed in a single layer. The oak chips are separated similar like for camera, they are not stuck together and can be clearly distinguished.

2. To have access to the surface of the oak chips, the captured image is subjected to the image treatment using ImageJ (for XOV US and XOV Fr 1.43q version was used, for DS Fr, OG Md and OS Md 1.50e version was used). The surface of each wood chips is determined. The total surface of a specimen of wood chips in part corresponds to the determined surface multiplied by two. The thickness of the wood chips during its contact surface characterization was not taken into account.

2.1. The image is opened in the ImageJ software (from the menu: File-Open-select photo) and is converted from color to black and white (Image-Type-8-bit) (Figure 3).

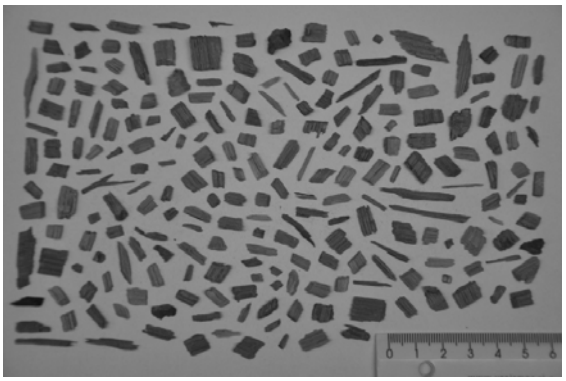

Figure 3. Image converted to black and white (8-bit).

Then, the measuring scale is selected by drawing a line (Straight button) on the desired length (50 mm), on the surface of the ruler. The measuring scale is set from the menu (Analyze-Set Scale) and in the box Known Distance it is written 50; it is also introduced the measuring unit - mm (box Unit of length). To check the correct selection of the measuring scale, another line is drawn on the ruler and it is determined its distance. You can continue if the distance is selected correctly, otherwise the measuring scale has to be reset in the way described above.

2.2. The image is processed to distinguish better the threshold of the oak chips pieces (from the menu Process-Binary-Make Binary).

The image of the ruler in the photo is removed in order not to disturb the subsequent determination of the contact surface (the surface of the ruler is selected by using the Rectangular instrument, and then from the menu select Edit-Clear) (Figure 4).

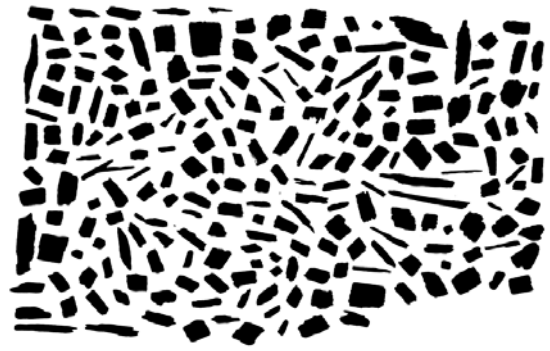

Figure 4. Threshold image.

2.3. The surface of the oak chips is determined (from the menu: Analyze-Analyze Particles), Show Outlines is selected, Display Results is ticked and then press the button OK (Figure 5). As a result, we get an image with each piece of wood chips well defined and numbered. The results regarding the calculation of the surface of oak chips automatically open in a separate window where the calculated surface for each piece of oak chips is shown. For further processing of the data obtained, these results are exported to an Excel file.

Figure 5. Final image.

2 Results and discussions

The data measured for the samples of oak chips show a total number of pieces of oak characterized by a number of 5606 pieces, for the XOV US oak chips, having a total area of 3674 cm^2 and a weight of 104 g. (Table 1).

Table 1. Data measured for the oak chips.

Oak chips	Number of captured images	Pieces of oak chips in the studied sample	Total contact surface, **cm^2**	Sample weight, **g**
Chips XOV US	40	5606	3674	104
Chips XOV Fr	40	6566	3815	101
Chips DS Fr	55	11328	7230	200
Chips OG Md (by camera)	41	10566	9074	218
Chips OG Md (by scanner)	41	10522	8989	218
Chips OS Md (by camera)	41	11591	2850	37
Chips OS Md (by scanner)	41	11535	2805	37
Bordeaux wine barrel (225 L)	-	1	20400	45000

In the case of XOV Fr oak chips, a number of 6566 pieces were analyzed, with a total area of 3815 cm^2, for a weight of 101 g. For the DS Fr sample, a total of 11328 pieces of oak chips were analyzed, with a total area of 7230 cm^2, having a weight of 200 g. In the case of OG Md sample, a number of 10566 (by camera) and 10522 (by scanner) pieces were obtained, with a total area of 9074 cm^2 (by camera) and 8989 cm^2 (by scanner) for a

 DOI: 10.1051/metrology/201716001

total weight of 218 g. For the last sample of oak chips studied OS Md, a number of 11591 (by camera) and 11535 (by scanner) pieces were obtained, with a total area of 2850 cm^2 (by camera) and 2805 cm^2 (by scanner) for a total weight of 37 g.

From the data obtained in the characterization of the contact surface of the oak chips and taking into account the current doses employed in oenology namely 2; 3; 4; 5 $g.L^{-1}$ [3] the wood/wine contact surface was calculated (Table 2).

Table 2. Data calculated for the oak chips.

Oak chips	Contact surface (dose of oak chips, x $g.L^{-1}$), **$cm^2.L^{-1}$**				Needed dose of oak chips for a contact surface similar a Bordeaux barrel (91 $cm^2.L^{-1}$), **$g.L^{-1}$**
	2 $g.L^{-1}$	3 $g.L^{-1}$	4 $g.L^{-1}$	5 $g.L^{-1}$	
XOV US	*(3674*2 /104)=* **71**	*(3674 *3/10 4)=* **106**	*(3674*4 /104)=* **141**	*(3674 *5/10 4)=* **177**	*(91*104 /3674)=* **2,57**
XOV Fr	*(3815*2 /101)=* **76**	*(3815 *3/10 1)=* **113**	*(3815*4 /101)=* **151**	*(3815 *5/10 1)=* **189**	*(91*101 /3815)=* ***2,41***
DS Fr	*(7230*2 /200)=* **72**	*(7230 *3/20 0)=* **108**	*(7230*4 /200)=* **145**	*(7230 *5/20 0)=* **181**	*(91*200 /7230)=* ***2,52***
OG Md (by camera)	*(9074*2 /218)=* ***83***	*(9074 *3/21 8)=* ***125***	*(9074*4 /218)=* ***166***	*(9074 *5/21 8)=* ***208***	*(91*218 /9074)=* ***2,19***
OG Md (by scanner)	*(8989*2 /218)=* ***82***	*(8989 *3/21 8)=* ***124***	*(8989*4 /218)=* ***165***	*(8989 *5/21 8)=* ***206***	*(91*218 /8989)=* ***2,21***
OS Md (by camera)	*(2850*2 /37) =* ***154***	*(2850 *3/37) =* ***231***	*(2850*4 /37) =* ***308***	*(2850 *5/37) =* ***385***	*(91*37/ 2850)=* ***1,18***
OS Md (by scanner)	*(2805*2 /37) =* ***152***	*(2805 *3/37) =* ***227***	*(2805*4 /37) =* ***303***	*(2805 *5/37) =* ***379***	*(91*37/ 2805)=* ***1,20***
Bordeaux wine barrel (225 L)	*(20400/ 225)=* **91**	*(2040 0/225) =* **91**	*(20400/ 225)=* **91**	*(2040 0/225) =* **91**	-

To calculate the contact surface ($cm^2.L^{-1}$) the calculation was used as follows: the total contact surface determined by image analysis (cm^2) was multiplied by the dose of the oak chips used ($g.L^{-1}$) and divided by the weight of the oak chips sample (g). For instance, in the case of Chips XOV US, for a dose of 2 $g.L^{-1}$, the following result was obtained: 3674 cm^2 * 2 $g.L^{-1}$ / 104 g = 71 $cm^2.L^{-1}$. Thus, it was performed the calculation for the studied methods and they are compared with the results known for the barrel (91 $cm^2.L^{-1}$) [5].

The contact surface was determined and we can to see the results are close for the studied samples, except oak chips OS Md, which larger surface. This sample has smaller pieces compared to the others samples. *For example,* for a dose of oak chips of 2 $g.L^{-1}$, there is a contact surface of 71 $cm^2.L^{-1}$ (XOV US), 76 $cm^2.L^{-1}$ (XOV Fr), 72 $cm^2.L^{-1}$ (DS Fr), 82-83 $cm^2.L^{-1}$ (OG Md), and 152-154 $cm^2.L^{-1}$ (OS Md). Except the OS Md, the dose of oak chips of 2 $g.L^{-1}$ for other samples has a smaller contact surface compared to that of the barrel, while the doses of oak chips of 3; 4; 5 $g.L^{-1}$ have a bigger contact surface that for the barrel. The obtained results concerning the contact surface, for the samples OG Md and OS Md, determined by capturing the images by two different methods (camera, scanner) are similar and doesn't depend on the method.

In the last column in Table 2 there are calculated the doses of oak chips necessary to have a wood/wine contact surface similar to that of an oak barrel ($g.L^{-1}$). Thus, the wood/wine contact surface in the case of an oak barrel (91 $cm^2.L^{-1}$) was multiplied by the weight of the oak chips sample (g) and divided by the total contact surface determined by image analysis (cm^2). For instance, in the case of Chips XOV US, the following result was obtained: 91 $cm^2.L^{-1}$ * 104 g / 3674 cm^2 = 2,57 g oak chips necessary to have a wood/wine contact surface similar to that of a barrel. As a result, in order to have a wood/wine contact surface of 91 $cm^2.L^{-1}$, when using oak chips, the following doses are necessary: XOV US oak chips of 2,57 $g.L^{-1}$; XOV Fr oak chips of 2,41 $g.L^{-1}$; DS Fr oak chips of 2,52 $g.L^{-1}$. Oak chips OG Md (by camera) of 2,19 $g.L^{-1}$ and oak chips OS Md (by camera) of 1,18 $g.L^{-1}$.

4 Conclusions

Wine aging in the presence of oak chips is an important process in oenology, hence the need to understand and better control this process. In the case of wine aging on oak chips, the wood / wine contact surface plays an important role for its characteristic features and the knowledge of this surface can bring to diminishing the time allotted for the supervision of the process, to reducing organoleptic and physical-chemical analysis, etc.

There were studied five samples of oak chips different from the point of view of their origin, production and supplier (XOV US, XOV Fr, DS Fr, OG Md and OS Md) used in oenology. It was calculated the necessary quantity of oak chips in order to have a wood/wine contact surface similar to that of the oak

barrel. Two different image capture tested method (by camera, by scanner) give the similar results.

The image analysis, performed by using the open-source software ImageJ, is a modern and accessible method for the understanding of the conditions of wine aging on oak chips.

References

1. P. Chatonnet, *Influence des procédés de tonnellerie et des conditions d'élevage sur la composition et la qualité des vins élevés en fûts de chêne,* PhD thesis, Institut d'oenologie, Université de Bordeaux II, (1995).
2. I. Chiciuc, *Etude des paramètres affectant le transfert d'oxygène dans les vins,* PhD thesis, Université Sciences et Technologies Bordeaux I, (2010).
3. P. Ribéreau-Gayon, Y. Glories, A. Maujean, D. Dubourdieu, *Traité d'oenologie : Tome 2, Chimie du vin, Stabilisation et traitement,* Editeur : Dunod, 566 p., (2004).
4. M. Stawarczyk, K. Stawarczyk, *Use of the ImageJ Program to Assess the Damage of Plants By Snails,* Chemistry-Didactics-Ecology-Metrology. Volume 20, Issue 1-2, pp. 67–73, (January 2016).
5. M. del Alamo Sanza, I. Nevares Dominquez, L.M. Carcel Carecel, L. Navas Gracia., *Analysis for low molecular weight phenolic compounds in a red wine aged in oak chips,* Analytica Chimica Acta 513, pp. 229-237, (2004).