What is the goal of the wine chromatic characterization in a CIE color space?

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ABSTRACT

There is a vast amount of specialized literature about color, and on the other hand, a vast amount of specialized literature about how to characterize wine color. The proposed methods to asses wine color were evolved: from Sudraud in the late 1950s through Glories in the mid-1980s to the nowadays CIE tristimulus based values. This evolution rise the question about the objective of a chromatic characterization of wines which in turns challenges the supposed advantages of evaluating the color of wine through a CIE color space. We present a bibliographic review in order to analyze the ideas behind wine color characterization. One finding of this review is the fact that wine color becomes an ambiguous concept that oscillates between a naive definition of color and a chemical one.

Keywords: *wine color, CIE color space, color characterization*

INTRODUCTION AND THEORY

Although color is one of wine the most outstanding characteristics, it could be said that the idea of a precise, and useful, wine color characterization begins when chemical knowledge reaches a level that allows us to explain “color” from the composition of the wine, particularly on the basis of phenolic compounds. That is the reason why Sudraud (1958) measured optical absorbancies at 420 and 520 nm to characterize “hue” and “color density” in order to quickly obtain some relevant information about wine age and condition; of course, such information comes from the fact that the phenolic composition interacts optimally with light at these wavelengths. The same logic was followed by Glories (1984) when incorporates a new wavelength (620 nm) to quantify “color intensity”, a modification to Sudraud’s method with the objective of enhance the weight of “red”. Both Sudraud and Glories, followed the same reasoning: compositional aspects of the wine (e.g. phenolics, tannins

and anthocyanins combinations) determinate wine color and these (chemical) compositional aspects can be estimated by measuring absorbancies at the specified wavelengths.

On the grounds of they work, the following formulas were obtained:

"Color" intensity (CI)	=	$A_{420} + A_{520} + A_{620}$
Hue (Tone)	=	A_{420} / A_{520}
Proportion of Blue	=	$100 * A_{420} / CI$
Proportion of Yellow	=	$100 * A_{520} / CI$
Proportion of Red (dA%)	=	$100 *(A_{520} – ½ * (A_{420} + A_{620})) * 1/A_{520}$

Table 1: "Color" indicators derived from Sudraud and Glories. All A values are absorbancies. All numbers in subscript are wavelengths.

A word on the measurement procedures must be said to complete the picture of the information that is encoded by these indicators. Using a spectrophotometer records are taken of the absorbance at 420, 520 and 620 nm with the sample in a cell of certain width (path length), typically 1, 2, 5 or 10 mm. Thus, absorbancies depends upon cell width and therefore absolute quantities (e.g. "color" intensity) will also varies accordingly. In order to compare two "color" intensities we must first ensure that the numbers were obtained from the same cell width. It is a common practice to refer all absorbancies to a cell width of 10 mm (Somers and Evans 1977).

The formulas cited above become usual in wineries and a standard for winemakers. The Office Internationale de la Vigne et du Vin (OIV) adopted these indicators in 1962 and in 1990. However, at the same time, the OIV had also recommended to follow a simplified CIE tristimulus, based method to characterize wine color (a more detailed story in Martínez et al. 2001; for a detailed review about the relationship between chemical wine compounds and color: Boulton 2001. A good starting point about the ideas of the relationship between chemical compounds and the effect on perceived color is Gonnet 1998). At this point, it is interesting to ask why (and what for) the OIV recommend both methods simultaneously.

Conceptually the Sudraud and Glories formulas, from a visual point of view, do not encode any color information at all (which explains our use of the quoted word "color" to refer to its terms). These formulas assume that the color belongs to the object itself and, consequently, avoids a description of the three "basic" color attributes: hue, saturation and lightness; it also reduces color to a physical phenomenon and does not take it as a psychophysical one, which involves a light source, an object and an observer. On the other hand, the CIE tristimulus method, does encode color information as a psychophysical phenomenon and, in principle allows us to derive the three basic color attributes. In fact, the XYZ values refers to a "metameric state" of the visual system: the same visual stimulation will be achieved by adjusting the XYZ primaries in those particular values onto a white reflective surface. Of course, assuming the observer is at the same (white light) adaptation state. Thus, it seems to refers to the wine's color "as seen in the glass".

This idea that wine color information is better coded by the CIE indicators led some researchers to look for a possible linear transformation of the absorbencies (used to calculate chemical color indicators) into XYZ primary values. Some studies have shown very good agreement between the

numbers obtained with the "primaries" of Sudraud-Glories method and their respective XYZ or Lab values (Monagas et al. 2006, Pérez-Magariño and González-Sanjosé 2003; see Table 2). However, the lack of a good correlation between instrumentally estimated values and visual evaluations of consumers and winemakers cast doubt on the benefits of this color characterization (Little 1980). While it is true that CIE indicators can be interpreted more easily with respect to color perception, the results do not show the expected best correlation with perceptual evaluations.

The above problems led, on the one hand, to seek alternative methodologies to characterize the color of the wine and on the other to indicate the limits of current methodologies (Martin et al. 2007, Pridmore 1999, 2005).

CIE primary		Formula
X	=	$0.42 * A_{625} + 0.35 * A_{550} + 0.21 * A_{445}$
Y	=	$0.20 * A_{625} + 0.63 * A_{550} + 0.17 * A_{495}$
Z	=	$0.24 * A_{495} + 0.94 * A_{445}$

Table 2: Linear transformation from absobancies to XYZ primaries. Formulas from the OIV. All A values are absorbancies. All numbers in subscript are wavelengths.

DISCUSSION

The logical path that has been followed, has combined a mixture of knowledge and technology that was at hand. Not wonder that has begun by the correlation between the chemical characteristics and those elements of the wine that determine its coloration: in the winemaking process, the chemical control of these variables is key, since otherwise the entire product can be ruined. On the opposite end, once the product has been prepared, winemakers embark on the competition for the conquest of the consumer, for which it is essential to achieve a specific color (Hutchings 2002). However, it is not so simple the relationship between the chemical variables that underlie the color of the wine and the color perceived by consumers or specialists. On the contrary, wine, from a visual point of view, is extremely complex: it is a translucent liquid substance, with different amounts of elements suspended in it and that can be seen in containers of variable geometry which results in different thicknesses of the beverage; in addition, lighting conditions can vary greatly. All this explains in some way the reasons why good correlations with color systems have not yet found. Its reduction to, generally, three variables, results in a too simplified version that does not succeed capture the most relevant keys related to the color of the wine.

This has resulted in the characterization appeals to a "chemical" color to indicate specific characteristics and a trichromatic color to indicate others. In this sense, while chemical characterization is based on a long tradition and proven utility, the reduction to a CIE color space does not end, from our point of view, of justifying their employment. This lack of justification lies above all in that the use of a CIE color space does not meet expectations about the usefulness of having such a characterization.

CONCLUSION

In conclusion, we can say that the characterization of the color of the wine through a CIE color space does not reach the objective of summarizing, in a few indicators, the most relevant information about the color of the wine "as seen in the glass". We think that it is necessary to think about what color appearance models propose, models that are still in development. In this regard, the wine complexity should be incorporated, developing and specifying the concepts that are considered as key. Some of them could be those that are already encoded in the vocabulary of color appearance.

A separate condition that should be verified, it would be the correlation between the indicators that characterize the color and the chemical characteristics that underlie this color.

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