System for Visual Assessment of Wine Color

Mark D. Fairchild [1,*]

[1] Program of Color Science / Munsell Color Science Laboratory, Rochester Institute of Technology, Rochester, NY USA; mdfpph@rit.edu

***** Corresponding author: mdfpph@rit.edu

Abstract

This paper presents a color chart explicitly designed for the color assessment of wines as a part of a more comprehensive hedonistic or analytical tasting systems. The chart is based on visual, colorimetric, and *in situ* evaluations of existent wine color and the techniques for its assessment in wine tasting. The system is specified in Munsell coordinates and corresponding sRGB values. Its derivation and use is described and a photographic-based system for measurement-based implementation of the system is also introduced.

Keywords: *Wine Color, Visual Assessment, Standard System, Reference Color Chart*

INTRODUCTION

Color perception is an integral part of the enjoyment of foods and beverages. Consumables with outstanding aromas and flavors often cannot overcome a negative first impression, based on visual perception, to be thoroughly enjoyed. The significant impact of visual perception on the overall perceived quality of wine is well recognized and systematic processes for sensory wine analysis usually start with an assessment of color and other visual attributes. In his book on *neuroenology*, Shepard (2016) explains that all wine descriptive language is organized around prototypical wine types and that sensory properties are not separately analyzed, but rather compared collectively with cognitive associations of wine color, aroma, and taste to recall words previously used to describe the same category of wine. Color takes on a primary role in this process because it is normally among the first perceptions of a wine sample. Additionally, it has been observed that color is, in fact, the only common category among expert tasters. In other words, color is likely the only independent perception of the wine and it is relied upon heavily to stoke the memories of the category of wine, which then helps generate appropriate words to describe the other sensory attributes for that particular category.

Unfortunately, the color descriptors used in wine analysis are often unclear and confusing to experts and novices alike. For example, the Court of Master Sommeliers (2017) uses terms such as water-white, straw, yellow, gold, purple, ruby, and garnet while the Wine and Spirits Education Trust (WSET, 2019, 2016) suggests lemon-green, lemon, gold, amber, brown, pink, salmon, orange, purple, ruby, garnet, and tawny in their level 2 and level 3 assessment systems. Many of these terms are ambiguous at best and some are not color names at all. For example, lemon, straw, and even garnet evoke different color perceptions in various observers. Additionally, lightness and saturation dimensions are often ignored or somehow combined into pale, medium, and deep descriptors of terms defined as either concentration or intensity.

This paper introduces a new system to describe wine color with the objectives of being based on sound color science, being made up of unequivocal color terms, and being simple to explain and use. The hope is that such a system might help bring more consistency to sensory analysis of wine and better quantify the relationships between color, expectations, and flavor. The system was developed through a systematic analysis of wine colors in the CIELAB space that indicated that wine colors tend to follow a single path through the color space as they vary in hue, lightness, and saturation simultaneously. Taking hue as the most important dimension, it becomes clear that the remainder of the variation can be explained with saturation (which also correlates well with lightness changes as suggested by the traditional terms of intensity or concentration). Once the path of wine colors through

color space was understood, representative samples were created as visual reference points for a scaling system. These reference points were ultimately specified systematically using the Munsell system and secondarily specified in sRGB coordinates.

The system is based on scaling the primary hue as either yellow, orange, or red and then a secondary hue as either green or orange for the yellow primary hue, yellow or red for the orange primary hue, and orange or purple for the red primary hue. Once the hue is established the saturation (or depth) of the color is then specified on a three point scale (low, medium, high) that is also represented with reference color samples. The system is embodied both as a reference color chart and as part of a systematic wine assessment grid. This paper will present the derivation of the system, its specification and embodiment, and a photographic system designed to allow automated specification of wine colors in addition to visual assessment.

THE COLORS OF WINE

The colors in wine are produced in complex and not fully understood ways. The main colorants in white wines are flavonoids that are responsible for coloration in many plants, while red wine colors are largely produced by anthocyanins, a particular class of flavonoids. However the exact colors in a given sample of wine depend on the grape variety, enological practices such as skin contact and other extraction techniques, other chemical constituents in the wine, wine pH, age, storage conditions, and ultimately the viewing or measurement techniques. Boulton (2001) provides an excellent review of many of the variables involved. In addition, Fairchild (2018) reviewed the colorimetry of wine and the important and significant influence of illumination color on the perception of wine. Unfortunately, illumination is often completely ignored in even sophisticated wine evaluation protocols, judging, and competition and this can result in wide ranging color assessments and conclusions for the same wine. For example, two extremely experienced sommeliers evaluated the same wine as “deep purple” and “garnet” (orangish-red). Careful analysis of the wine indicated that it was simply “red” with no hints of purple or orange. The large discrepancy results in very different interpretations of the wine and is likely caused by differences in illumination, but individual differences in color vision can also contribute.

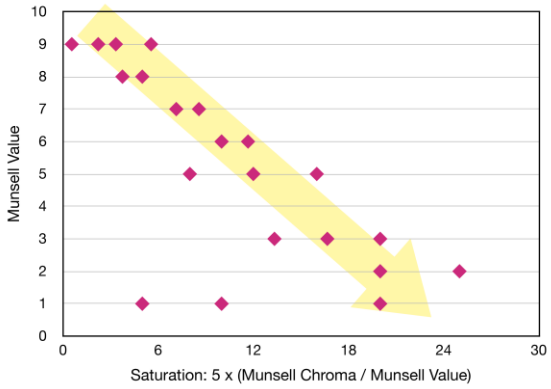

Figure 1: Munsell Value and saturation (computed as 5 times Munsell Chroma divided by Munsell Value) for the wine color reproductions rendered in the Color of Wine poster.

An exhaustive colorimetric evaluation of wine colors is prohibitive in both cost and time. To get an initial sense of the color ranges found in wine, the author referred to three sources. The first was a collection of tasting notes in which a wide variety of wines were analytically evaluated over a long time period. The other two are widely distributed posters that have been carefully designed and colored to represent the range of wine colors. In essence these represent “color order systems” for wine. The

Bouchard Aîné & Fils (undated) example illustrates a range of 74 wine samples and the Wine Folly (2019) chart includes 36 samples. Neither should be considered accurate colorimetric samples of wine, but both have been carefully visually assessed for accuracy and are representative of normal wine colors. The colors of the 36 samples from the Wine Folly chart are plotted in Munsell coordinates in Figure 1. It is clear from Figure 1 that most wine colors follow a one-dimensional path through the value-saturation space in which low value is correlated with high saturation. This agrees with visual assessment of real wine samples and indicates that a full three-dimensional color space need not be sampled to produce an effective representation of wine color. Instead, all that is needed is first a classification of hue, from greenish-yellow, through orange, to purplish-red followed by a second dimension representing the depth of color, which is the combined variation of lightness (value) and saturation represented in Figure 1.

DEVELOPMENT OF A WINE COLOR REFERENCE CHART

The wine reference chart was developed by selecting Munsell samples representative of the the three main wine hues, yellow, orange, and red and then variants of those in the directions of green and orange for yellow, yellow and red for orange, and orange and purple for red. These “medium-depth” samples are represented as the middle strip of colors in Figure 2. Then samples for more (deep) or less (light) depth were selected for the main primary hues. These are represented to the immediate left and right of the main strip of color samples. Figure 2 includes three copies of the chart. One labeled with color names, one unlabeled, and one labeled with Munsell designations.

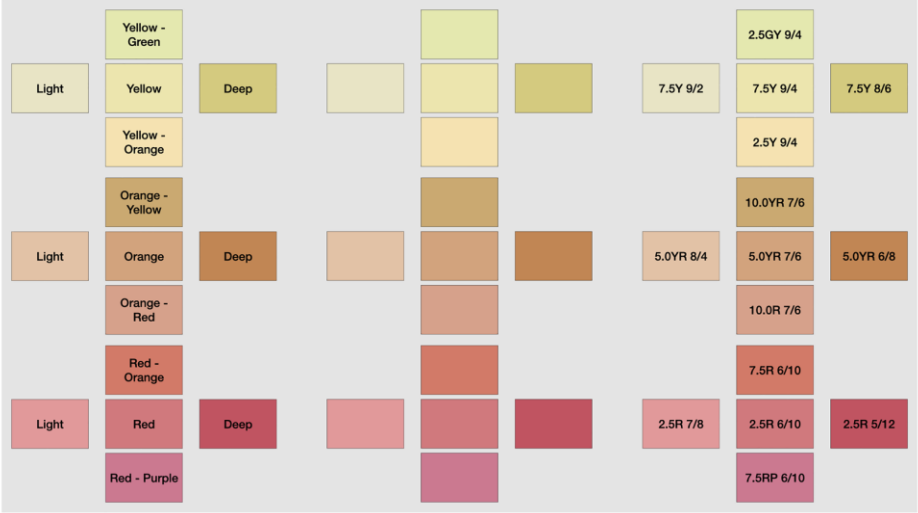

Figure 2: The representative samples from the proposed wine color reference chart on a light gray background. The set on the left includes descriptive color names for white (yellow), orange, and red wines and the set on the right includes the nominal Munsell designations of the reference samples.

The chart itself is not necessary once the simple process of naming wine color by primary hue (yellow, orange, red), secondary hue (green, yellow, orange, purple), and depth (light, medium, deep) is understood. However, wine color can also be scaled directly relative to the chart using the form illustrated in Figure 3. The Munsell samples on a light gray background are used on the left side of the chart while a uniform white area is used as a background to the wine glass on the right. Wine samples should be viewed in a tasting glass tilted toward the observer such that the thinnest part of the wine sample can be viewed directly rather than through the top glass surface if possible. Illumination should be natural daylight or a high quality daylight simulator (*e.g.* color rendering index of 95 or greater) at

an illuminance level on the order of 1000 lux. Observations are recorded by first naming the primary hue present in the sample: Yellow, Orange, or Red. Then if any secondary hue is present (*e.g*. Orange or Purple for red wines), it is also named. Thus wine hue is recorded as a one- or two-word simple hue name as illustrated in Figure 2. Lastly, a decision is made on whether the color depth in the wine is light, medium, or deep. Ultimately, these categorizations result in a simple set of 27 color categories for wine samples. While intermediate points could be used for more precision, even the most highly trained wine evaluators cannot consistently name wine colors with precision exceeding these 27 points, often not even agreeing on hue. In addition, color variation in wine is sometimes important. In such cases, this scaling procedure can be used separately for the body of the wine and the edge of the sample (know as rim variation and often recorded as a separate color).

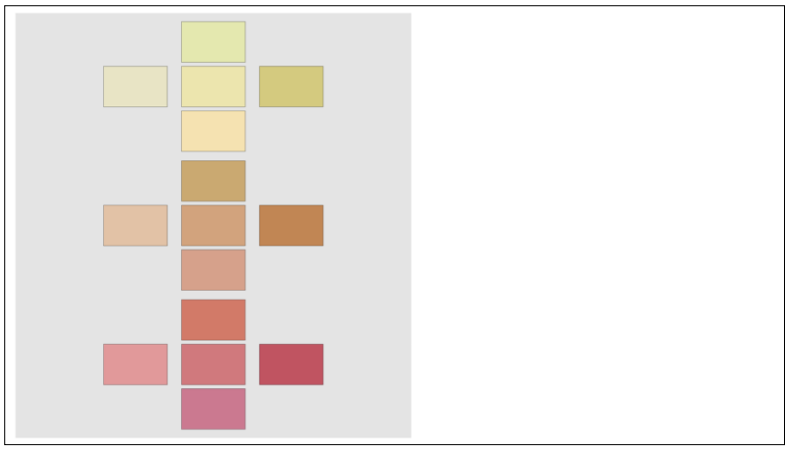

Figure 3: The wine color reference chart as is should be used with the samples on the left side of a page on a light gray background and a blank white area to the right over which the wine samples can be viewed *in situ*.

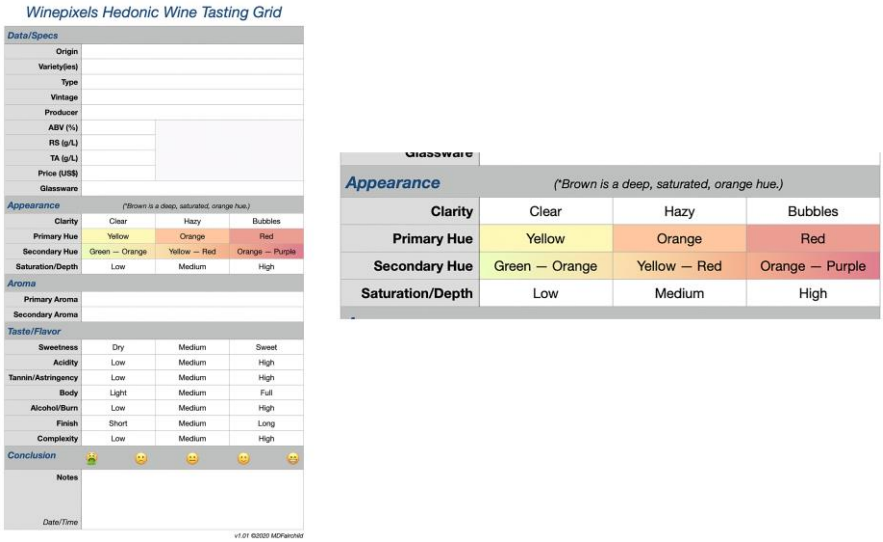

Figure 4: An example of a custom wine-tasting grid that includes the proposed system for wine-color specification (zoomed on the right).

Figure 4 illustrates this wine color naming system incorporated into a full, customized hedonic (rather than analytical) wine tasting grid. Tasters can simply circle their responses for the clarity, primary hue, secondary hue, and saturation/depth of the wine. This system is far easier for tasters, especially those with little training in wine tasting systems, to make consistent, repeatable, and

understandable color assessments of their wines. Thus, simply put, such a color naming system is more useful than the non-intuitive systems used by experts that require training and use non-color terms to scale color appearance (thus requiring consensus definitions). This system should also be easily translatable into other languages.

IMAGING-BASED SYSTEM IMPLEMENTATION

While the wine color chart was designed for use as a visual reference for direct comparison or through memory matching, it would also be desirable to design and implement an image-based measurement system that could be used to photograph wine samples and then assign them to one of the 27 categories. As such, a photographic system was designed, implemented and tested. This is a non-trivial task as the accurate hue-reproduction of wine photographs is known to be notoriously difficult. This is due to the observer-metameric properties of wine spectral reflectance/transmittance distributions, variations in illumination color and spectra, and variations in camera color responsivities relative to one another and relative to human observers. Nonetheless, the challenge was taken.

The system was constructed using a special holder for ISO tasting glasses such that they could be photographed from above while tilted at a significant angle with a consistent volume of wine. This simulates visual wine assessment and allows various wine thicknesses to be simultaneously imaged. The samples were illuminated from the two sides using LumeCube 2.0 professional lighting systems (5600K daylight at approximately 1500 lux). Images were collect with a dedicated Nikon D5100 DSLR built into the copy-stand system. Raw images were collected and then white balanced and linearized using an X-Rite ColorChecker Passport system and Adobe Photoshop. Images were then converted to calibrated sRGB values. A set of eight wines, white, orange, and red, were used to calibrate the system.

Figure 5 shows one example image from the system. As illustrated on the right side of Figure 5, a fixed circular area near the rim of the wined outside any surface reflections was selected, averaged, and sampled to provide a single representative color signal for indexing into the standard system. A simple linear model (sRGB in the image to sRGB in the chart) applied on R, G, and B, independently was used to correct the samples. Figure 6 illustrates the typical results for the worst case (Pinot Noir) and a typical case (Zinfandel). These predictions are just barely good enough to index into the system with digital value errors typically less than 10 out of 256. However it is clear that the metameric properties of the wine samples results in a typical hue shift (toward orange for red wines) in the photographs. This can be corrected with a more sophisticated color correction algorithm that has showed good promise in producing accurate renderings and will be the subject of a future paper.

Figure 5: Examples of a wine sample in an ISO taster glass photographed in a calibrated illumination system. The right image shows the sampled area that was averaged to create an automated classification system (and also provides a nice example of simultaneous contrast; the circular area is physically uniform).

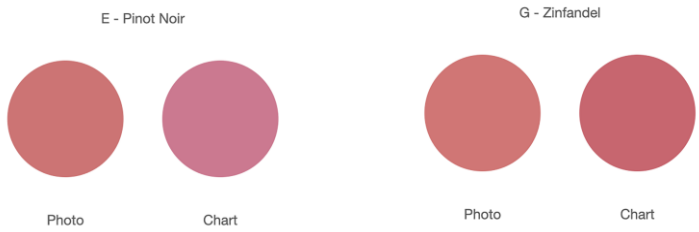

Figure 6: Examples of the worst (Pinot Noir) and typical (Zinfandel) automated classification of the wine samples.

CONCLUSIONS

The careful and consistent observation and recording of wine color is known to be critical for both analytical and hedonistic wine tasting, review, and judging. Historically the systems for recording wine color appearance are very imprecise, use non-color terminology, and are implemented in substandard and uncontrolled viewing conditions. This paper has introduced a simple, easy to use, intuitive, precise, accurate, and easily communicated wine color specification system along with a standard chart for reference purposes. It is hoped that such a system can bring clarity and consistency to the all-important judgement of wine color by wine lovers, enthusiasts, experts, and professionals alike and ultimately increase the enjoyment of wine while facilitating perceptual observation of the the other dimensions of aroma, flavor, and taste. In addition the first steps toward automating the system photographically were introduced as a work in progress.

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