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Sensory and chemical drivers of wine minerality aroma: An application to Chablis wines

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ABSTRACT

The goal of this work was to evaluate the effect of vineyard position on the minerality of wines and to establish relationships between minerality scores, sensory descriptors and chemical composition. Sensory analyses included minerality rating and free description performed by wine professionals under two conditions: orthonasal olfaction alone and global tasting. Chemical characterization included analysis of major and minor volatile compounds, volatile sulphur compounds, mercaptans, metals, anions and cations. Results showed a significant effect of the river bank on wine minerality scores only in the orthonasal olfaction condition, samples from the left being more mineral than those from the right bank. Methanethiol, involved in shellfish aroma, was significantly higher in wines from the left (more mineral) than from the right bank. Contrary, copper levels, related to lower levels of free MeSH, and norisoprenoids, responsible for white fruit and floral aromas, were higher in wines from the right bank (less mineral).

1. Introduction

Flavour plays an important role in food and beverages appreciation and consumption. Flavour perception is a system that involves diverse chemical compounds, peripheral receptors and the brain, resulting in a very complex system. An example of this complexity is wine, an alcoholic beverage comprising a wide range of volatile and non-volatile components interacting to form wine flavour. Quantification of sensory-active molecules has been useful for instance in better understanding the perceived quality of wines of different varieties and regions (Sáenz-Navajas et al., 2015), understanding the source of some wine aroma descriptors (Ferreira et al., 2016) and disclosing wine styles (Liu et al., 2015). One of the most intriguing wine styles is mineral wines. Minerality is an ill-defined sensory descriptor widely used nowadays, though absent from the famous "Wine Aroma Wheel" (Noble et al., 1984).

Recently, this term has been popularized by critics, winemakers and consumers, and has caught researchers' attention. As a result, a number of studies have been conducted to better understand this ill-defined sensory descriptor. Most of these studies were rather descriptive. Some focused on sensory perception, through the relationship between minerality and sensory descriptors like reductive notes, sulphur, cabbage, cardboard, flinty/smoky, chalky/calcareous, wet stone, citrus, and fresh, which are positively correlated with the mineral character and tropical fruits, passion fruit, butter, butterscotch, vanilla and oak which are negatively correlated with this character (Ballester, Mihnea, Peyron, & Valentin, 2013; Heymann, Hopfer, & Bershaw, 2014; Parr, Ballester, Peyron, Grose, & Valentin, 2015). Other studies were based on the correlation between sensory perception of minerality and chemical composition of the wines. According to Heymann et al. (2014), perceived minerality was moderately associated with free and total sulphur dioxide and strongly associated with malic acid, TA and tartrate level which supported the idea that sour taste would be involved in wine minerality. Moreover, in the particular case of Sauvignon blanc (Parr et al., 2016), the significant associations

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differed as a function of participant culture: for French assessors, minerality was positively associated with isoamyl acetate and free sulphur dioxide while other compounds as total acidity and tartaric acid, were negatively associated. For New Zealanders assessors, minerality was positively correlated with Na, Ca, total sulphur dioxide, malic acid and hexanoic acid and was negatively correlated with isoamyl alcohol, isobutanol and diethyl succinate.

Only a few studies looked at the theoretical origin of minerality. Baroň and Fiala (2012) hypothesized that minerality could come from yeast metabolism during the fermentation of musts poor in nitrogen. From a geological perspective, according to Maltman (2013) the minerals in wine are nutrient elements (typically metallic cations) and are only distantly related to vineyard geological minerals, which are complex crystalline compounds. Finally, Rodrigues, Ballester, Sáenz-Navajas, and Valentin (2015) and Deneulin and Bavaud (2016) looked at the conceptual aspects of perceived minerality and highlighted the idea of "*terroir*" as the origin of minerality in the mind of consumers. However despite these scientific efforts, the origin of minerality remains unclear.

The general goal of the present study is to verify if the idea of an origin of the minerality in the terroir has a scientific foundation. According to Van Leeuwen and Seguin (2006), terroir is *"concerned with the relationship between the characteristics of an agricultural product (quality, taste, style) and its geographic origin, which might influence these characteristics*". As it is very difficult to assess the joint effect of all the different geographic variables (soils, climate, microclimate, slope, etc) that make up a terroir (Van Leeuwen et al., 2004) the effects caused by those parameters on vine, grapes or wine have been independently reported (Van Leeuwen & Seguin, 1994). According to Bramley and Hamilton (2007), vineyards are not homogeneous and different wine styles can emerge from different parts of the same vineyard even when similar agricultural management is implemented. Within-vineyard variability can be attributed to either climate variability (i.e. what Van Leeuwen & Seguin, 2006 called *meso* climatic variability) or soil variations (i.e. what Van Leeuwen & Seguin, 2006 called topoclimatic variability). This is particularly the case of terroirs characterized by complex morphology as slopes and elevations. In this sense, different authors contemplate the study of vineyards variability from: a Precision Agriculture (PA) viewpoint (Bramley, 2001), from a grape berry quality perspective (Fourment et al., 2013) and considering the effects of topoclimatic variability on final wines (Bramley & Hamilton, 2007). This last approach is one of the few which demonstrated clear differences among sensory attributes of wines produced from areas of lower and higher grape yield and vine vigor within the same vineyards under uniform management.

In France, vineyard variability lead to the notion of *Crus* and an example of this is the AOC "Chablis *Premier Cru*". Depending on the specific geographic origin of grapes and thus on "topoclimatic variability" wines coming from a given cru can be fruitier or conversely more mineral than wines coming from another cru (Cahier des charges de l'Appellation d'Origine Contrôlée «Chablis Premier Cru»., 2012). The present work focuses on Chablis Premier Cru AOC: This AOC is marked by a temperate oceanic climate with continental trends (see agroclimatic data of Chablis zone in Supplementary Material 1) and has the peculiarity of being planted along both banks (right and left) of the Serein river (Fig. 1). According to Cannard (1999) the right bank has vineyards with predominant southwest sun exposure that can facilitate the grape maturity and the wines tend to be fruitier. On the other hand, the left bank tend to have southeast sun exposure, and thus less is conducive to maturation.

Building on this topoclimatic variability, to evaluate the effect of terroir on wine minerality we looked at the effect of the serein river bank on perceived minerality intensity of Chablis wines and we identified the sensory and chemical drivers of this effect. More specifically, the following two questions were addressed: 1) which river bank produces the more mineral wines? 2) Which are the sensory and chemical compounds associated with perceived mineral intensity?

2. Materials and methods

2.1. Sensory and chemical characterization of wines

2.1.1. Wines

Eight wines were selected among the AOC Chablis Premier Cru: four originating from the left bank of *Serein* (*Cote de Léchet, Montmains, Vaillons and Beauroy*) and four from the right bank (*Montée de Tonnerre, Mont de Milieu, Fourchaume and Vaucoupin*). To avoid an interaction between minerality and vintage all wines were from the 2013 vintage. Likewise to avoid other confounds like aging and vinification process all wines were aged one year in bottle and were elaborated by the same wine producer using the same winemaking process in stainless steel tanks. The list of samples, including sample information and basic compositional data is shown in Table 1.

2.1.2. Sensory analysis

2.1.2.1. Assessors. Thirty two wine professionals (69% men and 31% women, aged between 23 and 61 years old, average = 42 years) participated in this study. They were not informed of the topic of the study. All of them were wine producers from the Chablis area.

2.1.2.2. Experimental conditions. Assessors were first asked to read and sign a consent form. Wines were presented at room temperature, in black ISO glasses identified only by random three-digit codes. The poured volume per sample was 25 mL. Samples were presented according to a Williams Latin Square arrangement. Evian water and unsalted crackers were available for palate rinsing. Participants were asked not to swallow the samples but to expectorate into wine spittoons. The sessions were performed in two different days and the average duration of each session was 40 min. In both the first and second sessions, participants were invited to evaluate the perceived minerality intensity of the samples. In the second session, participants were additionally asked to carry out a free description of the samples after having rated their minerality.

2.1.2.3. Minerality rating. During the first session, assessors were presented with the eight wines and asked to smell each sample from left to right and to score their minerality on a seven-point scale, from 1 (absent) to 7 (very intense) based on orthonasal olfaction alone. Assessors were free to compare them before scoring if they wanted. Then, they were asked to taste each wine and to score their minerality on the same seven-point scale based on global tasting. This minerality rating procedure was replicated in the second session, with the same wines presented with different codes.

2.1.2.4. Free description task. In the second session, after completion of the minerality rating task, eight new glasses of wine with the same samples but with different codes were served. Participants were asked to describe sample aroma by orthonasal olfaction alone first and then by global tasting (aroma and in-mouth properties).

2.1.3. Chemical analysis

2.1.3.1. Reagents and standards. Solvents. N-hexane for organic trace analsis (UniSolv), dichloromethane and methanol of SupraSolv quality and ethanol of LiChrosolv quality were purchased from Merck (Darmstadt, Germany). Diethyl ether and mercaptoglycerol were from Merk (Darmstadt, Germany). Water was purified in a Milli-Q system from Millipore (Bedford, MA).