Food Research International 44 (2011) 456–464

Contents lists available at ScienceDirect

Food Research International

journal homepage: www.elsevier.com/locate/foodres

The Chardonnay wine olfactory concept revisited: A stable core of volatile compounds, and fuzzy boundaries

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ARTICLE INFO

Article history:
Received 9 December 2008
Accepted 21 September 2010

Keywords:
Chardonnay wines
Sensory evaluation
Typicality level
Experts
Gas chromatography–mass spectrometry–selected ion monitoring (GC–MS–SIM)
Volatile compounds
Chemical space

ABSTRACT

An earlier study by the same team showed that Chardonnay wines have common olfactory properties by which wine experts can recognize them. The specific Chardonnay olfactory space was also tentatively linked to the relative concentrations of 29 volatile compounds, regarded as possible aroma-impact compounds. The question now is whether or not those initial results hold independently of the sample under consideration, that is, whether these sensory and chemical spaces are vintage-specific. A series of investigations was conducted on a new set of 46 wines (23 Chardonnay wines and 23 non Chardonnay wines) using the same sensory (wine typicality level) and physico-chemical (Gas Chromatography–mass spectrometry–selected ion monitoring: GC–MS–SIM) approaches as in the earlier study. The sensory space of Chardonnay wines has been identified again in this new study. Compared with white wines of other grape varieties, Chardonnay wines do have distinctive and recognizable olfactory characteristics. LSD tests carried out on the chemical data and a PLS analysis predicting wine typicality level from the chemical data showed that the relative concentrations of 35 volatile compounds affected the wines' typicality scores. Of the 35 compounds, 18 were already among the 29 possible aroma-impact compounds identified by the earlier study. These 18 common volatile compounds seem to be vintage-independent and as such might represent the core of the Chardonnay wine olfactory space. The others seem to be specific to the new wines tested and may contribute to the fuzziness of the boundaries of the Chardonnay wine olfactory space. These results emphasize the complexity of the odor quality of Chardonnay wines, with some volatile compounds remaining stable across vintages, while others are specific to enological practices and to vintages.

1. Introduction

Our understanding of what it is that gives different wines their distinctive flavors has been greatly advanced by both sensory and physico-chemical investigations. Lee and Noble (2003) noted Schreier's (1979) claim that more than 800 volatile compounds have been identified in wines. However, not all contribute equally to wine flavor. Gas chromatography-olfactometry (GC-O) is a powerful and widely used technique for identifying those volatile compounds that give wines their characteristic odor (Campo, Ferreira, Escudero, & Cacho, 2005; Pérez-Silva et al., 2006; Senger-Emonnot et al., 2006). It was used in identifying cis-rose-oxide as the most active odorous compound of Gewürztraminer (Guth, 1997a,b) and interestingly of lychees too (Ong & Acree, 1999). The same technique was used in identifying methoxypyrazines and volatile thiols as imparting its characteristic odor to Sauvignon Blanc (Allen, Lacey, Harris, & Vance Brown, 1991; Darriet, Lavigne, Boidron, & Dubourdieu, 1991; Lacey, Allen, Harris, & Brown, 1991; Parr, Green, White, & Sherlock, 2007; Tominaga, Blanchard, Darriet, & Dubourdieu, 2000). So just a few constituent compounds may give a wine its specific sensory character, illustrative of what one might call its olfactory signature. By contrast, other wines such as Syrah (Segurel, 2005) and Grenache Noir (Ferreira, Lopez, Escudero, & Cacho, 1998) prove to be aromatically complex, like Chardonnay that is investigated here.

More than 140 volatile compounds have been identified in Chardonnay by headspace analysis (Sefton, Francis, & Williams, 1993; Simpson & Miller, 1984). Of these, esters and alcohols as well as aldehydes, ketones and phenols are considered important to aroma. Their concentrations may be varied by fermentation (Etaio et al., 2008; Hernández-Orte et al., 2008; Torrea, Fraile, Garde, & Ancin, 2003) or by oak barrels (Gonzalez-Marco, Jimenez-Moreno, & Ancin-Azpilicueta, 2008; Guchu, Díaz-Maroto, Pérez-Coello, González-Viñas, & Cabezudo Ibáñez, 2006; Spillman, Sefton, & Gawel, 2004). Using GC-O, Moio, Schlich, and Etiévant (1994) and Schlich and Moio (1994) found 11 key compounds that were necessary although not sufficient to give Chardonnay its aroma: vanillin, diacetyl, 4-vinylguaiacol, ethyl cinnamate, ethyl hexanoate, ethyl 2-methylbutanoate, ethyl butanoate, guaiacol, plus three unidentified compounds described as "burnt sugar", "wet ashes" and "honey". Le Fur and Etiévant (1998) listed 17

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doi:10.1016/j.foodres.2010.09.022

constituents that were decisive for the Chardonnay aroma. The diversity of the volatile compounds reported in these initial studies indicates that the Chardonnay aroma is not simply a matter of olfactory highpoints but involves a more complex mixture. The diversity of the volatile compounds reported in these initial studies suggests that the Chardonnay aroma cannot be ascribed to a few olfactory highpoints but that it involves something more complex.

Other works have sought to demarcate the sensory ranges of wines produced from grape varietals including Chardonnay (Ballester, 2004; Ballester, Dacremont, Le Fur, & Etiévant, 2005), Melon de Bourgogne (Ballester, Patris, Symoneaux, & Valentin, 2008), Sciaccarello (Candelon, Ballester, Uscidda, Blanquet, & Le Fur, 2004) and Sauvignon Blanc (Parr et al., 2007). More specifically, Ballester et al. (2005) studied 29 Chardonnay wines and 19 other single-varietal white wines, all from 1999 to 2000 vintages and unoaked. Panelists (participants in the Chardonnay du Monde® wine competition) were asked to indicate to what extent each sample was a good example of Chardonnay (Ballester et al., 2005). The average score awarded by the entire panel was the sample's degree of "typicality". Two assessments (orthonasal and global) were made, yielding two typicality scores per wine. The results formed a typicality gradient from poor to good and revealed a significant positive correlation between the orthonasal and global assessments. Two sets of nine wines with contrasting levels of typicality (poor vs. good examples) were formed and analyzed by GC-O and then by GC–Mass Spectrometry (MS). In all 101 volatile compounds were detected although not all of them were identified. The relative concentrations of the 101 compounds were determined by GC–MS-selected ion monitoring (SIM). ANOVAs were performed for each compound based on its relative concentrations in the 18 wines selected. The findings suggested that 29 compounds (four of which were unidentified) were important for the olfactory characteristics of Chardonnay. These 29 compounds consistently occurred together and so seem to form a subset within the larger set of 101 compounds making up the chemical environment. For now this should be considered no more than a working hypothesis based on these initial results.

Both sensory and GC–MS techniques were used in investigating these issues. The sensory approach sought (i) to determine the level of consensus among professional winetasters and whether they share a common perception of the odor of Chardonnay wines, (ii) to illustrate the distribution of typicality scores to confirm that Chardonnay wines are organized along a typicality gradient, (iii) to identify two contrasting groups, and (iv) to determine the proportion of Chardonnay (and non Chardonnay) wines in the "good example" group and so confirm or invalidate the existence of an olfactory domain specific to Chardonnay.

The GC–MS–SIM sought to determine (i) which volatile compounds present in the new set of wines could account for the typicality scores and (ii) whether those compounds were the ones reported previously (Ballester, 2004).

A further objective was to evaluate a new method for characterizing the contribution of volatile compounds. First the procedure in Ballester (2004) and Lorrain, Ballester, Thomas-Danguin, Blanquet, Meunier and Le Fur (2006) was used. A one-way ANOVA with wine as factor was performed for each compound, followed by pairwise comparison of means (Least Significant Difference: $\alpha = 0.05$). This procedure being descriptive, we then sought to validate its initial findings by Partial Least Squares (PLS) regression. This method is particularly useful for predicting a dependent variable from a large set of independent variables (Abdi, 2003) when the number of variables (here volatile compounds) is greater than the number of observations (Lee & Noble, 2003, 2006; Noble & Ebeler, 2002; Tenenhaus, Pages, Ambroisine, & Guinot, 2005).

2. Materials and methods

2.1. Reagents and standards

Diatomaceous earth cartridges (Chem-Elut CE20300) supplied by Varian (Paris, France) were used for extraction. Dichloromethane (Carlo Erba Reagents, Milan, Italy) was used as the solvent, methyl heptanoate (Aldrich, Gillingham, UK) as the internal standard. Water was removed from the extract using anhydrous sodium sulfate (Prolabo, Paris, France).

2.2. Wine samples

Forty-six white wines were selected using the same criteria as Ballester et al. (2005): all were young (1–3 years, 2003–2005 vintages) and non-sparkling with less than 3 g L^{-1} of residual sugar. The wines were fermented and matured in stainless steel tanks without contact with oak barrels, except for wine C16 which, after the sensory analysis had been completed, we discovered had been matured in barrels. The wines were commercially available and came from different wine-growing areas of France: Alsace, Beaujolais, Burgundy, Corsica, Languedoc, Loire Valley, Provence, Rhône Valley and Savoy. Twenty-three of the wines were Chardonnays and the other 23 were other pure white-grape varieties. The wine characteristics (grape variety, geographical origin, vintage, and code) are presented in Table 1. Thirty nine of the 46 wines had won winemaking awards in 2004 and/or 2005 ("Chardonnay du Monde ®": 13 wines, "Challenge International du Vin": 4 wines, "Concours Général Agricole de Paris": 17 wines, "Concours de Mâcon": 4 wines, "Guide Hachette": 1 wine), vouching in principle for an absence of defects. The other seven had also won awards although not for the vintages tested.

2.3. Panelists

The panel was composed of 22 wine professionals (5 women and 17 men, age range 32–65, mean age 49) with extensive experience of Chardonnay wines. Fourteen were members of the "Chardonnay du Monde ®" wine competition panel, and the other eight had obtained BIVB (*Bureau Interprofessionnel des Vins de Bourgogne*) diplomas between 2001 and 2003 (*Certificat d'Analyse Sensorielle des Vins de Bourgogne*).

2.4. Sensory experiment

Each panelist evaluated all 46 wines in two sessions (23 wines per session) each time with a 15-minute break after the first 12 wines. The panelists were instructed: *Imagine that you want to explain to someone what a Chardonnay wine is. For that, you can suggest that the person taste a wine. For each wine presented, you must answer the following question: Do you think that this wine is a good example or a poor example of what a Chardonnay wine is?* Panelists had to answer on an unstructured 130 mm scale (one scale per sample) anchored with "very poor example" at the left end and "very good example" at the right. The wines were assessed by orthonasal perception only (direct olfactory perception). Presentation was monadic and samples were presented by a Williams Latin square. The order of presentation was different for each panelist. Session 1 involved tasting 11 Chardonnay and 12 non Chardonnay samples; in session 2, 12 Chardonnay and 11 non Chardonnay wines were tasted. Sensory experiments were conducted in a sensory room with individual booths. Wine samples (20 ml) were poured at room temperature (around 19 °C) into official ISO/INAO dark tasting glasses with plastic caps.

2.5. Extraction of wines

Liquid extraction on diatomaceous earth cartridges is suitable for analyzing aqueous samples (Plessi, Bertelli, & Miglietta, 2006) and so for wine. The samples are not shaken and so emulsions do not form, and a large range of volatile compounds can be analyzed. Given the wide range of volatile compounds and the large number of samples, this method was preferred even though it requires more solvent than other approaches. Before extraction, each cartridge was filled with