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Access to wine experts' long-term memory to decipher an ill-defined sensory concept: the case of green red wine

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ABSTRACT

The present study aims to understand an ill-defined sensory concept by a long-term memory-based strategy with Spanish winemakers from four wine regions using "green wine" as a case study. A total of 77 Spanish winemakers from four Spanish wine regions carried out a non-tasting free description task. The description task yielded terms belonging to two main categories including origin-related terms as well as sensory terms. Sensory terms belonged to aroma, taste, trigeminal, colour, multimodal and hedonic subcategories, which elucidates the multidimensionality of the studied concept. The most cited specific terms were "vegetal aroma", "bitter" and "unpleasant". Despite these commonalities, a certain idiosyncrasy linked to taste ("excessive sourness") and trigeminal ("astringency") subcategories as well as to wine components ("tannins") was evidenced as they were cited distinctly by experts belonging to separate wine regions. The capacity of approaches based on long-term memory to decipher multidimensional and ill-defined concepts is highlighted. The regional effect is also explained in terms of cognitive processes (*i.e.*, knowledge and experience), which is linked to the use of sensory concepts by wine experts.

KEYWORDS

astringency, tannins, vegetal aroma, aroma, flavour, top-down, bottom-up, cognitive

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INTRODUCTION

The evaluation of food sensory characteristics, or sensory profiling, provides valuable information for the food industry. Producers have to know the exact sensory profile of their products for quality control purposes and to ensure that the production process fulfils the producer´s requirements. In terms of product development, sensory characteristic evaluation can help in the production processes by defining the ingredient composition and thus achieve a specific and desired sensory profile. In classical consumer science, the linkage of a product´s sensory profile to the consumer´s preference or perceived quality appraisal (*i.e.*, hedonic ratings) is a very common strategy. It allows the identification of the main sensory attributes which drive the consumer preference for any single product. Conventional descriptive analysis (DA) is among the most widely used techniques for sensory profiling. DA requires a panel which is usually composed of a minimum of eight participants. In each product, the panel must have previous experience with the specific sensory attributes to be evaluated. The selected attributes have to be associated with reproducible references that unequivocally represent each term (Lawless and Heymann, 2010). This classical approach has three main limitations. The first limitation is the cost; DA is a very expensive technique, mainly due to the highly qualified panel leaders, the development of references, and the investment needed to train the panel in terms of repeatability, reproducibility and consistency. The second limitation is related to linking DA and hedonic data which assumes that the trained panel and consumers have similar perceptions of the studied products (Varela and Ares, 2012). The third limitation is related to the use of DA for complex products such as wine (Campo *et al.*, 2010). In DA, differences among products are identified by measuring monodimensional attributes, while perception is multidimensional. This meaning that perception is the result of the integration of sensory signals elicited by different sensory modalities or dimensions (visual, olfactory, taste, trigeminal) rather than the sum of individual signals as those measured by DA (Prescott, 2015). This can make in some cases to neglect sensory differences in complex products. In the last decade, alternative descriptive techniques have gained prominence. Their main advantage is to reduce training time or even to avoid it because their purpose is not to reach a consensus among participants but to identify sensory differences among products, related to either monodimensional or multidimensional perception (Valentin *et al.*, 2012). Moreover, participants describing the products are consumers, which eliminates or reduces the differences in perception between consumers (hedonic ratings) and trained panellists (sensory profile) inherent to classical approaches. The hypothesis behind these strategies is that consumers can describe products (Varela and Ares, 2012). In general, alternative techniques are more rapid and, in certain occasions, can be good alternatives to classical DA; but cannot substitute DA when an accurate description is needed (for extensive reviews concerning alternative descriptive strategies see Valentin *et al.* (2012) and Varela and Ares (2012)). The main drawback of employing untrained panels for describing products is the difficulty interpreting the terms generated by them; consumers use words employed in daily conversations, defined by Lawless and Heymann (2010) as "everyday language". To avoid this problem, in certain domains, technical experts are selected to carry out the description of products as their vocabulary is *a priori* easier to understand and more consensual than the vocabulary of consumers. Sensory analysis in wine is a very good example of this type of approach. Wine experts, including winemakers, producers, oenologists and wine critics have developed specific language and terms for describing wines and exchanging information among themselves (Brochet and Dubourdieu, 2001). However, the communication capacity of experts' descriptions was questioned some decades ago when Lehrer (1975) demonstrated a lack of understanding among wine experts. Wine experts have developed a specific vocabulary that includes "scientific terms" and "everyday language". Scientific or monodimensional terms are also employed by trained panels because they can be unequivocally represented by sensory references such as "kerosene" (represented by the molecule TDN), "violet" (β-ionone) or "honey" (phenylethyl acetate) for aroma, "sweetness" (sucrose), "sourness" (tartaric acid) or "bitterness" (quinine sulphate) for tastes, among others. "Everyday language" refers to the individual previous experience of the expert and thus likely draws on top-down cognitive processes (Parr *et al.*, 2015). In relation to this last type of language, it is a challenge to unequivocally interpret some concepts normally employed by experts when describing wines. Some examples of difficult to interpret wine concepts are: "minerality" (Rodrigues *et al.*, 2015), "complexity" (Parr *et al.*, 2011), "*bouquet*" (Picard *et al.*, 2015)

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and "green" (Sáenz-Navajas *et al.*, 2018) among others. Experts accumulate an important number of tasting experiences and identify common sensory patterns that are verbalised by using this type of language. These ambiguous sensory concepts, which are usually multidimensional, are the result of the verbalisation of perception. In this context, it is important to understand and decipher these concepts to further understand perception.

The present article is focused on understanding the concept of green wines. This concept has been inconsistently and vaguely described by different wine dictionaries: "[…] *a flavour in wine generally associated with those of grass, moss, or vegetables. Also a flavour found in wines made from underripe grapes. A certain amount of greenness can be characteristic of, and, therefore, positive in some varietals like Sauvignon Blanc. With most red varietals, however, obvious greenness is considered a fault* […]." (MacNeil, 2015) or "[…] *pejorative tasting term for wine made from grapes that did not reach full ripeness* […]." (Robinson and Harding, 2015). Similarly, the scientific literature lacks consensus when it comes to the meaning of "green wine". The concept is mainly related to aroma terms such as green vegetables or fruity/boxwood (Green *et al.*, 2011), capsicum, grass, tomato leaf and asparagus (Makhotkina *et al.*, 2012), tallow-like aroma (Mohekar *et al.*, 2017), herbaceous aroma (Mozzon *et al.*, 2016; Slabizki *et al.*, 2016), or fresh cut grass and "stemmy and stalky", this last being exemplified by frozen blackcurrants and blackberries (Saltman *et al.*, 2017). In these articles, "green wine" mainly relates to a concept formed by a diversity of terms selected retrospectively by experimenters. This has contributed to the lack of the consensual definition for the term green for describing wines. On the other hand, Gawel *et al.* (2000) carried out an exhaustive study to identify different taste and mouthfeel categories for wine descriptions resulting in the mouthfeel wheel. On the wheel, "green" was included in the main category "astringency" and the subcategory "unripe". Unripe was defined with attributes from different modalities, including taste and flavour: "[…] *a negative hedonic grouping consisting of an astringent feel associated with excessive acidity and associated green flavour notes* […]." (Gawel *et al.*, 2000). More recently, following a tasting-based strategy, a group of wine experts from the Somontano region, in Spain, scored the level of "green character" of 54 red wines. They showed that "green character" was correlated to terms linked to two sensory modalities: aroma (vegetal aroma) and trigeminal sensations (astringency) and that it had a negative valence. One weakness of the tasting-based approach is that the work is limited to samples that are previously selected by experimenters as examples of green and not green wines. This can lead to a forced scoring of the attribute even if the character is not present or if there is no perceptible difference among samples. Thus, evaluators tend to score the characteristics that differ most among the wines; which may not necessarily be the focus of study. A second limitation is related to the fatigue generated during wine tasting, which is mainly linked to the accumulation of astringent and bitter sensations. To overcome these drawbacks, Jose-Coutinho *et al.* (2015) proposed a cognitive-based descriptive methodology considering experts' long-term memory without using actual wine tasting. They employed this methodology to perform the sensory profiling of Portuguese wines. This strategy was successful in defining three distinct geographical areas in Portugal which are associated with specific wine sensory profiles. The cognitive-based descriptive methodology is proving to be a promising tool to conduct large scale sensory studies; it also eliminates the drawbacks of approaches that involve wine tasting. Thus, the present research aims to provide reliable information about the green wine concept by using a non-tasting mental descriptive task, based on experts' long-term memory.

The difficulty in the interpretation of this sensory concept could be attributed to 1) the multimodality nature of the term and 2) a lack of consensus in its use by experts accumulating different sensory experiences. Thus, in the present work, we first hypothesised that the term is multimodal, being the result of the verbalisation of perception. Besides, the lack of consensus can be the result of the distinct learning phenomena among experts; the perspective of the participants is often formed in the region where they work as winemakers. This is based on the possibility that winemakers from one region usually attend similar education sources and tasting events, furthermore, they are most probably exposed to similar wines, in contrast to experts from different regions. These common experiences within winemaking regions can lead to the development of a common referential lexicon to describe and verbalise sensory experiences and concepts (Temmerman, 2017). In this context, the second hypothesis of this article is the presence of a regional effect on experts' understanding of the green wine concept. To evaluate this hypothesis, the concept of

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green wine has been studied in four different denominations of origin in Spain by a descriptive task based on long-term memory. Therefore, the description of a real wine from memory (*i.e.*, *describe the last green wine you tasted*), which will be different for each participant, was employed to generate a more realistic description of the category, than approaches applied for the identification of a central tendency stored in mind, and thus to theoretical wine prototype (*e.g.*, *what is for you a green wine?*).

MATERIAL AND METHODS

1. Participants

Seventy-seven Spanish winemakers (65% men and 35% women, aged between 23 and 67, average of 41 years old), from four wine regions, with two to 43 years' experience in their region (average of 16 years) were interviewed. The four regions in Northern Spain mainly produce red wines (> 80% of overall production in all cases). These four regions were selected because they present marked differences in the wines produced within them. Their main differences are their geographical locations, climate, soil properties and variety. The DO Somontano region produces wines with a wide range of varieties, including foreign and national cultivars such as Cabernet Sauvignon, Merlot and Tempranillo; the latter being the most important variety. The other three regions are producers of one main national variety: Garnacha in DO Campo de Borja and Tempranillo in both DOCa Rioja and DO Ribera del Duero. These last two regions have prominent differences in both climatic conditions and soil characteristics.

Table 1 illustrates the demographic data of participants. The panel of participants did not present significant differences in terms of gender and age. Winemakers from DO Somontano had significantly more years of experience (average = 20) than those from DO Ribera del Duero (average = 12).

2. Procedure

Questionnaires were sent by email to LAAE´s database of winemakers. The questionnaire included two main parts. The first part consisted of a non-tasting free description task evoking the last green wine they had tasted: "*Remember the last time you tasted a green wine, could you please describe it?"* In the second part of the questionnaire, participants were asked if they are used to taste green wines and if they believe that wines with green character are a problem in their region. Lastly, demographic questions were asked (gender, age, wine region and years of experience as winemakers).

3. Data analysis

One corpus was obtained for each region. Terms were lemmatised and synonyms were regrouped. Then, the terms were grouped in categories and subcategories to compare their frequency of citation across regions by using a triangulation procedure (Abric, 2003). Three experimenters grouped terms belonging to similar categories and subcategories. When discrepancies were found, they were discussed until consensus was reached. Finally, the frequencies of occurrence of each individual term, category and subcategory were calculated for each group of wine experts. Only terms mentioned by at least 10% of the participants in at least one region were included in further analyses.

The effect of region on the frequency of citation of terms, subcategories and categories was assessed by means of Chi-square ($\chi 2$). Marascuilo post-hoc pairwise comparisons (95%) were carried out for significant effects. The similarities and differences among the four denominations of origin were visualised using a correspondence analysis performed on the term frequency table.

Analyses were carried out using XLSTAT (version 19.03, Addinsoft, New York, USA) and SPAD (version 5.5, CISIA-CESRESTA, Montreuil, France) software.

TABLE 1. Gender, age ranges and average age (in brackets) and range and average (in brackets) years of experience in producing wine. Significance (P-value) for each variable (ns: no significant differences). Different letters in a row mean significant differences between regions for a given variable according to post-hoc tests (Fischer test).

	DOCa Rioja (n = 19)	DO Somontano (n = 19)	DO Campo de Borja (n = 19)	DO Ribera del Duero (n = 20)	P
gender (men/women)	9/10	14/5	15/4	12/8	*ns*
age (years)	26 – 67 (41)	5 – 30 (44)	3 – 43 (42)	2 – 26 (37)	*ns*
experience (years)	4 – 35 (15)^{ab}	2 – 26 (20)^{a}	3 – 43 (18)^{a}	5 – 30 (12)^{b}	< 0.05

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FIGURE 1. Hierarchical classification of common categories, subcategories and specific terms related to the green wine concept evoked by wine experts. Areas are proportional to the frequency of citation for each category, subcategory and term.

RESULTS AND DISCUSSION

1. Categories, subcategories and terms linked to the concept of green wine

Figure 1 illustrates a hierarchical classification of terms employed to describe green wines.

A total of 23 terms were cited by ≥ 10% of participants in at least one region (Table 2). These individual terms were classified in two main categories: 1) intrinsic wine characteristics related to sensory properties (cited by 69% of experts, as shown in Table 2) and 2) origin of green wines (cited by 60% of experts). These two term categories, employed to describe the green wine concept, included six and five subcategories for sensory and origin, respectively. For the sensory category, the following subcategories could be identified: aroma, taste, trigeminal, colour, multimodal and hedonic. These subcategories correspond to the usual structure followed by experts when describing wine and recently defined as "wine tasting script" in an analogy to computer science script (Honoré-Chedozeau *et al.*, 2020). The following description is an example of the wine tasting script: "*a wine with low colour intensity, young, herbaceous aromas and in the mouth tasteless, astringent, acidic, in short, unbalanced. It was an unpleasant wine*". The structure of descriptions carried out by experts starts with a description of the colour (low colour intensity), followed by aroma (herbaceous aromas), taste and mouthfeel sensations (tasteless, astringent, acidic), then the use of global multimodal descriptors (unbalanced) and finally an overall hedonic judgement of the wine (unpleasant).

By the occurrence of these two main categories, sensory properties and origin, we see that experts follow a combination of bottom-up and top-down cognitive strategies to describe wines as was recently observed for both perceptual and conceptual categorisation of Beaujolais wines (Honoré-Chedozeau *et al.*, 2020) and previously reported by several other authors (Parr *et al.*, 2003; Solomon, 1997). The bottom-up strategy is based on the surface characteristics of the product (*i.e.*, sensory cues), that is: "tasting before thinking", while the top-down strategy refers to the participant´s previous knowledge and experience (*i.e.*, the origin of the green wine concept): "thinking before tasting" (Honoré-Chedozeau *et al.*, 2019). This means that wine experts integrate both cognitive processes when

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TABLE 2. Frequency of citation (expressed in %) of terms, categories (intrinsic/sensory, origin) and subcategories elicited in the four regions derived from the descriptive task, total frequency of terms (%) cited by all winemakers (77 participants), and significance (P) calculated from chi-square test (ns: non-significant; *P < 0.1; **P < 0.05; ***P < 0.001). Significant terms marked in bold. Different letters for a given attribute mean significant differences based on pair-wise post-hoc Marascuilo test.

CATEGORY/ Subcategory/Term	**DOCa Rioja** (%)	**DO Campo de Borja** (%)	**DO Somontano** (%)	**DO Ribera del Duero** (%)	**TOTAL** (%)	**P**
1. INTRINSIC/SENSORY	79	53	74	70	69	*ns*
1.1. Aroma	37	26	42	60	42	*ns*
vegetal	26	11	32	25	23	*ns*
herbaceous	16	5	11	20	13	*ns*
asparagus	0	0	0	15	4	*ns*
1.2. Taste	**53a**	**16b**	**42ab**	**20ab**	**32**	**
excessive sourness	**32a**	**5b**	**26ab**	**5b**	**17**	**
bitter	26	11	11	15	16	*ns*
1.3. Trigeminal	**53a**	**16b**	**42ab**	**30ab**	**35**	*
dry	21	5	16	5	12	*ns*
astringent	**26a**	**5ab**	**16ab**	**0b**	**12**	**
low body	11	5	5	15	9	*ns*
hard/aggressive	11	0	11	5	6	*ns*
1.4. Colour	21	16	21	5	16	*ns*
low colour	11	0	16	0	6	*ns*
red wine	11	5	5	5	6	*ns*
1.5. Multimodal	21	16	32	5	18	*ns*
unbalanced wine	21	16	21	5	16	*ns*
low complexity	5	5	11	0	5	*ns*
1.6. Hedonic	32	16	26	10	27	*ns*
unpleasant/default	26	11	26	10	18	*ns*
low quality	0	0	16	0	4	*ns*
2. ORIGIN	63	42	68	65	60	*ns*
2.1. Wine components	**37b**	**0c**	**32b**	**75a**	**36**	***
tannins	**26a**	**0b**	**32a**	**10ab**	**17**	*
pyrazines	11	0	5	20	9	*ns*
2.2. Wine ageing	32	32	32	45	35	*ns*
unripe/young wine	32	32	32	45	35	*ns*
2.3. Grape variety	11	32	16	10	17	*ns*
Cabernet	5	21	11	10	12	*ns*
2.4. Grape maturity	21	11	16	20	17	*ns*
unripe grape	11	5	11	15	10	*ns*
no phenolic maturity	11	11	0	5	6	*ns*
2.5. Vintage	16	0	11	20	12	*ns*
vintage 2015	0	0	11	10	5	*ns*
vintage 2018	16	0	0	5	5	*ns*

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verbalising the sensations produced by a product. In the present case, the concept of green wine activates a pure description strategy for which the participants use sensory-related terms as well as a higher-order cognitive process in which they make a diagnosis based on their technical expertise. This top-down process developed with expertise can be considered an advantage over trained panels or consumers when the objective of the task is to produce an elaborated description alongside a diagnosis of the problem. However, trained panels or consumers should be preferred when a surface description without cognitive inference is the aim, mainly because the panellists and the consumers tend to follow the bottom-up strategy (Honoré-Chedozeau *et al.*, 2019; Parr *et al.*, 2003; Solomon, 1997).

For the green wine concept, aroma (42%) was the sensory subcategory cited most, it was followed by trigeminal (35%), taste (32%) and hedonic (27%) subcategories; illustrated in Table 2. More specifically, "vegetal aroma" (cited by 23% of total wine experts), and the hedonic term "unpleasant/default" (18%) were among the most frequently cited followed by two taste-related terms: "excessive sourness" (17%), and "bitter" (16%).

Alongside sensory-related terms, the origin category presented high overall citations for the wine component subcategories (36%) and wine ageing (35%) with their respective terms "tannin" (17%) and among the most cited, "unripe/young wine" (35%). Notably, "tannin" was always accompanied by an adjective, namely "aggressive tannin", "green tannin" or "unripe tannin".

The relatively low frequency of citation of terms is related to the nature of the approach because participants were asked to describe the last green wine they tasted, and thus to exemplify the category of green wines, rather than searching for the description of a prototype, which would have led to higher frequencies of citations. The multidimensionality observed for the green wine concept in the present research coincides with the results observed in a study carried out by experts from DO Somontano which involved the tasting of 54 red wines (Sáenz-Navajas *et al.*, 2018). In that article, "green character" of wines was scored and significantly correlated with the aroma term "vegetal aroma", the trigeminal term "astringency" and with a term linked to wine components such as (dry and green) "tannins". Besides this, "green character" was negatively correlated with preference. On the one hand, these results confirm our first hypothesis related to the multidimensionality of the green wine concept. Thus, it seems to be reasonable to think that flavour perception is the result of the integration of independent sensory inputs, mainly aroma, taste and trigeminal sensations, rather than the perception of independent stimuli. This integration leads one to form a global conceptual unit (Prescott, 2015), in this case, the green wine concept. This integration of stimuli could be the result of the multidimensionality attributed to a wide range of sensory concepts such as minerality (Parr *et al.*, 2015), complexity (Parr *et al.*, 2011) or quality (Sáenz-Navajas *et al.*, 2016) among others. Prescott (2015) attributed flavour integration to repeated co-exposure of similar sensory properties or profiles for a given product, and thus to associative learning. In this context, the green concept could have been built to share and communicate experts´ sensations (Temmerman, 2017) or concrete sensory profiles that encompass multidimensional sensations co-occurring repeatedly in wines; verbalised as green. From a methodological standpoint, the long-term memory strategy employed in the present research yielded terms similar to those appearing in classical approaches while evoking new terms. The terms common to both strategies are "vegetal aroma", "astringency", "tannin" and the hedonic term "unpleasant". The new terms were linked to the sensory category and taste subcategory such as "excessive sourness" and "bitter" as well as the origin category including the subcategories "wine ageing", "grape variety", and "maturity".

2. Effect of expert´s region on the terms linked to the green wine concept

Among the 23 terms generated (Table 2), four were the most cited in the four regions. Among them three belong to the sensory category: "vegetal aroma" (23% overall citations), followed by "unpleasant/default" (18%), and "bitter" (16%) whereas, the fourth, "unripe/young wine", belongs to the origin category. Besides these commonalities, the other terms varied from one region to the other one. The significant differences observed for three specific terms (Table 2) were noteworthy. Two were sensory-related terms linked to taste ("excessive sourness") and trigeminal subcategories ("astringent"), and one belonged to the origin category and wine components subcategory ("tannin"). "Excessive sourness" and "astringent" were mainly cited by

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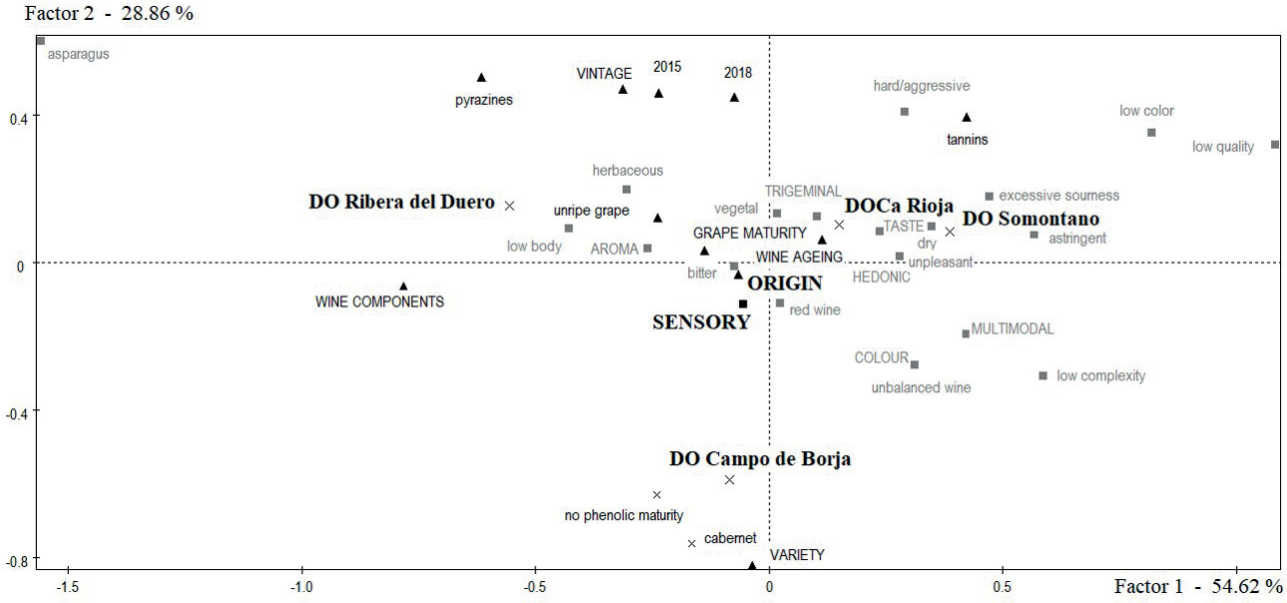


FIGURE 2. Correspondence Analysis space projection of categories, subcategories and terms elicited by participants (cited by at least ≥ 10% of participants in at least one region) from the four regions on Factors 1–2.

experts from Rioja and Somontano, but barely used by participants from the other two regions. The term "tannin" was never cited in DO Campo de Borja, and highly cited in DO Somontano and DOCa Rioja.

The similarities and differences among regions are synthesised in the Correspondence Analysis (CA) plot (Figure 2).

The first two factors, explaining 82.9% of the original variance, were retained based on Kaiser criteria (eigenvalues higher than average). The first factor (53% of original variance) places DO Ribera del Duero in opposition to the other three regions. Experts from this region are characterised by the usage of the "wine components" subcategories, which they cited significantly more often (75%, $P < 0.001$) than experts from the other regions, more specifically the term "pyrazines" was employed. The second factor, which explains almost 30% of the original variance, places DO Campo de Borja on the opposite side of the other three regions. This factor is mainly explained by the subcategory "variety" and the specific term "Cabernet", both belonging to the category origin. This could be attributed to an effect of higher exposure and thus the experts´ familiarity with wines elaborated with this variety from this region. Cabernet is mainly cultivated in DO Somontano followed by DO Campo de Borja. The lower citation of the term Cabernet in DO Somontano may be because they cultivate a wider range of varieties that are associated with the green wine concept such as Moristel or Merlot in comparison to DO Campo de Borja where Cabernet was the sole variety cited.

Descriptions of winemakers from DOCa Rioja and DO Somontano seem to be more convergent, with a rather high emphasis on taste ("excessive sourness") and trigeminal ("dry" and "astringent") sensory subcategories. DO Campo de Borja presents an intermediate position with a closer projection to DOCa Rioja and DO Somontano. This is mainly due to the relative importance given to common categories related to the origin of green wine, such as the "wine ageing" subcategory ("unripe/young wine") and sensory-related terms linked to "colour" and the multimodal term "unbalanced wine".

These results demonstrate our second hypothesis, that even though there are common terms, shared by experts from the four regions, which belong to the sensory category and aroma, taste and hedonic subcategories ("vegetal aroma", "bitter" and "unpleasant") an important idiosyncrasy is linked to the green wine concept that is contingent on the region of origin of the wine experts. Our second hypothesis is demonstrated by the fact that the region affects the development of sensory concepts by wine experts as the one studied in the present research (green wine). This result could be attributed to the experts´ distinct exposures to green wines and thus to different levels of

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familiarity with this concept. However, this does not seem to be the case because the self-reported incidence of green wines presented no significant difference among regions (45 - 60% of participants acknowledged the presence of green wines in their regions). Alternatively, differences in the concept of green wine among regions could be related to variations based on distinct technical and sensory experiences acquired by experts from different regions. Zannoni (1997) stated that the same word can be associated with different concepts depending on the location because it is linked to the culture of individuals. He cleverly showed the example of the word "bread" that can be easily translated into different languages ("*pan*" in Spanish, "*pain*" in French, "*Brot*" in German, or "*pane*" in Italian). However, the concept associated with bread is totally different (in terms of texture, form, composition…) for individuals belonging to different cultures. Thus, experts belonging to different production regions accumulate different experiences which can influence the formation of sensory concepts. Thus, one can assume that top-down cognitive processes are used to form knowledge from experience, which would generate differences among experts from different regions. Along these lines, Parr *et al.* (2015) reported that multidimensional concepts (complexity, familiarity or liking), as could be the case of green wine, show greater differences in their meaning among diverse cultures (understood as social groups exposed to different experiences), than simple analytical descriptors which are employed to verbalise specific aroma or taste concepts. This difference is related to the distinct processes involved in the formation of both types of concepts. Multidimensional concepts are mainly related to top-down strategies, while analytical descriptors correspond more to bottom-up processes.

CONCLUSIONS

The present work has shed light on the concept of green wine which is conceptualised with a long-term memory strategy. To start with, the results confirm that experts use a combination of bottom-up and top-down strategies to carry out wine descriptions; their descriptions are supported by the use of both sensory and origin categories to describe wines. Secondly, the multidimensionality of the green wine concept has become evident in that it includes aroma, taste, trigeminal, colour, multimodal and hedonic sensory subcategories.

Thirdly, the sensory dimensions "vegetal aroma", "bitter" and "unpleasant" are the specific terms shared by experts from the four regions to describe green wines and may represent the core of the green wine concept. Despite these commonalities, an important regional effect related to sensory terms associated with taste ("excessive sourness") and trigeminal ("astringent") sensations and wine components ("tannin") was demonstrated. This effect is attributed to the top-down process involved in the conceptualisation of green wine. Thus, technical and sensory experiences differing among experts from distinct wine regions can contribute to the formation of diverse wine concepts. Thus, more studies evaluating the green wine concept in other wine regions are required to understand the sensory concept and improve communication among wine audience.

The results illustrated that this approach can decipher and promote the characterisation of ill-defined concepts used by winemakers. The main advantages of memory-based approaches over classical methods are that they do not require the infrastructure needed in classical tasting approaches, and they consume far less time and resources. A potential limitation of the present approach is that participants were asked to remember the last red wine they tasted, which leads to low frequencies of citations of specific terms. The idea behind this approach is that the characterisation of different exemplars stored in the memory of experts will provide a better description of the category, being closer to reality, than the description for a central tendency or a prototype of wine, which provide a more theoretical characterisation, but leads to higher frequencies of citations.

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REFERENCES

Abric, J. C. (2003). La recherche du noyau central et de la zone muette des représentations sociales. *Méthodes d'étude des représentations sociales (pp. 59-80)*. https://doi.org/10.3917/puf.jodel.2003.01.0203

Brochet, F., & Dubourdieu, D. (2001). Wine descriptive language supports cognitive specificity of chemical senses. *Brain and Language, 77*(2), 187-196. https://doi.org/10.1006/brln.2000.2428

Campo, E., Ballester, J., Langlois, J., Dacremont, C., Valentin, D. (2010). Comparison of conventional descriptive analysis and a citation frequency-based descriptive method for odor profiling: An application to Burgundy Pinot noir wines. *Food Quality and Preference, 21*(1), 44-55. https://doi.org/10.1016/j.foodqual.2009.08.001

Gawel, R., Oberholster, A., & Francis, I. L. (2000). A mouth-feel wheel: terminology for communicating the mouth-feel characteristics of red wine. *Australian Journal of Grape and Wine Research, 6,* 203-207. https://doi.org/10.1111/j.1755-0238.2000.tb00180.x

Green, J. A., Parr, W. V., Breitmeyer, J., Valentin, D., & Sherlock, R. (2011). Sensory and chemical characterisation of Sauvignon blanc wine: Influence of source of origin. *Food Research International, 44*(9), 2788-2797. https://doi.org/10.1016/j.foodres.2011.06.005

Honoré-Chedozeau, C., Chollet, S., Lelièvre-Desmas, M., Ballester, J., & Valentin, D. (2020). From perceptual to conceptual categorization of wines: What is the effect of expertise? *Food Quality and Preference, 80*. https://doi.org/10.1016/j.foodqual.2019.103806

Honoré-Chedozeau, C., Desmas, M., Ballester, J., Parr, W. V., & Chollet, S. (2019). Representation of wine and beer: influence of expertise. *Current Opinion in Food Science, 27*, 104-114. https://doi.org/10.1016/j.cofs.2019.07.002

Jose-Coutinho, A., Avila, P., & Ricardo-Da-Silva, J. M. (2015). Sensory profile of Portuguese white wines using long-term memory: a novel nationwide approach. *Journal of Sensory Studies, 30*(5), 381-394. https://doi.org/10.1111/joss.12165

Lawless, H. T., & Heymann, H. (2010). *Sensory evaluation of food: Principles and practices* (2nd ed.). Springer Science & Business Media. New York. https://doi.org/10.1007/978-1-4419-6488-5

Lehrer, A. (1975). Talking About Wine. *Language, 51*(4), 901-923. https://doi.org/10.2307/412700

MacNeil, K. (2015). *The wine Bible*. Workman Publishing. New York.

Makhotkina, O., Pineau, B., & Kilmartin, P. A. (2012). Effect of storage temperature on the chemical composition and sensory profile of Sauvignon Blanc wines. *Australian Journal of Grape and Wine Research, 18*(1), 91-99. https://doi.org/10.1111/j.1755-0238.2011.00175.x

Mohekar, P., Osborne, J., Wiman, N. G., Walton, V., & Tomasino, E. (2017). Influence of winemaking processing steps on the amounts of (E)-2-decenal and tridecane as off-odorants caused by brown marmorated stink bug (*Halyomorpha halys*). *Journal of Agricultural and Food Chemistry, 65*(4), 872-878. https://doi.org/10.1021/acs.jafc.6b04268

Mozzon, M., Savini, S., Boselli, E., & Thorngate, J. H. (2016). The herbaceous character of wines. *Italian Journal of Food Science, 28*(2), 190-207. https://doi.org/10.14674/1120-1770/ijfs.v304

Parr, W., White, G., & Heatherbell, D. (2003). The nose knows: Influence of colour on perception of wine aroma. *Journal of Wine Research, 14*(2-3), 79-101. https://doi.org/10.1080/0957126041000167796 9

Parr, W. V., Ballester, J., Peyron, D., Grose, C., & Valentin, D. (2015). Perceived minerality in Sauvignon wines: Influence of culture and perception mode. *Food Quality and Preference, 41*, 121-132. https://doi.org/10.1016/j.foodqual.2014.12.001

Parr, W. V., Mouret, M., Blackmore, S., Pelquest-Hunt, T., & Urdapilleta, I. (2011). Representation of complexity in wine: Influence of expertise. *Food Quality and Preference, 22*(7), 647-660. https://doi.org/10.1016/j.foodqual.2011.04.005

Picard, M., Tempere, S., de Revel, G., & Marchand, S. (2015). A sensory study of the ageing bouquet of red Bordeaux wines: A three-step approach for exploring a complex olfactory concept. *Food Quality and Preference, 42*, 110-122. https://doi.org/10.1016/j.foodqual.2015.01.014

Prescott, J. (2015). Multisensory processes in flavour perception and their influence on food choice. *Current Opinion in Food Science, 3*, 47-52. https://doi.org/10.1016/j.cofs.2015.02.007

Robinson, J., & Harding, J. (2015). *The Oxford companion to wine*. American Chemical Society. https://doi.org/10.1093/acref/9780198705383.001.0001

Rodrigues, H., Ballester, J., Sáenz-Navajas, M. P., & Valentin, D. (2015). Structural approach of social representation: Application to the concept of wine minerality in experts and consumers. *Food Quality and Preference, 46*, 166-172. https://doi.org/10.1016/j.foodqual.2015.07.019

Sáenz-Navajas, M. P., Arias, I., Ferrero-del-Teso, S., Fernández-Zurbano, P., Escudero, A., & Ferreira, V. (2018). Chemo-sensory approach for the identification of chemical compounds driving green character in red wines. *Food Research International, 109*, 138-148. https://doi.org/10.1016/j.foodres.2018.04.037

Sáenz-Navajas, M. P., Avizcuri, J. M., Echávarri, J. F., Ferreira, V., Fernández-Zurbano, P., & Valentin, D. (2016). Understanding quality judgements of red wines by experts: Effect of evaluation condition. *Food Quality and Preference, 16*, 216-227. https://doi.org/10.1016/j.foodqual.2015.10.001

Saltman, Y., Johnson, T. E., Wilkinson, K. L., Ristic, R., Norris, L. M., & Bastian, S. E. P. (2017). Natural flavor additives influence the sensory perception and consumer liking of Australian chardonnay and shiraz wines. *American Journal of Enology and Viticulture, 68*(2), 243-251. https://doi.org/10.5344/ajev.2016.16057

Slabizki, P., Legrum, C., Wegmann-Herr, P., Fischer, C., & Schmarr, H. G. (2016). Quantification of cork off-flavor compounds in natural cork stoppers and wine by multidimensional gas chromatography mass spectrometry. *European Food Research and Technology, 242*(6), 977-986. https://doi.org/10.1007/s00217-015-2604-x

Solomon, G. E. A. (1997). Conceptual Change and Wine Expertise. *Journal of the Learning Sciences, 6*(1), 41-60. https://doi.org/10.1207/s15327809jls0601_3

Temmerman, R. (2017). Verbalizing sensory experience for marketing success: The case of the wine descriptor minerality and the product name smoothie. *Terminology, 23*(1), 132-154. https://doi.org/10.1075/term.23.1.06tem

Valentin, D., Chollet, S., Lelievre, M., & Abdi, H. (2012). Quick and dirty but still pretty good: a review of new descriptive methods in food science. *International Journal of Food Science and Technology, 47*(8), 1563-1578. https://doi.org/10.1111/j.1365-2621.2012.03022.x

Varela, P., & Ares, G. (2012). Sensory profiling, the blurred line between sensory and consumer science. A review of novel methods for product characterization. *Food Research International, 48*(2), 893-908. https://doi.org/10.1016/j.foodres.2012.06.037

Zannoni, M. (1997). Approaches to translation problems of sensory descriptors. *Journal of Sensory Studies, 12*(3), 239-253. https://doi.org/10.1111/j.1745-459X.1997.tb00065.x

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