Exploration of consumer perception of Sauvignon Blanc wines with enhanced aroma properties using two different descriptive methods

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Abstract

The aim of this study was to evaluate consumers' perception of a complex set of stimuli as aromatically enriched wines. For that, two consumer based profiling methods were compared, concurrently run with overall liking measurements: projective mapping based on choice or preference (PM-C), a newly proposed method, and check-all-that-apply (CATA) questions with an ideal sample, a more established, consumer-based method for product optimization. Reserve bottling and regular bottling of Sauvignon Blanc wines from three wineries were aromatically enriched with natural aromas collected by condensation during wine fermentation. A total of 144 consumers were enrolled in the study. The results revealed that both consumer-based highlighted the positive effect of aromatic enrichment on consumer perception and acceptance. However, PM-C generated a very detailed description, in which consumers focused less on the sensory aspects and more on the

usage, attitudes, and reasons behind their choices. Providing a deeper understanding of the drivers of liking/disliking of enriched Sauvignon Blanc wines.

Keywords: *Sauvignon Blanc, aroma, consumers, choice, projective mapping, CATA.*

Highlights

- Sauvignon Blanc wines were enriched with natural aromas collected from fermentation.
- Projective mapping based on choice and CATA questions were performed by consumers.
- Both methods showed the positive effect of aromatic enrichment on consumer perception.
- Projective mapping based on choice generated a more detailed description than CATA.

1. Introduction

Wine is a complex product. Its sensory attributes depend on several factors including grape variety, environmental factors, fermentation conditions, and aging. Sensory attributes, which contribute to wine quality (e.g., color, mouth-feel, flavor, and aroma), have been characterized (Rochfort, Ezernieks, Bastian, & Downey, 2010). Among them, taste and aroma are the main determinants of wine quality and value (Swiegers, Bartowsky, Henschke, & Pretorius, 2005).

Wine quality is related to the presence of aromatic compounds in the final product (Ferreira, Escudero, Campo, & Cacho, 2008). Low boiling points allow aromatic compounds to escape into the atmosphere, which are detected by smell. Wine aroma is attributed to hundreds of aromatic compounds present in the wine. The difference between a world class wine and a common wine are small differences in the concentration of these aromatic compounds (Swiegers et al., 2005).

During fermentation, released carbon dioxide strips a series of aromatic compounds (Colibaba, Cotea, Niculaua, & Schmarr, 2012; Gomez, Martinez, & Laencina, 1993; Morakul et al. 2013; Mouret, Morakul, Nicolle, Athes, & Sablayrolles, 2012). The losses in these aromatic compounds may be significant (Mouret et al., 2014) and may impact the final concentration of volatile aromatic compounds (Morakul et al., 2013). Different technologies have been implemented to preserve those aromas (Sablayrolles, 2009), like the use of low temperatures. Recently, Guerrini et al. (2016), analyzed red wines aromatically enriched with aroma condensates, and reported that aromatic losses affected the sensory profile of wines. However, few studies have investigated how those losses affect consumer perception and acceptability. Several factors affect the composition of wine aroma, making it challenging for sensory characterization studies (Tsakiris et al., 2006). Additionally, it is very difficult to measure consumer perception of complex products, especially aroma

description, because the sense of smell is limited to the ability to analytically recognize components in complex odor mixtures (Melorose, Perroy, & Careas, 2015). However, the need to assess wine quality from the consumer's standpoint is important (Pretorius & Høj, 2005).

The application of alternative methods of sensory characterization based on consumer descriptions has become more popular (Varela & Ares, 2012; Jaeger et al., 2013), with the advantage of obtaining product descriptions directly from consumers, sometimes in their own words (Moussaoui & Varela, 2010).

Check-all-that-apply (CATA) questions is a well-established alternative to classic descriptive analysis, characterized for its ease of use with consumers. It is based on the evaluation of individual attributes previously determined by the researcher (Varela & Ares, 2012) and may include sensory aspects, hedonic and emotional dimensions, product use, and concept fit (Dooley, Lee, & Meullenet, 2010). In particular, the evaluation of an ideal sample through CATA and the subsequent penalty analysis approach have been used for product optimization (Ares et al., 2014). A CATA-type approach has been successfully used in the evaluation of Pinot Noir wines (Campo, Ballester, Langlois, Dacremont, & Valentin, 2010); therefore, CATA may represent a convenient alternative when a complex aroma assessment is required. However, to our knowledge, CATA questions have not been implemented with consumers in the evaluation of wines. Reinbach, Giacalone, Ribeiro, Bredie and Frøst (2014) successfully used CATA questions with consumers for the description of beers and compared it to projective mapping (PM), a "holistic" assessment that collects bi-dimensional perceptual maps for each assessor using their own criteria (Risvik, McEvan, Colwill, Rogers, & Lyon, 1994; Varela & Ares, 2012). PM enables the identification of the most salient, predominant characteristics perceived by consumers in an undirected manner (Varela & Ares, 2012). PM has been used with experts and trained panels (Pagès, 2005; Perrin et al., 2008). However, Torri et al. (2013), who applied PM on

90 Sangiovese wines with consumers and experts, reported that PM might represent an
91 adequate approach when using experienced assessors as opposed to consumers.
92 Recently, Varela et al. (2016) proposed a modification of the PM method and
93 introduced a PM based on choice or preference (PM-C), which differs from the "classic" PM
94 approach in the way in which consumers map the products, basing the sample allocation on
95 what they would choose for different occasions. Varela et al. (2016) observed that with this
96 approach consumers generated a more detailed description of the samples, with an
97 enhanced understanding in terms of the drivers of liking and disliking. In a complex, highly
98 involved product like wine (Laurent & Kapferer, 1985), which is associated with pleasure and
99 emotions (Ferrarini et al., 2010), PM-C appears to be offer a better understanding of
100 consumer perceptions that could be applied to product optimization. Thus, a natural
101 consumer-based method to compare with, will be CATA questions with an ideal.
102 In this study, we recovered the aromas lost during the fermentation of Sauvignon
103 Blanc wine and used the collected condensates to aromatically enrich samples of reserve
104 bottling and regular bottling of Sauvignon Blanc wines that were evaluated by consumers.
105 The main objective of this study was to better understand consumer perception of a complex
106 set of stimuli as aromatically-enriched wines and the relation to their liking. For that we
107 compared two consumer based profiling methods, PM-C and CATA questions, and their
108 application with the ultimate aim of product optimization.
109
110
111 **2. Materials and methods**
112
113 *2.1 Samples*
114 We used eight samples of Sauvignon Blanc wines (Table 1). The wines were
115 classified into two groups: one of high quality (reserve bottling) and another made from

ordinary grape (regular bottling; Weil; 2005). Two reserve wines (Rv samples) and two regular wines (Rg samples) from one winery (company A) were enriched with two different doses of aromatic condensate: d1 was the lower dose (Rv.d1 and Rg.d1 samples) and d2 was the higher dose used (Rv.d2 and Rg.d2 samples), which were recovered from alcoholic fermentation of Sauvignon Blanc wines in the same company. Unenriched samples and two wines from two different competitor wineries, one reserve (Rv2 sample) and one regular (Rg2 sample), were included. All wines used were Sauvignon Blanc commercial wines from the 2014 harvest (Table 1) and acquired from local supermarkets. The samples were enriched the day before the sensory test and were served in ISO tasting glasses covered with Petri dishes 10 min before the test and stored at 8ºC.

2.2. Consumer tests

In this study, 144 consumers were interviewed in a 15-d period. In the first half of each session, consumers performed PM-C (Varela et al, 2016). In the second half of each session, consumers rated overall liking and aroma liking of the samples and answered CATA questions. In both half-sessions, new samples with new codes were delivered to the consumers, who had a 15-min break between tests to minimize sensory fatigue (details of each test follow below).

2.3. Consumers

Consumers (n = 144) were recruited from a consumers database based on their interest and availability to participate in the study. All of the participants (21−65 y of age) consumed white wine more than twice per month. The consumers, who were from different household compositions and had different income levels and education levels, provided informed written consent and were compensated with a gift. The test took place in the Pontificia Universidad Católica de Chile in Santiago de Chile, under white lighting, controlled

142 temperature (23ºC), and airflow conditions. Each session lasted approximately 50 min
143 (Table 2). Data acquisition was carried out with Compusense cloud software (Compusense
144 Inc., Guelph, Ont., Canada).
145
146 *2.3.1. Test 1: Projective mapping based on choice or preference*
147 Prior to starting the test, each participant watched a video, which explained the
148 basics of the technique using different types of desserts, with no mention of wines. The
149 instructions of this test differ from the "classic" PM approach in the way in which consumers
150 have to base their categorization and sample allocation (Varela et al, 2016). Instructions
151 were as follows, *"Please evaluate the samples and position them on the assigned space*
152 *according to their differences and similarities basing your criteria on what you would choose,*
153 *thinking about different food occasions"*. The consumers positioned the samples on the
154 assigned space according to the principle that samples of similar characteristics should be
155 placed close to each other, while different samples should be placed further apart from each
156 other with regards to each consumer`s preference. The consumers had to observe, smell,
157 and taste each wine, place the samples on the two-dimensional space on the screen, and
158 write down the terms that they perceived in connection with each sample or group of
159 samples on the space reserved in the software (Ultra-flash profiling). For direct comparisons,
160 the eight wine samples were presented simultaneously in wine glasses coded with three-
161 digit numbers.
162
163 *2.3.2. Test 2 – Liking and CATA questions*
164 New wine samples with different codes were assessed in a sequential monadic
165 approach according to the balanced random design (Williams' design). Each sample could
166 be re-tasted when necessary. First, consumers rated overall and aroma liking using a
167 structured nine-point hedonic scale (box-scales). To evaluate the effect of aromatic

168 enrichment on consumer perception, a CATA question was introduced including an ideal
169 product evaluation following the real samples. For each sample, participants completed the
170 task after scoring liking. The CATA question consisted of 30 terms, including 17 sensory
171 terms and 13 extrinsic wine attributes. These terms were selected based on previous testing
172 with a trained sensory panel and with internal marketing information obtained from the
173 producer. The selected sensory terms were *bitter, balanced, unbalanced,*
174 *vegetable/herbaceous, intense aroma, weak aroma, bad aroma, good aroma, bad flavor,*
175 *good flavor, fruity, floral, tropical, citric, sweet fruit, apple/pear,* and *earthy/humid.* The
176 extrinsic wine attributes were, "*It is an elegant high-quality wine*", "*I would consume it*
177 *frequently with meals*", "*it is a fresh wine*", "*it is too complex*", "*I would pay less for it than I*
178 *normally do*", "*I would pay more for it than I normally do*", "*it is new and different*", "*I would*
179 *buy it*", "*I would not buy it*", "*I would drink it for a special occasion*", "*I would recommend it*",
180 "*it is a young/modern wine*", and "*I would give it as a gift*". The attributes were randomized
181 within each group and among products and consumers.
182
183 2.4 Data Analysis
184
185 *2.4.1. Projective mapping based on choice*
186 Data were obtained from PM using the x and y coordinates of wines from the
187 individual perceptual spaces and analyzed by multiple factor analysis (MFA, Pagès, 2005).
188 The consumer elicited words in the descriptive step were qualitatively and individually
189 analyzed by two researchers, any coincidences was cross-checked. A search for recurrent
190 terms was performed and classified into different categories based on meaning and
191 synonymy. Categories mentioned by > 10% of the consumers were used in the analysis.
192 Frequencies in each category were determined by counting the number of consumers using
193 common terms to describe each wine. The attributes generated in the descriptive step were

194 used as supplementary variable in MFA. Data analyses were performed using R version
195 3.2.5 (R Development Core Team, 2016) using either native functions or functions from the
196 FactoMineR package (Lê, Josse, & Husson, 2008).
197
198 *2.4.2. Liking and CATA questions*
199 Overall and aroma liking scores were analyzed by analysis of variance (ANOVA).
200 The samples represented the fixed source of variation, and the consumers represented the
201 random effects. Mean differences between samples were compared using Tukey's test at a
202 5% significance level ($p \leq 0.05$). A hierarchical cluster analysis (HCA) was performed on
203 centered and reduced overall liking scores to identify consumer segments with different
204 preference patterns. The analysis was performed considering Euclidean distances, Ward's
205 aggregation criterion, and automatic truncation. Differences between samples in each
206 cluster were determined using one-way ANOVA.
207 CATA data were analyzed using Cochran's Q test and Marascuilo multiple
208 comparison (Manoukian, 1986) to identify significant differences among samples for each
209 of the terms included in the CATA question. CATA data were subjected to correspondence
210 analysis (CA; Pagès, 2004) to generate a map of the perceptual space. Frequency of
211 mention of each attribute of the CATA question was determined by counting the number of
212 consumers that used each term to describe each sample. Additionally, CATA data were
213 subjected to penalty analysis (PA) to identify the extent to which overall liking scores were
214 reduced due to deviations in sensory profiles between real and ideal products (Ares, Dauber,
215 Fernández, Giménez, & Varela, 2014). The analysis was conducted as reported by
216 Meyners, Castura, & Carr (2013) using XLStat 2014 (Addinsoft, Paris, France).
217
218 *2.4.3. Method comparison*

Methods were compared in terms of: (1) conclusions obtained: individual perceptual spaces and visual comparison of samples configuration; (2) richness of information obtained by each, based on the number of attributes evaluated/generated and the significant attributes obtained by each, in the Cochran and Chi square tests respectively; (3) perceptual spaces were further compared by superimposing samples representations from both methods in the same perceptual space via MFA using XLStat 2014 (Addinsoft, Paris, France).

3. Results and discussion

3.1. Overall liking

Overall liking varied significantly among wine samples, ranging from 5.2 for Rv2 to 6.0 for Rg.d2. The higher dose of aromatic enrichment (d2) had a significant effect ($p < 0.05$) on consumer overall liking scores (Table 3), suggesting that consumers reacted differently to the sensory characteristics of the wines. Rv.d2 and Rg.d2 had higher overall liking scores than Rv2. Rg.d2 had the highest overall liking score, whereas Rv2 wine had the lowest overall liking score. For most samples, overall liking scores were classified as indifferent or slightly liked in the nine-point hedonic scale (from five to six). In general, the higher dose (d2) increased overall liking scores. On the other hand, aromatic enrichment did not have significant effects on the regular wines.

With respect to aroma liking, the best rated wines were those enriched with d2. Aroma liking increased in both regular and reserve wines enriched with aromatic condensate.

3.2. Segmentation of consumers

A segmentation of consumers was carried out by agglomerative hierarchical clustering (AHC with Ward criteria), which is an iterative classification method that is based on dissimilarities between objects to be grouped together. The three clusters of consumers showed different liking patterns (Table 3).

The first cluster (n = 37 consumers) was the smallest and was characterized by its acceptance of reserve wines and by the rejection of the Rg2 wine, suggesting that this cluster consisted of consumers who were the most knowledgeable about wines. This cluster was not able to distinguish between Rg.d2 and reserve wines, which shows the positive effect of wine enrichment on a wine of inferior quality.

The second cluster (n = 60 consumers) was the largest and was characterized by a high acceptance rate of most wines. This cluster did not differentiate the aromatic enrichment in reserve wines in terms of liking. In the case of regular wines, the higher dose of aromatic enrichment significantly increased the acceptance of this type of wine with no significant differences with Rv2 and Rg2 wines (top liked). This cluster consisted of consumers who had some knowledge about wines.

The third cluster (n=47) was representative of consumers with limited knowledge on wines, because they accepted and liked all wines (enriched and non-enriched). This cluster did not find significant differences among enriched and non-enriched samples. However, they rejected the Rv2 wine.

3.3. CATA questions

There were significant differences in the frequency with which consumers used 11 of the 30 terms included in the CATA questions (Table 4). The aromatic enrichment generated a positive response from consumers, increasing the frequency of attributes (sensory and non-sensory) considered to be positive (*fruity, apple/pear, good aroma*, etc.)

and reducing the frequency of attributes considered to be negative (*herbaceous, bitter, weak aroma*, etc.). This sensory improvement mainly occurred in regular wines, which were originally perceived to be of lower quality than reserve wines (with a more frequent mention of "*good flavor*"). This result is indicative of the effect of aromatic enrichment on wines, which improves the sensory characteristic of low-quality wines and increases the frequency of mention of CATA positive terms.

The aromatic enrichment on regular wines allowed to improve the frequency of the attribute "*good flavor*" and have no significant differences with the most frequently mentioned wine (Rv wine). In general, the lower doses (d1) of aromatic enrichment had no effect on the quality of evaluated wines.

It is noteworthy that the higher dose (d2) of aromatic enrichment affected the attribute "*good aroma*" of both the enriched reserve wine and regular wine. Specifically, the enriched reserve wine (Rv.d2) and regular wine (Rg.d2) had higher mentions of "*good aroma*" than the Rv2 and Rg wines, respectively. This is relevant because the intensity and quality of the aroma constitutes the primary quality factor in white wine (Campo, Ferreira, Escudero, & Cacho, 2005). Additionally, the higher dose contributed to a significantly higher number of mentions of the non-sensory attribute "*I would recommend it*" in both categories of wine evaluated.

The effect of the higher dose of aromatic enrichment on reserve wines was reflected in the attribute "*good aroma*". The frequency of mention of "*good aroma*" for Rv.d2 was significantly higher than that of Rv2 (72 vs. 45, respectively). This allowed the enriched reserve wine to surpass the reserve wine (Rv2) in this specific attribute.

In the Rg.d2 wine, aromatic enrichment significantly increased the selection of fruitiness attributes: "*fruity*" (from 40 for Rg wine to 63 mentions for Rg.d2 wine). Additionally, Rg.d2 was significantly more intense than Rv and Rg2 wines. A similar response was observed for the "*apple/pear*" attribute, with the frequency of mention increasing from 14 for

Rg wine to 33 mentions for Rg.d2 wine, even higher than the Rv2 wine. Additionally, the Rg wine (46 mentions) reached 71 mentions for the attribute "*good aroma*" following enrichment (Rg.d2 wine). The number of mentions for the attitudinal attributes "*I would pay more for it than I normally do*" and "*I would buy it*" was higher in the Rg.d2 than in Rv2 wine.

With respect to the negative attributes, enriching the regular wine with d2 (Rg.d2 wine) reduced the associations with bitterness perception. Bitterness is often considered an undesirable attribute in white wines (Fischer, & Noble, 1994). It is interesting to note that the aromatic enrichment was not expected to affect flavor itself, but it lowered the associations with bitterness perception. This effect could have been attributed to cross modal interaction between aroma and flavor. The fruity aromas in the enriched sample could have been perceptually linked to lower bitterness perception. Moreover, enrichment significantly decreased the number of mentions of the attribute "*vegetable/herbaceous*", with no significant differences between Rg.d2 and Rv2 wines. Additionally, enrichment significantly decreased the associations with negative attributes like "*weak aroma*" and "*I would pay less for it than I normally do*".

The ideal sample (Table 4) was described as one with good flavor and fruity aroma (high frequencies of mention) and with low associations with bitter or vegetable/herbaceous. Additionally, an ideal wine was one that consumers would buy, pay more for it than usual, and recommend.

The perceptual map obtained via CA shows that the first two dimensions explained 76.5% of the variability in the original data. As shown in Figure 1, samples were placed on the first dimension according to their aromatic quality. Three groups were placed in the perceptual space. The first group, which consisted of samples Rg.d2 and Rv.d2, was placed on the positive quadrant of the first dimension and was described by positive terms “*fruity*”, “*tropical*”, “*good flavor*”, and “*good aroma*” and non-sensory terms such as “*I would buy it*”, “*I would recommend it*”, and "*I would give it as a gift*”. On the opposite side of the perceptual

space, the group that consisted of Rv2 and Rg samples was characterized by the attributes "*weak aroma*", "*bad aroma*", and "*I would pay less for it than I normally do*".

A third group of samples (Rg2, Rg.d1, Rv, and Rv.d1) was in the middle of the perceptual space and was described by the terms "*vegetable/herbaceous*" "*bitter*" and "*I would pay less for it than I normally do*". The third and fourth dimensions of CA did not provide relevant information on the sensory characteristics of the samples (data not shown). The ideal sample, plotted as supplementary sample in CA, appeared on the far right, far from the real samples, and was described as having good flavor and aroma and positive attributes. The real samples closer to it were the ones enriched with the high dose of aroma extract. The use of the ideal sample in the CA of the CATA questions may assist in product optimization in a similar manner as PM because the position of the ideal sample in the perceptual space represent the area of maximum liking. Previous studies (Ares, Varela, Rado, & Giménez, 2011) have reported that when considering data from CATA questions, the ideal product may appear outside the sensory space defined by the evaluated real samples, as several terms with strong hedonic connotation were considered. For example, in this study, bitter and bad aroma were not associated with the ideal product and could have polarized its location in the perceptual space.

3.5. Penalty analysis based on CATA questions (PA)

PA is used in sensory data analysis to identify potential directions for the improvement of products (Ares et al., 2014). In PA, the overall liking scores, the CATA evaluation of the eight samples, and the ideal product were considered. The analysis is based on the differences between real and ideal products, if a particular attribute has been used for both or none (congruence) of the products, or only for the real or ideal product (incongruences), and the impact this might have on the associated liking scores. The difference in liking with congruent and incongruent elicitations is an estimation of the

349 average impact on liking that the attribute might have. Meyners et al. (2013) proposed the
350 extension of the concept to positive effects on liking (necessary or “must have” attributes)
351 and negative effects on liking (negative or ‘‘to-be-avoided’’ attributes).

352 PA on CATA data highlighted the “must have” attributes for the analyzed wines
353 (Table 5). As expected, the hedonic terms “*good flavor*” and "*good aroma*" and the attitude
354 terms “*I would buy it*”, “*I would recommend it*”, and “*I would give it as a gift*” were maximized
355 in the ideal product. The term “*fruity*” was highlighted by PA as a “must have”, an adequate
356 cue for wine optimization. When “*fruity*” was not present in the product, overall liking score
357 decreased by 2.0 (31% consumers found it as incongruent); therefore, it would be desirable
358 to have a higher “*fruity*” character in optimized wines. The sample Rg.d2 had the highest
359 frequency of “*fruity*” mentions (63 mentions) and it was the closer to the ideal wine in this
360 attribute (75 mentions), while Rv and Rg samples had significantly lower mentions (Table
361 4).

362 Regarding drivers of disliking, the attribute "*bitter*" decreased overall liking score by
363 approximately 1.9 points (25% of consumers). All evaluated samples were far from the ideal
364 in this negative character; therefore, an improvement in this characteristic could mean a
365 general improvement in this category of wines. Nevertheless, Rg.d2 had the smallest
366 association with “*bitter*”, getting closer to the ideal sample (Table 4).

367 PA was also run on the three identified clusters, the summary conclusions of this
368 analysis is presented also on Table 5. The interpretation of these outcomes allow to better
369 understand liking segmentation (Table 3). Cluster 1 one was the most demanding in terms
370 of sensory drivers of liking; PA highlighted “*fruity”, “balanced”, “intense aroma”, “good*
371 *flavour”* and *“good aroma”* as must have attributes, reflecting this cluster was the most
372 knowledgeable about wines, in line with the liking segmentation. Cluster 2 on the other
373 hand, were less demanding, with only *“good flavour”* as must have sensory attribute, and
374 even with “*bad flavour*” highlighted as indifferent. They did not have aroma related terms as

drivers of liking, in agreement with their overall liking ratings, as they did not significantly preferred enriched reserve wines, only favoring the higher dose of enrichment in regular wines. For cluster 3, PA highlighted "*fruity", "good flavour", "good aroma"* and "It's a fresh wine" as must have attributes; even if they were in principle quite positive with most tasted wines regardless of the enrichment, it seems they did care to certain extent about aroma. In fact, the sample rejected by this cluster was within the ones less associated to "*fruity" and "apple/pear"*, significantly less linked to "*good aroma"* and significantly more associated to *"weak aroma"* (Table 4), what might explain their rejection.

3.6. Projective mapping based on choice

Figure 2 shows the MFA plots. The plots display four dimensions of the mapped samples according to their aroma, flavor, consumption occasion, and hedonic terms and explain 67.5% of the variance. The analysis of the graphs made it possible to observe how the aromatic enrichment positively affected consumer perception. In general, the aromatic enrichment (at d1 and d2) changed consumer perception, moving the samples within the perceptual space towards the area of enhanced sensory and hedonic attributes.

As shown Figures 2c and a, the samples Rv and Rv.d1 were associated with a flavor of particular intensity. The consumers reported that they would consume these samples frequently at dinners or romantic occasions and with salads (Rv wine) or fish/seafood or meat (Rv.d1 wine). Furthermore, Rv.d1 was considered to be a wine of frequent and occasional consumption. Other terms present in the attribute plot to describe these samples were *astringent*, *citric*, *acid*, and *persistent flavor*. Furthermore, wines were described as *balanced*, with *nice color*, *full bodied*, and good to share with family during a summer afternoon. On the other hand, Rv.d2 was described mainly as a *fresh wine* with *nice and intense fruity aroma*, adequate for a special occasion, cocktail, or consumed with cheese (Fig. 2a). The perceptual space revealed other terms such as *fruity* and *gentle flavor*, *sweet*

401 *and citric aroma,* and *bright color*. The Rv2 wine was rejected (consumers declared "*I would*
402 *not consume it*" or "*buy it*") mainly because of its *weak*, *unpleasant*, and *little fresh aroma*,
403 emphasizing the importance of aroma in the final consensus of wine quality (Fig. 2b). Other
404 terms mentioned for this sample were *astringent* and *persistent flavor*, *vegetable* and *strong*
405 *aroma*, and *ordinary wine*. These generally negative descriptions of Rv2 can be linked to its
406 generally low overall liking scores, low aroma liking scores, and high rejection rates (cluster
407 3 rated it with an overall liking score of 3).
408 Sample Rg was described as an *ordinary wine* with a *low fruity*, *unpleasant*, and
409 *weak aroma* and *weak flavor* that was suitable for cooking purposes or for lunch. The
410 enriched sample Rg.d1 was described as a wine with *weak flavor*, *fresh* and *gentle aroma*,
411 and suitable for special occasions. Other attributes included *sweet*, *intense*, and *tropical*
412 *aroma*, and *gentle flavor*. The regular wine Rg.d2 was classified as a *fresh wine* with a *nice,*
413 *gentle*, *fruity aroma* and *fruity flavor*. The attribute plot defined Rg.d2 as a *sweet wine* with
414 *intense aroma* and *bright colors*, suitable for cocktails (with cheese) and special occasions.
415 The regular sample from the competitor Rg2 had negative attributes (e.g., *bitter* and
416 *unpleasant flavors*, *weak* and *unpleasant aromas*, "*I would not consume it/buy it*"), which
417 explain the low overall liking scores (cluster 1 rated its overall liking with a 3.6). Other terms
418 associated with this sample were *acid flavor*, *vegetable*, *strange*, and *woody aroma*, and
419 *pale color* (Fig. 2a and b).
420 Figures 3 (a-f) show the perceptual spaces defined by the first two dimensions of the
421 MFA on the PM-C data, for each of the consumer clusters identified by the liking
422 segmentation. The three groups separated the enriched samples from the non-enriched and
423 the commercial ones but using different criteria, the different dimensions of the MFA had
424 different weights for different clusters.
425 Cluster 1 had a similar configuration than the consensus one, with the first dimension
426 driven by the enrichment, and the second dimension separating reserve and regular wines

(Figures 3a and 3b). However, by visual inspection, samples were generally better discriminated by cluster 1, with Rg.d1, Rg.d2 and Rv.d2 better spread in the perceptual space. Sample allocation was not directly related to liking, as samples that were quite differently rated as Rv2 (OL=6.2) and Rg2 (OL=3.6) laid close in the map. The sample allocation seemed to be driven mostly by the wine sensory characteristics (reserve, regular, and enrichment). Samples to the right of figure 3b (enriched) were described by "*intense"* and "*good aroma"* associations, and special occasions of consumption. Samples to the left (regular) were described as poor in aroma and with some negative characters as "*vegetable*" and "*unpleasant*". Wines at the bottom (non-enriched) were associated to *bitter, astringent* and *intense* flavours.

Cluster 2 also differentiated samples in terms of enrichment in the first dimension of the MFA, however, enriched samples laid quite close in the perceptual space, described with more intense and nice aroma (Figures 3c and 3d). The second dimension for cluster 2 was mainly driven by the liking; sample Rg (OL=4.9, described in figure 3d as with "*intense* and *astringent flavor*" and "*vegetable aroma"*) and sample Rv2 (OL=6.2, described as "*elegant"*, "*gentle", "fresh"* and, "*light"* in figure 3d) were polarized in that dimension, being the bottom and top liked respectively by that cluster. This result is in agreement with what was seen in the PA for cluster 2, where this group of consumers did not give that much weight to aroma in their liking assessment.

Cluster 3 related enrichment to the second dimension instead, with enriched samples in the top of the plot and non-enriched in the bottom half (Figures 3e and 3f). The rejected sample (Rv2) laid at the bottom of the plot, described as with "*unpleasant and poor aroma",* and *"vegetable aroma"*. This confirms what was discussed in section 3.5, even if they like most samples, the rejected one was perceived as less aromatic. Interestingly, the type of wine was the driver of the first dimension of the MFA, with the descriptions in figure 3f helping in better this allocation. Most reserve wines appeared towards the positive side, described

with "*intense flavor", "balanced"* and "*full bodied"* linked to special occasions, and the regular wines to the negative side of that dimension, linked to "*unpleasant* and *poor taste*". So this dimension was driven by the "in mouth" experience, while the second one to the aromatic profile.

4. General discussion. Comparison of the consumer-based sensory methods

The purpose of this study was to compare two consumer-based sensory methods using sensory maps and descriptive terms to get a better understanding of the aromatic characteristics that are important for consumers in a complex matrix as Sauvignon Blanc white wines, some of them aromatically enriched. Comparison studies have reported that CATA and PM generate overall similar results in terms of main drivers of liking and disliking, supporting the high validity of both sensory methods (Ares, Giménez, Barreiro, & Gámbaro, 2010; Reinbach et al., 2014). Nevertheless, the methods are not equivalent. CATA is a simple method, which could be used for optimization, expanded by the profiling of an ideal sample, and based on fairly straightforward calculations, and draw conclusions on drivers of liking and disliking. However, the main disadvantage of this method, is that attributes are provided by the researcher and, in this way, limited by the previous knowledge of the sample category. PM-C however, is in a way "profiling out of the box", leaving consumers completely free to express themselves regarding reasons underlying choice and preferences and allowing to understand nuances in perception, even within similarly liked samples. Its main disadvantage is that the interpretation of the words generated in the descriptive stage is more time consuming and requires certain level of experience from the researcher. Its main strength is the richness in the consumer description, from its holistic approach, particularly enhanced in the PM-C version of projective mapping. The present work extended the knowledge on PM based on choice (PM-C), a novel approach that provides a detailed

479 description of the reasons underlying preferences, not yet used in wines, in an attempt to
480 ascertain additional information of the aromatic enrichment.
481
482 *4.1. Practical aspects*
483 PM-C and CATA questions provided a sensory profile of the samples. Both sensory
484 methods were easily performed by the consumers with the instructions provided. Even
485 though some consumers have reported that PM is difficult to perform due to difficulties with
486 the use of spatial positioning (Veinand, Godefroy, Adam, & Delarue, 2011), the video
487 presented to the participants helped them understanding the instructions. The time spent by
488 consumers on each method was similar. PM-C is a comparative method, while CATA, even
489 if shorter to perform, requires a serial monadic presentation of the samples, with more
490 logistics required for the organizers.
491
492 *4.2. Comparison of the sensory maps*
493 Both methods were able to discriminate among wine samples. The ability to identify
494 the main sensory characteristics for each of the eight wines was similar between the sensory
495 profiling methods, in line with the fact that only the high dose of aromatic enrichment had a
496 significant effect ($p < 0.05$) on consumer overall liking scores and was separately grouped
497 both in CATA and PM-C. Nevertheless, the two descriptive methods did not yield the same
498 results, as shown by the combined sample plot of CATA and PM-C (Fig. 4). The two
499 perceptual spaces presented a low multidimensional correlation (regression vector
500 coefficient = 0.595). For some samples, the differences were larger, particularly for the
501 regular samples, in which the consumers seemed to disagree on both methods. This is in
502 part aligned with the acceptability data, where the consumers disagreed in terms of liking
503 (segmented liking for Rg, liked mostly by cluster 3 and Rg2, rejected by cluster 1). Those
504 differences in the sensory maps could be explained when studying the four dimensions of

505 the MFA originating from the PM-C data, particularly as related to the vocabulary
506 spontaneously generated by consumers in this task. See further discussion in the next
507 section. Added to this, all samples tested by PM-C laid towards the outer part of the map,
508 stretching the perceptual space much more as compared to CATA (Fig. 4). This shows that
509 PM-C discriminated better among the wine samples.

510 PA based on CATA highlighted the negative, positive, and indifferent attributes
511 related to the set of products (*bitter*, *fruity*, *good flavor*, *good aroma*, "*I would recommend it*",
512 "*I would buy it*", "*I would give it as a gift*", *apple/pear*, *tropical*, *vegetable/herbaceous*, and
513 *weak aroma*), which were in agreement with part of the terms generated in PM-C.

514 Reserve and regular wines were significantly influenced by aromatic enrichment
515 improving significantly its perceived quality. CATA questions highlighted that the samples
516 enriched at the higher dose (d2) were associated with positive attributes (sensory and non-
517 sensory), achieving a remarkable enhancement mainly over regular wine. In PM-C, the
518 same effect was observed, samples Rg.d2 and Rv.d2 were associated with positive
519 dimensions in the generated sensory map. This results suggests that consumers reacted
520 similarly, when mapping products based on their preferences and in sensory aspects. On
521 the other hand, Rg and Rv2 samples were associated with negative and undesirable terms
522 in CATA questions, while both samples from the competitor wineries (Rg2 and Rv2) were
523 negatively described by consumers when placed in the bi-dimensional perceptual space in
524 PM-C related to rejection, highlighting the role of aromatic enrichment in the quality of wines.
525

526 *4.3. Consumer vocabulary elicitation*

527 Even when the general sample positioning and conclusions were partially
528 comparable between both methods and the main sensory concepts from CATA were
529 similarly obtained by PM-C, the vocabulary generated in the descriptive step of PM-C was
530 significantly larger than the standardized list of attributes from the CATA questions (Table

6). PM-C generated much richer and detailed sensory and non-sensory information, providing an enhanced understanding in terms of the drivers of liking and disliking of the different samples in relation to the aromatic enrichment. When evaluating the numbers of attributes, 30 sensory and non-sensory were proposed by the researchers in the CATA questions, while 122 different attributes were generated by the consumers in PM-C, using their own words. More attributes allowed discrimination among samples in PM-C than in CATA. Additionally, PM-C had a higher number of attributes and greater level of detail in all descriptive categories. From a sensory perspective, PM-C was more detailed. For example, CATA generated one significant flavor attribute, *bitter*, while PM-C generated nine highly mentioned, statistically significant flavor attributes: *acid*, *alcoholic*, *bitter*, *astringent*, *sweet*, *fruity*, *intense*, *light* and *gentle*. The description of occasions of consumption and hedonic terms was more detailed in PM-C. Furthermore, consumers frequently mentioned two complex, global attributes*: full-bodied* (37 mentions) and a highly mentioned *fresh wine* (131 mentions).

The in-depth description obtained by PM-C allowed a better understanding of the reasons behind the consumer preferences (when associated to the liking ratings and consumer segmentation) and their potential choices, as determined by the various usage and occasions suggested. The first two dimensions of the MFA of the PM-C data (Fig. 2a) clearly showed how consumer perception shifted from the regular wines without enrichment (Rg), which were described as *ordinary*, having *poor and unpleasant aroma and poor and unpleasant flavor*, to the enriched wines (Rg.d1 and Rg.d2) with a more complex sensory profile and highly positively hedonic and attitudinal consumer perception: a *balanced wine with fruity, sweet, intense and elegant aroma, nice flavor*, for special occasions, with desserts, with cheeses, for cocktails. Regular samples, however, were not very well separated in the CATA perceptual space (Fig. 2).

556 The PM-C space determined by the first and third dimensions of the MFA (Fig. 2b)
557 allowed a better understanding of the generally low acceptability values of sample Rv2,
558 widely rejected by some of the consumers (rejected by cluster 3, overall liking rating of 3).
559 Consumers spontaneously described it as having *intense flavor* with *vegetable*, and *weak*
560 *aroma*, *pale color* and *ordinary wine*. Consumers reported that Rv2 was suitable for cooking
561 as opposed to consumption. The CATA data, however, did not allow for a specific description
562 of this sample, which was not well separated from other samples in the perceptual space.
563 The fourth dimension of the MFA from the PM-C data allowed us to understand the
564 effect of enrichment on reserve wines, separating the sample without aromatic addition and
565 the two enriched ones. The adequate discrimination among these three samples in this
566 dimension revealed the perceptual variation with enrichment, from a flavor described as
567 *acid*, *alcoholic*, and *light wine* (Rv), to a more *intense and persistent flavor* in sample Rv.d1,
568 to a well-liked wine in both flavor and aroma in Rv.d2, *fruity* and *gentle flavored*, with an
569 especially *intense aroma* for special occasions.
570
571
572 **5. Conclusions**
573
574 In general, main outcomes by CATA questions and PM-C were comparable. Our
575 findings revealed that aromatic enrichment positively affected the quality of Sauvignon Blanc
576 wine, with aroma as the main driver of consumer preferences, both in intensity and profile
577 (fruitiness). Bitterness and vegetable flavor were the main drivers of disliking. Consumers
578 liked better the samples that were enriched at the higher dose.
579 From a methodological perspective, a wider and more detailed description was
580 provided by PM-C than by CATA questions with an ideal sample evaluation. The enhanced
581 and spontaneous description generated by PM-C, in consumers' own words, allowed a

582 better understanding of the reasons underlying their preferences and choices, with details
583 on the sensory and hedonic perception towards the samples as well as usage and attitudes.
584 PM-C provided a deeper understanding of the drivers of liking and disliking of a
585 sample set or category of products. Specifically, PM-C could be applied in different aspects
586 of industrial research and development, product optimization from a sensory perspective,
587 and marketing and communication. More studies are required to make further
588 recommendations on the applicability of PM-C, and to validate this methodology in other
589 complex products (for example products with complex textural characters, meals, etc.).
590
591
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593
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600

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726 **Table 1.** Sample coding and treatments
727

Reserve wines	Description	Regular wines	Description
Rv	Commercial reserve bottling of wine from company A.	Rg	Commercial regular bottling of wine from company A.
Rv.d1	Commercial reserve bottling of wine from company A enriched with d1 (lower dose).	Rg.d1	Commercial regular bottling of wine from company A enriched with d1 (lower dose).
Rv.d2	Commercial reserve bottling of wine from company A enriched with d2 (higher dose).	Rg.d2	Commercial regular bottling of wine from company A enriched with d2 (higher dose).
Rv2	Commercial reserve bottling of wine from company B.	Rg2	Commercial regular bottling of wine from company C.

728
729

730 **Table 2.-**Characteristics of consumers (n = 144)
731

Age consumers Range	Gender Female (%)	Gender Male (%)	Total (%) All consumers
19-24	9.9	16.4	13.1
24-29	35.1	30.1	32.6
30-34	28.3	19.2	23.8
35-39	7.0	16.4	11.7
40-44	9.9	4.1	7.0
45-49	4.2	5.5	4.8
50-54	4.2	2.8	3.5
>54	1.4	5.5	3.5
Total (%)	49.3	50.7	100

732

733 **Table 3.** Overall liking for all consumers and per cluster, and aroma liking for consumers
734

Category	Overall Liking * (all consumers)	Overall Liking Cluster 1	Overall Liking Cluster 2	Overall Liking Cluster 3	Aroma Liking * (all consumers)
Rv	5.8 ^{ab}	6.6 ^{a}	5.2 ^{ab}	5.8 ^{a}	6.1 ^{ab}
Rv.d1	5.8 ^{ab}	6.8 ^{a}	5.0 ^{b}	6.1 ^{a}	6.0 ^{ab}
Rv.d2	5.9 ^{a}	6.6 ^{a}	5.3 ^{ab}	6.0 ^{a}	6.5 ^{a}
Rv2	5.2 ^{b}	6.2 ^{ab}	6.2 ^{a}	3.0 ^{b}	5.6 ^{bc}
Rg	5.4 ^{ab}	5.1 ^{b}	4.9 ^{b}	6.3 ^{a}	5.2 ^{c}
Rg.d1	5.5 ^{ab}	5.2 ^{b}	5.4 ^{ab}	5.8 ^{a}	5.8 ^{abc}
Rg.d2	6.0 ^{a}	5.9 ^{ab}	6.2 ^{a}	5.9 ^{a}	6.2 ^{ab}
Rg2	5.5 ^{ab}	3.6 ^{c}	6.2 ^{a}	6.2 ^{a}	5.9 ^{abc}

735 Mean liking scores were significantly different according to Tukey's test (confidence level of 95%). * Evaluated
736 in a structured nine-point hedonic scale.
737

738 **Table 4.** Frequency of mention in which each term of the CATA question was used by consumers (n = 144) to
739 describe wines samples and their ideal product. Cochran's Q test and Marascuilo multiple comparison results
740 are shown by asterisks and letters between brackets
741

Terms	Samples								
	Rv2	**Rv**	**Rv.d1**	**Rv.d2**	**Rg2**	**Rg**	**Rg.d1**	**Rg.d2**	**Ideal**
Fruity *	41	40 (a)	45	48	40 (a)	40 (a)	46	63 (b)	75
Apple/pear **	13 (a)	17	23	27	22	14 (a)	22	33 (b)	23
Bitter *	41	44	40	37	50 (b)	40	37	23 (a)	7
Vegetable/herbaceous **	10 (a)	20	17	11	17	27 (b)	23	9 (a)	13
Good flavor **	47	69 (b)	50	61	50	41 (a)	56	65	115
Good aroma ***	45 (a)	56	57	72 (b)	58	46 (a)	49	71 (b)	112
Weak aroma **	34 (b)	26	24	21	18	30	30	12 (a)	14
I would recommend it **	32	36	30	46 (b)	34	23 (a)	38	47 (b)	103
I would pay more for it than I normally do *	8 (a)	17	12	18	14	10	12	25 (b)	63
I would pay less for it than I normally do *	33 (b)	24	32	23	31	29	25	13 (a)	1
I would buy it *	45 (a)	60	60	69	56	52	60	71 (b)	114

742 * Significant differences at $p < 0.05$.
743 ** Significant differences at $p < 0.01$.
744 *** Significant differences at $p < 0.001$.
745

Table 5. Penalty analysis results based on CATA. Attributes classified as "necessary", "Indifferent", and "negative" for the Sauvignon Blanc samples for all consumers and the 3 identified clusters.

All Consumers		
Necessary	**Indifferent**	**Negative**
Fruity	Apple/pear	Bitter
Good flavor	Tropical	
Good aroma	Vegetable/herbaceous	
I would recommend it	Weak aroma	
I would buy it		
I would give it as a gift		
Cluster 1 (n=37)		
Necessary	**Indifferent**	**Negative**
Fruity		
Balanced		
Good flavour		
Good aroma		
Intense aroma		
I would recommend it		
I would drink it in a special moment		
I would buy it		
I would give it as a gift		
Cluster 2 (n=60)		
Necessary	**Indifferent**	**Negative**
Good taste	Bad flavour	
I would recommend it		
I would drink it in a special moment		
I would buy it		
I would give it as a gift		
Cluster 3 (n=47)		
Necessary	**Indifferent**	**Negative**
Fruity		
Good flavour		
Good aroma		
It's a fresh wine		
I would recommend it		
I would drink it in a special moment		
I would buy it		
I would give it as a gift		

751 **Table 6.** Attributes proposed in CATA questions and generated in PM-C and attributes that were significant in
752 the Cochran and Chi square tests respectively.

CATA questions		
Category	Total proposed	Significant attributes
flavor	3	1
aroma	8	4
color	0	0
occasion	8	5
hedonics	6	4
complex/global	5	0
Total	**30**	**14**

Projective mapping based on choice		
Category	Total generated	Significant attributes
flavor	33	9
aroma	31	6
color	6	1
occasion	32	9
hedonics	16	9
complex/global	4	2
Total	**122**	**36**

Significant attributes	**Frequency**
Flavor	**Nº mentions**
bitter	312
Aroma	**Nº mentions**
fruity	363
apple/pear	171
tropical	226
vegetable/herbaceous	134
Color	**Nº mentions**
Occasion/Attitude terms	**Nº mentions**
I would recommend it	286
I would pay less for it than I normally do	210
I would pay more for it than I normally do	116
I would buy it	473
I would give it as a gift	309
Hedonics	**Nº mentions**
good flavor	439
good aroma	454
bad aroma	126
weak aroma	195
Complex/global attributes	**Nº mentions**

Significant attributes	**Frequency**
Flavor	**Nº mentions**
acid	166
alcoholic	52
bitter	171
astringent	46
sweet	63
fruity	60
intense	99
light	57
gentle	134
Aroma	**Nº mentions**
sweet	112
fruity	300
intense	220
tropical	64
gentle	150
vegetable	33
Color	**Nº mentions**
bright	55
Occasion/Attitude terms	**Nº mentions**
lunch	60
friends	30
dinner	86
cocktail	57
fish /seafood	71
dessert	32
special	68
frequent	70
romantic	35
Hedonics	**Nº mentions**
nice flavor	184
unpleasant flavor	140
elegant flavor	55
weak flavor	107
nice aroma	200
unpleasant aroma	69
weak aroma	76
balanced wine	84
I would not consume it/buy it	105
Complex/global attributes	**Nº mentions**
full-bodied wine	37
fresh wine	131

Figure captions

Fig. 1. Representation of the wine samples and the terms used to describe the samples, in the first two dimensions of the correspondence analysis (CA) of the data from the CATA question.

Fig. 2. Representation of the samples and descriptions in the first four dimensions of the multiple factor analysis (MFA) performed on data from PM-C (a) first and second dimension, (b) first and third dimensions, and (c) first and fourth dimensions.

Fig. 3. Representation of the samples and attributes in the first two dimensions of the multiple factor analysis (MFA) performed on data from PM-C, for each of the clusters identified by the liking segmentation: (a) sample plot cluster 1, (b) attribute plot cluster 1; (c) sample plot cluster 2, (d) attribute plot cluster 2; (e) sample plot cluster 3, (f) attribute plot cluster 3

Fig. 4. Superimposed representation of wines (MFA, plane 1–2). Each wine is represented using three points corresponding to each method: (a) CATA and (b) PM-C and consumer descriptions. The mean point of the two methods is the middle point, which takes into account both methodologies.