Acceptability of partially dealcoholized wines – Measuring the impact of sensory and information cues on overall liking in real-life settings

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ABSTRACT

In this study, the effect of partial alcohol reduction in wine on consumer expectation and overall liking was investigated in real-life settings (by a Home-Use-Test). By varying the wine in the bottle and by manipulating the information on the label, it was possible to assess the relative impact of sensory properties and information cues on overall liking.

Standard Chardonnay and Syrah wines were partially dealcoholized from about 13.5% to about 9.5%. After bottling, these dealcoholized wines were presented once with information about real alcohol content (9.5%) and once with false information about alcohol content (13.5%). A third bottle with standard wine inside was also presented with real information about alcohol content (13.5%). A group of 194 French wine consumers rated the three wines at home for liking before and after tasting on continuous hedonic scales. Another group of 90 French wine consumers evaluated the wines at the laboratory.

The same order of preference was obtained in both laboratory and home conditions but wines generally attained significantly higher hedonic scores in Home-Use-Tests. A strong segmentation of consumers highlighted specific consumer behaviors regarding expectation and overall liking of wines. Results emphasized the importance of both sensory and information cues in the development of overall liking by consumers.

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1. Introduction

Due to global warming and viticulture progress related to consumer demand for flavorful wines, the alcohol content of wine is increasing (Conibear, 2006). Techniques are thus being developed to reduce alcohol content in wines (Pickering, 2000) and some partially alcohol-reduced wines are now being marketed.

However, there is a lack of data about the consequences of partial alcohol reduction on the perceived sensory quality of these wines and their acceptability by consumers. Do consumers like sensory modification induced by partial alcohol reduction in wine (Meillon, Urbano, & Schlich, 2009)? It is also important to assess whether consumers accept the concept of alcohol-reduced wines, and if so, how this acceptance interacts with the sensory perception of these wines.

Theory relates that before experiencing a product for the first time, consumers tend to rely on its extrinsic cues to infer its quality (Speed, 1998), leading to the unconscious formation of hedonic expectation. Once the product has been consumed, expectations and perceived sensory properties are integrated and combined into overall liking. Anderson (1973) defined disconfirmation as the mismatch between expected and perceived quality and suggested two main models to describe how this disconfirmation can influence product perception. In most studies, the assimilation model was emphasized with a change in product evaluation in the direction of expectation (Cardello & Sawyer, 1992; Deliza & Macfie, 1996; Lange, Rousseau, & Issanchou, 1999; Schifferstein, Kole, & Mojet, 1999). Few studies have emphasized the contrast model, where there is a change in product evaluation in the opposite direction to expectation when the discrepancy between expectation and perception is too high (Yeomans, Chambers, Blumenthal, & Blake, 2008; Zellner, Strichouser, & Tornow, 2001).

Meillon, Dugas, Urbano, and Schlich (2010) investigated the impact of partial alcohol reduction in wine on consumer liking and acceptability, showing that both taste and information about alcohol reduction influenced overall liking of wines. The study was conducted by Central Location Test (CLT), under standardized and controlled conditions, to avoid bias due to environmental context. The main objective of our study was to assess, with and without information, the liking of Partially Alcohol-Reduced Wines (PARW) by consumers in real-life settings (Home-Use-Test: HUT). Contextual factors such as social interaction, place and moment of consumption are known to significantly impact product...

The two main questions were:

(1) A priori, without having tasted the wines, what are consumer expectations about PARW?

In a normal purchase situation (supermarket), consumers cannot taste products and can only use extrinsic cues to make a choice. It is therefore important to understand what the immediate reaction would be when faced with PARW for the first time.

(2) Once tasted, is perceived overall liking of PARW a matter of taste or of image?

In other words, when the consumer has tasted a PARW, what is the relative impact of sensory and information cues on overall liking?

Several studies have assessed the relative impact of sensory properties and extrinsic cues on consumer response, emphasizing a strong interaction between these two factors on overall liking (Cardello, 2007; Lange, 2000; Siret & Issanchou, 2000 for review). In these studies, a three-step methodology is generally used. First, expected liking is measured without tasting, based only on extrinsic cues. Then perceived liking is measured by evaluating the product by blind tasting, without any information. Finally, overall liking is measured by evaluating the product by tasting, with information. It is then possible to determine a disconfirmation score by subtracting perceived liking from the expected liking score. The information deviation score is obtained by subtracting perceived liking from the overall liking score.

This methodology has led to interesting results but its use for HUT can be discussed for two main reasons. First, it is both time-consuming and expensive (sending the samples to the consumers’ homes twice). So finding a way of running such a study at a lower cost is a worthy goal. Second, the tasting procedure includes blind tasting which is not really ecological for consumers. Expectations and psychological representations induced by extrinsic cues can indeed influence perceived sensory properties (Cardello, 2007; Mizutani et al., 2010; Morrot, Brochet, & Dubourdieu, 2001). Moreover, subtracting hedonic scores obtained in three different situations seems rather problematic as consumers will not necessarily use hedonic scales in the same way in each situation.

A methodological approach is thus proposed to measure the relative impact of sensory and information cues on overall liking in such a way that both parameters can be assessed in only one step, in the same ecological conditions and at the individual level (for each consumer). This approach is based on the principle of manipulating information about products as mentioned in Caporale and Monteleone (2001).

2. Materials and methods

2.1. Products

2.1.1. Wine samples

Two grape varieties were studied: Chardonnay (white) and Syrah (red). For each grape variety, a standard wine at about 13.5% was selected and then partially dealcoholized by the INRA Pech’Rouge experimental unit (Narbonne), resulting in an alcohol-reduced wine at about 9%. Exact alcohol contents of the wines are given in Table 1.

<table>
<thead>
<tr>
<th>Varietal</th>
<th>Standard (%)</th>
<th>Dealcoholized (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chardonnay</td>
<td>13.28</td>
<td>9.07</td>
</tr>
<tr>
<td>Syrah</td>
<td>13.17</td>
<td>8.98</td>
</tr>
</tbody>
</table>

Both standard wines were produced in the Languedoc Roussillon region (France) and bought (in bulk) from cooperative wineries in the same region (Fleury). Wine-making was conventional, free of oak treatment and from the 2006 vintage. The dealcoholization step was carried out 3 months before the tasting sessions, using the same reverse osmosis procedure as in Meillon et al. (2009), combined with a membrane contactor step to return the endogenous water to the wine.

2.1.2. Wine presentation: experimental design

Three bottled wines were prepared as shown in Fig. 1. One of the three bottles, called “standard”, contained the standard wine at about 13.5% and was also labelled “13.5%”. The other two bottles contained the dealcoholized wine at about 9.5%. One of them, called “dealcoholized”, was labelled “partially dealcoholized wine” and “9.5%”. The second one, called “false” was labelled “13.5%”. The comparison between “standard” and “false” wines should therefore correspond to the sensory effect of alcohol reduction, as the wines are different but the information is the same. The comparison between “false” and “dealcoholized” wines should correspond to the effect of information about alcohol reduction as the wines in the bottles are the same but the information is different.

Ideally a fourth wine at 13.5% but labelled 9.5% should have been included to balance the experimental design. This option was deliberately rejected, as presenting a wine labelled with a lower alcohol content than its true level would be ethically unsafe for consumers (driving, health).

2.1.3. Labels and back labels

Three labels and their matching back labels were specially designed for the experiment with the help of an infographic agency. All three labels displayed the same information in order to keep them in the same product space: appellation (Vin du pays d’Oc), grape variety (Chardonnay or Syrah), vintage (2006), and origin (product of France).

Both the label and the matching back label were designed with individual brands and esthetics in order to make them appear different to the consumers. Three virtual brands were thus created: “Couleurs du Roussillon”, “Soleil du Languedoc” and “Lumières du Pays d’Oc”. In order to compensate for possible effects of brand or design on overall liking, each of the three products “standard”, “false” and “dealcoholized” was not associated to one specific brand but to all three brands which were balanced according to a William Latin Square. Each brand was thus produced in 13.5% and 9.5% versions.

On the three back labels of the wine at 13.5%, a description was given with the same keywords but written differently. First a description of the sensory properties of the wine was given: white meats and seafood for Chardonnay/red meats and cheese for Syrah. The back label description of dealcoholized wine was exactly the same for the three brands. It pointed out the lightness of dealcoholized wines (obtained by a simple filtration process), emphasizing the fruitiness of the wines, ideal to drink at meal time.

The six Chardonnay labels and back labels of the wine at 13.5% and 9.5% versions are
presented in Supplementary Material Figs. S1 and S2. In the case of Syrah, labels were the same but the color was red instead of green. To reinforce verisimilitude (real bottle appearance), the Chardonnay bottles were topped with white heat-shrinkable capsules and the Syrah bottles were topped with black ones.

2.2. Consumers: two tasting conditions

Wine consumers living in and around Paris were recruited to participate in the home test. The 194 participants were divided into two panels according to the type of wine they generally drank (white or red): the first panel evaluated white Chardonnay wines (n = 98) and the second panel evaluated red Syrah wines (n = 96).

A third panel of 90 wine consumers from Burgundy was recruited to participate in controlled laboratory tasting in Dijon. This panel evaluated both Chardonnay and Syrah wines in a 1-h session. Consumers were recruited to best fit the French wine consumer population given in the 2005 Viniflor (Onivins)/INRA survey according to gender, age and frequency of wine consumption. Table 2 gives the distribution of each of the panels according to gender and age. The CLT panel was under-represented in people over 65 because it was difficult for them to come to the laboratory. Of the 284 participants, 21.9% drank wine about twice a month, 45.4% drank wine once or twice a week and 32.7% drank wine daily.

2.3. Evaluation procedure

All participants had to answer a questionnaire to collect information about wine evaluation and another one to collect information about the participants.

2.3.1. Wine evaluation

Participants were asked to rate their liking on continuous hedonic scales (10 cm). Before tasting the wine, to measure consumer expectation, they were asked: “A priori, without having tasted this wine, how much do you think you would like it?”, with “I would not like this wine” as the zero point on the continuous scale and “I like this wine” as the 10-cm mark. After having tasted and experienced the wines, participants were asked: “After having tasted this wine, how much do you like it?” to measure overall liking; the continuous scale went from “I do not like this wine” to “I like this wine”.

Participants from the HUT panel received a set of three bottles and two questionnaires at home. They first had to evaluate their expectations regarding the three bottled wines by completing the first part of the questionnaire about wine and returning it immediately by post. One week after the questionnaires had been returned, participants were allowed to start drinking and evaluating the wines, at the rate of one bottle a week, respecting the presentation order indicated in the questionnaires. Once the three bottles had been evaluated (after 3 weeks), participants had to return the second part of the questionnaire by post. Participants were allowed to drink the wines at their convenience (with friends or family or alone; during lunch or dinner or any other time; in several sessions or the whole bottle in one session). They were however asked to keep a record of the way they consumed each wine (volume, place, time of day, social environment).

Participants from the CLT panel came to the laboratory for a 1-h session. Half the participants evaluated Chardonnay wines first and the other half evaluated Syrah wines first. A 10-min break was enforced between evaluations of each series of wines. In each series, participants were first faced with the three bottles at the same time (as in HUT conditions) and rated their hedonic expectations for each bottle. Then, they monadically tasted and rated their liking for the three wines. All the sessions took place with a maximum of 16 participants, in sensory booths with controlled temperature (20 ± 1 °C). Sessions were held at lunchtime (12 h) or in the evening (18 h) according to participant availability.

2.3.2. Information about participants

The questionnaire focused on the measurement of consumer attitudes toward wine such as knowledge of and involvement in wine which have often been shown to impact product acceptability and purchase intention (Chocarro, Cortiñas, & Elorz, 2009; Lockshin, Jarvis, D’Hauteville, & Perrouty, 2006; Quester & Smart, 1998). According to Chocarro et al. (2009), consumer knowledge is a concept involving both expertise and familiarity. Expertise was measured through a 25-item quiz about wine (technology, appellation, grape variety, etc.). This questionnaire is presented
in Supplementary Material. Familiarity was measured through two behavioral parameters: the frequency of wine consumption and the number of wine bottles owned in the cellar.

Consumer involvement in wine was measured on 7-point Likert scales, using Mittal and Lee’s (1989) 6-item questionnaire: (1) I do not have a strong interest in wine, (2) Wine is important to me, (3) For me, wine matters, (4) Which wine I buy does not matter for me, (5) I choose my wine carefully, (6) Deciding which wine to buy is an important decision for me. This questionnaire has been successfully used in several wine studies (Aurifeille, Quester, Lockshin, & Spawton, 2002; Holleeke, Jaeger, Brodie, & Balemi, 2007; Lockshin, Jarvis, D’Hauteville, & Perroux, 2006). The first three items enable wine purchase involvement to be measured. The last three items measure wine purchase involvement. Demographic data such as gender and age were also collected.

2.4. Data analysis

All ratings on continuous liking scales were quantified out of 10 and all statistical analyses were performed with SAS software (Release 9.1, SAS Institute Inc., Cary, NC).

2.4.1. Analysis at group level

To check the absence of any brand effect on the evaluations, a two-way ANOVA model with interaction (brand + wine + brand * wine) was run for each grape variety on the expectation and overall liking variables. Multiple mean comparisons were also performed with a Least Significant Difference test (LSD) at p < 0.05.

To assess the effects of wines and tasting conditions (CLT vs. HUT) on the evaluations, a three-way ANOVA model with interaction (context + consumer (context) + wine + context * wine) was run for each grape variety on the expectation and overall liking variables. Multiple mean comparisons (LSD) were also performed at p < 0.05.

The sensory effect of dealcoholization was obtained by subtracting overall liking scores for false wine from those for standard wine. The effect of information about dealcoholization was obtained by subtracting overall liking scores for dealcoholized wine from those for standard wine. These sensory and information variables were calculated for each participant and when the result of the subtraction was above zero, the effect was considered positive and vice versa. To assess the impact of the seven participant characteristics collected from the questionnaires on these two variables, seven one-way ANOVA models were carried out with each characteristic as a factor. Multiple mean comparisons (LSD) were also performed at p < 0.05.

2.4.2. Segmentation of participants

An expectation index was designed to classify participants in three groups according to their expectations regarding PARW: negative, neutral or positive expectations.

Standard and false wines were both labeled 13.5%, while dealcoholized wine was labeled 9.5%. Information about alcohol reduction is therefore considered to have had some effect if the liking scores for standard and false wines were similar, but different from the liking score for dealcoholized wine. This information effect is negative when dealcoholized wine obtained a lower liking score than standard and false wines and positive when dealcoholized wine obtained a higher score. The expectation index was thus designed by dividing the variance between dealcoholized (D) wine and the average between false (F) and standard (S) wines by the variance between standard (S) and false (D) wines (Eq. (1)). To avoid division by zero, one was added to both denominator and numerator. The expectation direction was given by multiplying this variance ratio by the sign of the difference between D and the average between F and S.

\[
I_{ex} = \text{sgn}(D - F + S) \times \frac{1 + \text{var}(D; F + S)}{1 + \text{var}(F; S)}
\]  

where D is the dealcoholized wine; F is the false wine; and S is the standard wine.

An expectation index between +1 and −1 was taken to indicate neutral expectations regarding PARW. Expectations about PARW were taken to be positive when the index was superior to +1 and negative when the index was inferior to −1.

Segmentation of overall liking was performed using the Varclus procedure in SAS (centroid option). Consistency of the segmented groups was checked with the F value of product * group of segmentation interaction using a three-way ANOVA model (consumer, group of segmentation, product) in a split plot. The higher this value, the better the group consistency.

2.4.3. Demographic and behavioral data

Parameters measured in a continuous way, such as wine purchase involvement, wine product involvement and knowledge, were transformed into qualitative characteristics.

Scores were reversed where necessary in order to express the responses to negatively formulated sentences as positive statements, and totals were then calculated. The participant distribution of total scores was drawn for each characteristic and split into three groups where gaps appeared after having combined Chardonnay, Syrah and laboratory panels (N total = 284). Description of the three different levels for each characteristic is given in Table 3.

Table 4 recapitulates all seven participant characteristics collected for the study.

To explain segmented groups (expectation and liking), a cross-tabulation of participant characteristics (Table 4) in each

<table>
<thead>
<tr>
<th>Variables</th>
<th>Level</th>
<th>Nb consumers</th>
<th>Mean</th>
<th>Standard deviation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Knowledge Scores out of 25</td>
<td>Low</td>
<td>40</td>
<td>8.2</td>
<td>1.69</td>
</tr>
<tr>
<td></td>
<td>Medium</td>
<td>196</td>
<td>14.7</td>
<td>2.27</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>48</td>
<td>20.5</td>
<td>1.52</td>
</tr>
<tr>
<td>Purchase involvement Scores</td>
<td>Low</td>
<td>47</td>
<td>13.3</td>
<td>1.77</td>
</tr>
<tr>
<td>out of 21</td>
<td>Medium</td>
<td>96</td>
<td>16.3</td>
<td>1.44</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>141</td>
<td>18.8</td>
<td>1.23</td>
</tr>
<tr>
<td>Product involvement Scores</td>
<td>Low</td>
<td>32</td>
<td>10.5</td>
<td>1.46</td>
</tr>
<tr>
<td>out of 21</td>
<td>Medium</td>
<td>103</td>
<td>15.5</td>
<td>1.43</td>
</tr>
<tr>
<td></td>
<td>High</td>
<td>140</td>
<td>19.6</td>
<td>1.24</td>
</tr>
</tbody>
</table>

Table 4 Consumer characteristics collected for the study and their different qualitative levels.
segmented group was carried out and associated $\chi^2$ values were calculated ($\alpha = 5\%$).

3. Results

3.1. Brand effect

For each grape variety, brand and wine + brand $p$-values in the two-way ANOVA model, as well as brand means, are given in Table 5 for the expectation and overall liking variables.

Wine effect was significant in all cases, as discussed later. Brand effect was never significant, indicating that no brand was preferred by the entire group of participants. This eliminated any possible brand effect that might have masked the wine effect. Wine + brand interaction was not significant for Chardonnay but however tended to be significant for Syrah in both evaluations. A closer examination of means suggested that dealcoholized wine was depreciated when it was branded “Couleurs du Roussillon” for the expectation part and false wine was preferred when it was branded “Couleurs du Roussillon” for the tasting part. No coherent interpretation could be found to explain this unexpected interaction.

3.2. Tasting conditions effect: CLT vs. HUT

For each grape variety, context and wine + context $p$-values of the three-way ANOVA model and context means are given in Table 6 for the expectation and overall liking variables.

No significant context + wine interaction was emphasized, indicating that wine preferences were ranked in the same way in both CLT and HUT contexts. However, a significant context effect was emphasized in the case of Chardonnay expectation and Syrah overall liking (some tendency with Syrah expectation). The HUT panel generally gave significantly higher hedonic scores than the CLT panel.

As there was no difference in wine preference (ranking) between CLT and HUT contexts, results from CLT and HUT panels were combined for further analysis.

3.3. Participant expectation regarding PARW

3.3.1. Expectation regarding PARW: results from the entire group of participants

According to the results of the three-way ANOVA model (context + wine + consumer context + wine), a strong wine effect was emphasized for Chardonnay ($p < 0.0003$) and Syrah ($p < 0.0001$). Dealcoholized wine induced a significantly lower hedonic expectation than the other two wines (Fig. 2). The negative expectation was stronger for dealcoholized Syrah than for dealcoholized Chardonnay. As a methodological issue, it was expected that standard and false wines would induce the same expectation as they were both labeled 13.5%, and this was indeed the case. This result therefore validates the methodological approach used in the study.

The $R^2$ square of the three-way ANOVA model suggests the existence of disagreement among participants for Chardonnay ($r^2 = 0.61$) and Syrah ($r^2 = 0.58$), justifying the use of a segmentation index.

3.3.2. Segmentation of expectations

Fig. 3 shows for Chardonnay and Syrah the size and mean liking details of each of the expectation groups regarding PARW: negative, neutral (no) and positive expectations.

Contrary to what the overall means suggested, only 38.8% of the panel had negative expectations regarding PARW for Chardonnay and 47.3% for Syrah. However these consumers strongly rejected the concept of PARW since hedonic means of dealcoholized wines went below 4 for Chardonnay and 3 for Syrah. More than a third of the consumers did not express any expectations about PARW. Either they did not notice the information about alcohol reduction, or they noticed it but mainly focused their opinion on brands rather than on information, or did not feel a priori, any expectation regarding PARW and gave the same hedonic scores to the three wines. A potential segment of consumers (17%) had positive expectations about PARW for both Chardonnay and Syrah.

The $\chi^2$ tests performed between expectation groups and participant characteristics emphasized a significant effect of “number of wine bottles in cellar” ($p = 0.008$) and “wine purchase involvement” ($p = 0.004$) in the case of Chardonnay. The “negative expectation” group was mainly characterized by a population owning more than 50 bottles in their cellars (55%) whereas the “no expectation” group was mainly represented by a population with fewer than 20 bottles in their cellars (48.2%). The “positive expectation” group was strongly characterized by a population with high purchase involvement (78%) and a lesser extent with a moderate (from 20 to 50 bottles) number of bottles in their cellars (47%).

In the case of Syrah, a significant effect of age was emphasized ($p = 0.05$). “Negative” and “positive expectation” groups

---

Table 5

<table>
<thead>
<tr>
<th>Evaluations</th>
<th>Grape variety</th>
<th>$P_{\text{brand}}$</th>
<th>$P_{\text{wine-brand}}$</th>
<th>Soleil L.</th>
<th>Lumières P.O.</th>
<th>Couleurs R.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expectation</td>
<td>Chardonnay</td>
<td>0.20</td>
<td>0.21</td>
<td>5.39a</td>
<td>5.25a</td>
<td>4.99a</td>
</tr>
<tr>
<td></td>
<td>Syrah</td>
<td>0.12</td>
<td>0.06</td>
<td>5.20a</td>
<td>5.02a</td>
<td>4.75a</td>
</tr>
<tr>
<td>Overall</td>
<td>Chardonnay</td>
<td>0.48</td>
<td>0.48</td>
<td>4.99a</td>
<td>4.77a</td>
<td>4.71a</td>
</tr>
<tr>
<td>liking</td>
<td>Syrah</td>
<td>0.57</td>
<td>0.05</td>
<td>4.02a</td>
<td>3.83a</td>
<td>4.10a</td>
</tr>
</tbody>
</table>

$a$ Means with same letter within a row are not significantly different (LSD test, $\alpha = 5\%$).

Table 6

<table>
<thead>
<tr>
<th>Evaluations</th>
<th>Grape variety</th>
<th>$P_{\text{context}}$</th>
<th>$P_{\text{wine-context}}$</th>
<th>CLT</th>
<th>HUT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Expectation</td>
<td>Chardonnay</td>
<td>&lt;0.01</td>
<td>0.74</td>
<td>4.85a</td>
<td>5.54a</td>
</tr>
<tr>
<td></td>
<td>Syrah</td>
<td>0.17</td>
<td>0.66</td>
<td>4.83a</td>
<td>5.14a</td>
</tr>
<tr>
<td>Overall</td>
<td>Chardonnay</td>
<td>0.45</td>
<td>0.36</td>
<td>4.71a</td>
<td>4.92a</td>
</tr>
<tr>
<td>liking</td>
<td>Syrah</td>
<td>&lt;0.01</td>
<td>0.91</td>
<td>3.62a</td>
<td>4.32a</td>
</tr>
</tbody>
</table>

$ab$ Means with same letter within a row are not significantly different (LSD test, $\alpha = 5\%$).
were mainly represented by older participants (>50 years old) (about 51%) whereas the “no expectation” group was characterized by younger consumers (<39 years old) (38%). The “negative expectation” group had fewer young participants (16%) than the “positive expectation” group (25%).

3.4. Overall liking of wines

3.4.1. Overall liking for the entire group of participants

The results of the three-way ANOVA model (context + wine + consumer (context) + context * wine), emphasized a strong wine effect for Chardonnay ($p < 0.0001$) and Syrah ($p < 0.0001$). Standard wine was significantly preferred to false wine for Chardonnay and Syrah (Fig. 4). As both wines were labeled 13.5% but were in reality respectively 13.5% and 9.5%, this means that independently from information about alcohol content, the taste of dealcoholized wine was not liked by the entire group of participants. Alcohol reduction was thus perceived to negatively impact the sensory properties of standard wine. False wine was significantly preferred to dealcoholized wine for both Chardonnay and Syrah, whereas they were in reality exactly the same wine at 9.5% but labeled differently. This means that, independently from the taste of wine, information about alcohol reduction induced a significant decrease in the perception of wine sensory quality in the minds of the consumers. Cumulated sensory and information effects both led to a decrease of about one point in liking score means.

As for expectation scores, the $R^2$ square detail of the three-way ANOVA model suggests the existence of disagreement among consumers for Chardonnay ($r^2 = 0.56$) and Syrah ($r^2 = 0.52$), justifying the use of a segmentation procedure.

3.4.2. Overall liking segmentation

Results of segmentation respectively emphasized three and two groups with different reactions toward PARW for Chardonnay ($F_{\text{group/product}} = 106.8$) and Syrah ($F_{\text{group/product}} = 114.8$).

In the case of Chardonnay, the first group ($n = 77$) significantly and strongly depreciated dealcoholized wine compared to standard wine with a decrease of more than three points in the liking score mean (Fig. 5). This strong rejection of dealcoholized wine was slightly but significantly induced by its sensory properties but mainly by the information about alcohol reduction. The second group ($n = 59$) significantly but moderately depreciated dealcoholized wine compared to standard wine. This group strongly depreciated the taste of dealcoholized wine but significantly preferred it when information about alcohol reduction was given. The third group ($n = 52$) significantly preferred dealcoholized wine to standard wine with an increase of 2.45 points in the liking score mean.

This increase was mainly attributed to the positive sensory properties of dealcoholized wine but not significantly to the positive effect of information about alcohol content.

The $\chi^2$ tests performed between segmented groups and participant characteristics showed a significant effect of “gender” ($p = 0.01$), “number of bottles in cellar” ($p = 0.03$) and “wine knowledge” ($p = 0.01$). Participants in groups 1 and 2 were mainly represented by men (about 63%) and people with more than 50 bottles in their cellars (about 45%). They differed from consumers in group 3 who were mainly represented by women (60%) and people with few bottles in their cellars (<20 bottles) (54%). There were more wine novices in group 3 (29%) than in groups 1 and 2 (about 10%). There were also fewer wine connoisseurs in group 3 (6%) than in groups 1 and 2 (about 20%).

In the case of Syrah, the first group ($n = 102$) significantly and strongly depreciated dealcoholized wine compared to standard wine with a decrease of more than three points in the liking score mean (Fig. 5). This strong rejection of dealcoholized wine was mainly attributed to its sensory properties and to a lesser extent to information on alcohol reduction. The second group ($n = 84$) did not like all three wines since the liking means never rose above 5 out of 10. Dealcoholized wine was however significantly preferred to standard wine. This increase was almost totally attributed to the sensory properties of dealcoholized wine and the impact of information was not significant.

The $\chi^2$ tests performed between segmented groups and participant characteristics emphasized a significant effect of “age” ($p = 0.04$) and “product involvement” ($p = 0.05$). The proportion of...
younger people was lower in group 1 (21%) than in group 2 (32%) and there were more high-involved and fewer low-involved consumers in group 1 (45–21%) than in group 2 (56–9%).

3.4.3. Impact of sensory and information cues on overall liking

Results of the eight one-way ANOVA models (Table 7) carried out on the sensory effect variable emphasized a significant effect of gender for Chardonnay. The taste of dealcoholized Chardonnay wine was significantly preferred by women rather than by men (Fig. 6). “Number of wine bottles in cellar”, “wine knowledge”, “purchase involvement” and “frequency of consumption” also tended to be significant and LSD tests (α = 5%) showed that the taste of dealcoholized Chardonnay was significantly preferred by occasional drinkers and consumers with low wine knowledge rather than by daily drinkers and consumers with high wine knowledge. In the case of Syrah, only “product involvement” tended to be significant. The taste of dealcoholized Syrah was significantly preferred by less-involved rather than by highly-involved consumers (Fig. 6).

Regarding the information effect variable, a significant effect of “wine knowledge” and “product involvement” was emphasized for Chardonnay. “Number of bottles” in cellar also tended to be significant. Information about dealcoholization had a significantly more positive impact on overall liking in consumers with low wine knowledge and medium wine involvement than in participants with high wine knowledge and high wine involvement (Fig. 7). In the case of Syrah, a significant effect of “purchase involvement” and a tendency effect of “age” were emphasized. Information about dealcoholization had a significantly more positive impact on overall liking for consumers with medium purchase involvement, aged from 25 to 39, than for participants with high purchase involvement, aged from 40 to 49 (Fig. 7).

Table 7

<table>
<thead>
<tr>
<th>Factors</th>
<th>Chardonnay Sensory</th>
<th>Chardonnay Information</th>
<th>Syrah Sensory</th>
<th>Syrah Information</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>0.02</td>
<td>0.26</td>
<td>0.30</td>
<td>0.91</td>
</tr>
<tr>
<td>Age</td>
<td>0.44</td>
<td>0.39</td>
<td>0.76</td>
<td>0.07</td>
</tr>
<tr>
<td>Frequency consumption</td>
<td>0.15</td>
<td>0.38</td>
<td>0.20</td>
<td>0.53</td>
</tr>
<tr>
<td>Number bottles cellar</td>
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<td>&lt;0.01</td>
<td>0.35</td>
<td>0.35</td>
</tr>
<tr>
<td>Wine knowledge</td>
<td>0.13</td>
<td>0.58</td>
<td>0.71</td>
<td></td>
</tr>
<tr>
<td>Purchase involvement</td>
<td>0.12</td>
<td>0.98</td>
<td>0.26</td>
<td>0.04</td>
</tr>
<tr>
<td>Product involvement</td>
<td>0.33</td>
<td>0.05</td>
<td>0.15</td>
<td>0.29</td>
</tr>
</tbody>
</table>

Fig. 5. Wine liking means and their confidence interval (α = 5%) in the segmented groups of participants for Chardonnay (A) and Syrah (B).

Fig. 6. Box plots of the sensory effect of dealcoholization variable according to participant gender, wine knowledge and frequency of consumption for Chardonnay (A) and participant wine involvement for Syrah (B).
3.5. Impact of expectation on overall liking

The sensory effect of dealcoholization (False-Standard) was plotted for each participant as a function of the information effect about dealcoholization (Dealcoholized-False) for Chardonnay and Syrah (Fig. 8). The type of expectation regarding PARW was also indicated in the same figure to visualize how consumer expectations interact with these two variables.

Results suggest a great diversity in consumer reactions toward taste, information and expectation about PARW. It does not underline any typical consumer behavior such as a change in product evaluation in the direction of expectation (assimilation) or a change in product evaluation in the opposite direction to expectation (contrast) in relation to the perceived quality of wines (Anderson, 1973). Consumers who had negative expectations about PARW were not systematically negatively influenced by information once wines had been tasted and vice versa. Pearson correlation coefficients, calculated between the expectation index (before wine tasting) and the information effect variable (after tasting) were not significant for Chardonnay ($r = 0.05$, $p = 0.46$) or Syrah ($r = 0.07$, $p = 0.35$).

4. Discussion

4.1. CLT vs. HUT

Conclusions about the wine hedonic ranking were similar in both CLT and HUT conditions but wines generally obtained significantly higher hedonic scores in HUT than in CLT.

These higher hedonic scores obtained in natural consumption settings are not surprising since they have often been described in the literature (Boutrolle et al., 2007; King et al., 2004; Kozlowska et al., 2003; Meiselman et al., 2000). According to Boutrolle et al. (2007), the natural setting of HUT may help consumer well-being and thus increase consumer rating. Moreover, products can be tasted at consumer convenience and in most self-appropriate conditions according to mood or satiety/thirsty state. Besides, CLT may reinforce the analytical process of rating and make consumers more critical about products than HUT.

In our study, consumers from CLT and HUT conditions were not from the same region of France and we cannot exclude the possibility of a region effect. The CLT panel was composed of consumers from Burgundy, a famous and important wine production area in France, whereas the HUT panel was made up of consumers from around Paris. Consumers from Burgundy may be more used to drinking Burgundy wines and less well disposed than consumers from Paris to appreciate and accept wines from other regions like the Languedoc-Roussillon wine proposed in our study.

Regarding our result about similar hedonic product ranking obtained in CLT and HUT, it is not easily comparable to literature which involves blind hedonic rating (Boutrolle et al., 2007; Petit & Siefferman, 2007). It is however easily conceivable that sensory and hedonic perception can be influenced by contextual variables, but perception of information should not be influenced. If people like the concept of PARW in controlled conditions in the laboratory, they also should like it at home in natural settings. The only difference between the two conditions regarding information evaluation is that consumers can change their opinion in HUT through discussion with others or by seeking information about PARW, whereas they cannot in CLT. This modification of opinion should not impact overall results as HUT consumers could still change their opinion either way.

This result is of importance as it suggests that such methodologies do not necessarily require a home environment. This point is economically non-negligible but still needs to be validated by other studies.
4.2. A priori, without having tasted the wines, what are consumer expectations about PARW?

A priori, without having tasted the wines, expectations about PARW were negative for the entire group of participants but in reality this masked a strong segmentation.

For both Chardonnay and Syrah, less than half of the participants expressed negative expectations about PARW, while 17% of them expressed positive expectations. Reading free comments by participants can provide reasons for these negative and positive expectations. The main reasons indicated by consumers for negative expectations, ranked in decreasing order of frequency were: the loss of tradition and authenticity in wine, worry about the final quality of the wine, worry about wine preservation and a feeling of tampering with wine. Some consumers also mentioned to a lesser extent that they were worried about the viability of small producers and about wine industry development. The main reasons indicated by consumers for positive expectations, ranked in decreasing order of frequency were: better sobriety when driving, better health, renewed wine consumption, a solution for wines that are becoming too strong in alcohol, and a better slimming diet.

Information about alcohol reduction tended to induce more negative expectations about red wines than white wines. This stronger rejection of dealcoholized red wines by consumers has already been indicated in Meillon et al. (2010). The authors reported that in the mind of the consumer, red wines are perceived to be more complex than white wines and therefore from the viewpoint of final quality would not be able to withstand dealcoholization. They also reported that the dealcoholization process is perceived as “interfering with traditional winemaking” which is thus more difficult to accept for red wines because of their cultural, traditional, and even sacred status. Further qualitative studies are therefore necessary in order to understand this stronger rejection of PARW for red wines.

Parameters driving expectation segmentation were different for Chardonnay and Syrah. In the case of Chardonnay, “number of bottles in cellar” and “wine purchase involvement” could explain consumer expectation whereas in the case of Syrah, only the “age” parameter could explain it. No explanation was found to explain this difference between the two types of wines but the possibility of a panel effect cannot be excluded. In the case of Chardonnay, participants with low wine involvement and few bottles in their cellars tended to express no expectations about PARW. This observation seems coherent and confirms previous findings reporting that less-involved consumers relied less on information attributes for wine purchase decisions (Hollebeek et al., 2007; Lockshin, Jarvis, D’Hauteville, & Perroux, 2006). However it is difficult to explain how consumers with high purchase involvement tended to have positive expectations about PARW and consumers with a large number of bottles in their cellars tended to have negative expectation, as these parameters appear similar. A large number of wine bottles in their cellars may reflect appreciation of wines with potential for aging instead of wine familiarity. In that case, consumers with many bottles in their cellars would not consider PARW wines in a positive way, as these wines do not have enough alcohol to be kept in the cellar for any length of time. Wine purchase involvement may not really reflect involvement but social desirability in the responses to the questionnaire on wine involvement. In that case, high purchase involvement consumers may consider PARW wines in a positive way, as they could help to reinforce their image as regards sobriety, health and/or slimming.

In the case of Syrah, younger consumers tended to express no expectations about PARW and to express less negative expectations about PARW than older consumers. Older consumers may be more conservative and less disposed to accept novelty, particularly as regards wine, which conveys a strong, cultural and traditional image.

4.3. Once the wines have been tasted, is perceived overall liking of PARW a matter of taste or image?

The perceived overall liking of PARW was a matter of taste and image because both sensory and information cues were significantly depreciated for the entire group of participants. However a strong segmentation of consumers was emphasized with different typical reactions.

In the case of Chardonnay, the impact of information cues was stronger than the impact of sensory cues in the first group. In the other two groups, the impact of sensory cues was stronger than information cues but negative in one group and positive in the other. In the case of Syrah, sensory properties of dealcoholized wines were more important than information cues for overall liking. One group of consumers significantly depreciated the taste of PARW and another significantly liked it.

Regarding the sensory effect of dealcoholization, it appeared for Chardonnay but not for Syrah that women tended to appreciate the taste of PARW more than men. This gender-related preference for PARW could be explained by a lower gustative ethanol detection threshold in women than in men (Mattes & DiMeglio, 2001). Women may be more sensitive to the burning sensation induced by ethanol and may thus perceive its taste to be less pleasant than men do. But why did this gender effect appear for white wine but not for red wine? We support the hypothesis that alcohol reduction does not affect any other tactile properties than the burning sensation in white wines, but that it also increases perceived astringency in red wine (Fontoin, Saucier, Teissedre, & Glories, 2008; Meillon et al., 2010). This increase may compensate for the decrease in the burning sensation in dealcoholized red wines. A sensory profile would have been useful to describe the wines in the study and to confirm this hypothesis. It also appeared for Chardonnay that preference for PARW is driven by the level of expertise. The more wine knowledge consumers had and the more frequently they drank wine, the more they depreciated the sensory properties of PARW. This result has already been shown by Meillon et al. (2010) and could be explained by the theory of mere exposure (Zajonc, 1968), according to which people tend to develop preferences for things merely because they are familiar with them. Frequent wine drinkers and high wine knowledge consumers are more often widely exposed to wines, so they may have become accustomed to a higher alcohol level in wine as it gradually rose over the past few decades.

Regarding the information effect, it appeared for Chardonnay that the more experienced the consumers (high knowledge, many bottles in cellar and high wine involvement), the more negative the impact of information about dealcoholization on overall liking. Wine-experienced consumers may appreciate qualitative wines with a potential for aging and may thus negatively consider PARW as such wines do not have enough alcohol to be aged for a long time in the cellar.

4.4. Contributions and limitations

4.4.1. Methodology

By manipulating the information on the label, the methodology designed for this study allows the impact of sensory and information cues about alcohol reduction on overall liking to be measured in real-life settings, without requiring traditional blind evaluation. In sensory studies involving real-life settings, much attention has been paid to creating natural conditions by acting on environmental context. However, products are sometimes presented in blind conditions, without packaging, with codes, in small portions, to
control and normalize their extrinsic parameters. Is it worth spending money to recreate environmental real-life settings if the products do not look real? Products presented blind, with codes, may induce in the mind of the consumer an “experimental tasting” feeling and may lead them to be more critical about products. Further studies should be undertaken to compare the evaluation of the same products blind and with a “real” appearance in order to assess this. In any case, the risk of “experimental tasting feeling” is not completely avoided using this methodology since consumers are nevertheless asked to carry out complex and unusual tasks throughout the tasting procedure (rating expected liking on information alone, many questionnaires to complete, questionnaires to return by post rapidly).

However, as a consequence of information manipulation, this methodology presents a non-negligible bias concerning a possible mismatch between expectation induced by false information and genuine sensory properties. Sensory differences between evaluated products should therefore not be too great in order to avoid a strong mismatch for consumers, leading to bias in results. In our study, a fourth wine should have been presented to consumers in order to balance the experimental design and the possible mismatch between expectation and experience but ethically this was not possible. Furthermore, this methodology cannot be applied to all types of food and needs to be used with easily disguisable products.

Another consequence of information manipulation and of real-life settings is the need to design different designs/brands for the products that do not affect overall liking and that do not interact with the information. In our study, a significant interaction wine-brand was sometimes observed in the case of Syrah wine and no reasons were found to explain such a reaction. This interaction probably affected our results, although they appeared coherent, and so we recommend performing a preliminary experiment to test the absence of wine-brand interaction in further studies.

4.4.2. Acceptability of PARW

This study is the first to deal with the acceptability of PARW in real-life settings. It thus emphasizes a group of consumers potentially attracted to these wines, either for their sensory properties or simply because of lower alcohol levels. This topic is now of interest since more and more winemakers partially dealcoholize their wines before marketing them and little is known about the consequence of such a process on wine acceptability.

Conclusions about PARW cannot however be generalized, as the study involved French consumers, French wines from Languedoc and specific information about alcohol reduction. Further studies should involve other consumers, wine styles, or type of information regarding alcohol reduction. It is expected that consumers from New World wine countries would have more positive expectations about PARW than French consumers.

Also, since it was a deliberate choice not to draw attention to the goal of our study (dealcoholization), we cannot assume that all responses were influenced by the information about “partially dealcoholized wine” or even that all consumers noticed that information. Many consumers in the “no expectations” groups may simply not have seen the information about alcohol reduction and should therefore have been placed in another expectation group. However, such consumers do not always look at the information on wine labels in real-life settings and their behavior cannot be excluded from the study.

Another possible cause of bias is that we cannot absolutely certify that all consumers followed the recommended protocol when evaluating the wines at home (HUT). Furthermore, our protocol for the lab test did not follow the normal rules when studying expectations, i.e. in this study, expected and actual hedonic responses were collected during the same session. However, the results for HUT and CLT are significantly not different and seem coherent, so such biases seem to have had little or no effect.

Our results cannot predict consumer purchase decisions as they are only declarative. Real purchase behavior under economic constraints may well be different. Further studies should be undertaken to measure consumer willingness to pay for PARW, by combining our methodology with methodologies from experimental economy such as the Vickrey auction (Vickrey, 1961) or the BDM mechanism (Becker, DeGroot, & Marschak, 1964). Further qualitative studies would also be useful in order to determine the best way to present information about alcohol reduction on wine labels and bottles.

Acknowledgments

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Appendix A. Supplementary material


References


