DynamicsensorydescriptionofRiojaAlavesa
redwinesmadebydifferentwinemaking
practicesbyusingTemporalDominance
ofSensations

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Abstract

BACKGROUND: Although sensory description of wines in scientific literature is very large, there is an evident lack of studies
describingwinesfromadynamicapproach.Theobjectiveofthisstudywastodescribetheevolutionofthesensationsperceived
inredwinesfromRiojaAlavesabyusingTemporalDominanceofSensations(TDS)andalsotocomparewinesmadewiththetwowinemakingproceduresusedinRiojaAlavesa:carbonicmaceration(CM)anddestemming(DS).

RESULTS:Tensensoryattributeswerenevaluatedineightwines(fourCMandfourDSwines)intriplicatebyapanelof16trained
assessors. Red/blackberryandwoodyaromasweredominantfirstly,whereasheat,astringent,bitterandpungentsensations
weredominantlater. CMwinesshowedhighestdominanceforwoody,spicy,pungentandsensationsandlowerdominance
forred/blackberryaromaandastringencythanDSwines.

CONCLUSION: Thisstudyisthefirsttodescribereionawinesfromadynamicapproachanditalsoprovidesinformationabout
thesensorydifferencesbetweenwinesmadebyCMorbyDS. Inthissense, thisworkshowstheusefulnessoftododescribe
differentiate wines and to provide additional information to the conventional static descriptive analysis.

Keywords:TDS; Rioja wine; carbonic maceration; sensory analysis; Tempranillo

INTRODUCTION

RiojaAlavesa(RA)isoneofthethree sub-zonesintheRiojawine
regionincludedintheProtectedDesignationofOrigin(PDO)Rioja.
Amongthegrapevarietiesacceptedforwinemaking, Tempranillo
isthepredominantoneinredwines(96.36%ofthesurface
cultivatedwithredgrapevarieties).1 Mostoftheredwinesare
madeexclusivelywiththeTempranillograpevarietyorbymixing
Tempranillowithothergrapevarietiesinalowproportion(usually
lowerthan10%).Theseminorgrapevarietiesalsoincludesome
whitegravearitiessuchasViura(also calledMacabeo)whichis
themainone.

Young wine is the most typical wine in RA and it has been tra-
ditionally made by the carbonic maceration (CM) technique. CM is
also used in different European regions to make traditional wines,
such as Médoc, Bordeaux, Beaujolais or Provence.2,3 The mainte-
nance of many small, family wineries in RA has perpetuated this
practice although the use of destemming (DS), i.e. winemakingby
crushingthe grapes before fermentation, is progressively displace-
ning CM.

CM was described for the first time by Flanzy4 and it refers
to placing the entire grapes in a vat within a CO2 atmosphere
(anaerobiosis)for several days so that several enzymatic reactions
take place without yeast participation: ethanol production (until
20–30mL−1), malic acid consumption and polyphenol transfer
from skin to the pulp. Then, the grapes break down because of the
internal pressure and the fermentation by yeast starts.

Actually, CM practised in RA is not a strict CM since some grapes
break when they are placed in the vat (thus initialising the fer-
mentation by yeast, so both phenomena take place simultaneously),

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SO₂ is added and CO₂ is not. Next, free run must from the grapes and must from pressed clusters are mixed to continue the alcoholic fermentation, usually without the skins. In the DS process, grapes are crushed and fermentation by yeast occurs immediately in contact with skins.

Although RA wines are recognised as high quality wines, scientific reports describing their organoleptic characteristics using sensory panels are very scarce. Regarding sensory characteristics that differentiate CM wines from DS wines, the scientific literature is quite general and ambiguous. In addition, the sensory practices used do not always meet the minimum required in scientific sensory analysis. Odour of CM wines has been described as ‘distinctive’ and ‘rich’. Sensory attributes frequently used to describe the aromas of these wines are related to fruits, i.e. generic fruits, or specific fruit attributes such as strawberry and raspberry or cherry and kirsch. Other aromas reported are floral and spicy.

Regarding sensations in mouth, CM wines have been described as soft and velvety but without comparing them directly with wines made by DS. Among the very few studies comparing CM and DS wines by using sensory panels, Fuleki reported that CM wines from Concord grapes made with the same grapes. In the case of Tempranillo wines from the Temporal Dominance of Sensations (TDS) technique allows the sensory characteristics elicited by food products to be described and rated for order and carry-over effects. The main chemical characteristics of the wines are shown in Table 1.

Assessors
Sixteen French assessors (nine women and seven men) aged 29–65 years (mean age 45 years) participated in this study which took place at the Centre des Sciences du Goût et de l’Alimentation (CSGA) in Dijon (France). They were selected according to their results in previous sensory discrimination, ranking and recognition tests and had recently participated in a TDS panel training and red wine sensory profile training for 3 months. They were paid for their involvement in the study.

Training sessions
Assessors were trained during three 1-h sessions to TDS evaluation of the RA wines. In the first session descriptive sensory attributes were generated for the eight wines of the study. Assessors were instructed about the tasting protocol: at zero seconds, put the wine in mouth; at 12 s, inspire three times drawing air through the wine; at 20 s, click the tongue three times and wait until no more sensations are perceived. Throughout the evaluation of each sample, assessors had to write down all the mouth sensations they perceived as dominant. The 10 more cited terms were selected and kept for further TDS evaluations. The two following sessions were dedicated to check the appropriateness of the data collected. The 10 attributes selected for the study (four aromas and six gustative and mouth-feel sensations) and the composition of the sensory references are shown in Table 2.

Wine evaluation by TDS
Wine evaluations by TDS took place in isolated sensory booths at standardised temperature (20 ± 1 °C) and under red light to mask wine colour. Wine samples were presented in plastic opaque cups (10 mL) coded randomly with three digits. Evaluations were carried out in three 1-h sessions in order to have three replications. In each session, the eight wines of the study were monadically presented according to a Williams Latin Square design balanced for order and carry-over effects.

Data acquisition was achieved with Fizz Software (BIOSYSTEM, Couternon, France) with a period of 500 ms. The list of the 10 attributes was displayed on a computer screen associated with unstructured scales (30 cm), ranging from weak (left) to strong.
Assessors put all the cup content in mouth and clicked the ‘start’ button to start the temporal sensory evaluation. Once the chronometer started, they identified and rated the intensity of the sensations they perceived as dominant while performing the tasting protocol. Score recording extended throughout 120 s although when not perceiving sensations anymore, assessors had to click ‘stop’ button. A 2 min break was established between samples to eliminate residual sensations by rinsing the mouth with unsalted crackers and Evian water.

The order of the attributes in the list was randomised across assessors to balance the fact that first attributes of the list could be more often cited.35

Table 1. Main chemical characteristics of the wines (mean values ± standard deviation)33

<table>
<thead>
<tr>
<th>Wine</th>
<th>Winemaking technique</th>
<th>Grape variety</th>
<th>Ethanol (cL L⁻¹)b</th>
<th>pHc</th>
<th>Total acidity (g tartaric acid L⁻¹)d</th>
<th>Total polyphenol indexe</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM1</td>
<td>Carbonic maceration</td>
<td>Tempranillo</td>
<td>13.69 ± 0.13</td>
<td>3.75 ± 0.01</td>
<td>4.32 ± 0.13</td>
<td>55.25 ± 0.96</td>
</tr>
<tr>
<td>CM2</td>
<td>Carbonic maceration</td>
<td>Tempranillo</td>
<td>14.48 ± 0.17</td>
<td>3.67 ± 0.02</td>
<td>4.45 ± 0.17</td>
<td>62.75 ± 1.26</td>
</tr>
<tr>
<td>CM3</td>
<td>Carbonic maceration</td>
<td>Tempranillo</td>
<td>13.34 ± 0.13</td>
<td>3.80 ± 0.01</td>
<td>4.08 ± 0.13</td>
<td>59.25 ± 0.96</td>
</tr>
<tr>
<td>CM4</td>
<td>Carbonic maceration</td>
<td>Tempranillo + Viura</td>
<td>13.96 ± 0.14</td>
<td>3.61 ± 0.01</td>
<td>4.27 ± 0.14</td>
<td>45.75 ± 0.50</td>
</tr>
<tr>
<td>DS1</td>
<td>Destemming</td>
<td>Tempranillo</td>
<td>13.24 ± 0.18</td>
<td>3.75 ± 0.01</td>
<td>4.55 ± 0.18</td>
<td>63.50 ± 1.29</td>
</tr>
<tr>
<td>DS2</td>
<td>Destemming</td>
<td>Tempranillo</td>
<td>14.13 ± 0.15</td>
<td>3.63 ± 0.01</td>
<td>4.67 ± 0.15</td>
<td>64.25 ± 0.96</td>
</tr>
<tr>
<td>DS3</td>
<td>Destemming</td>
<td>Tempranillo</td>
<td>13.42 ± 0.06</td>
<td>3.89 ± 0.01</td>
<td>4.13 ± 0.06</td>
<td>70.75 ± 1.26</td>
</tr>
<tr>
<td>DS4</td>
<td>Destemming</td>
<td>Tempranillo + Viura</td>
<td>14.03 ± 0.15</td>
<td>3.58 ± 0.01</td>
<td>4.83 ± 0.15</td>
<td>57.25 ± 0.96</td>
</tr>
</tbody>
</table>

Table 2. Sensory attributes evaluated in the wines and reference composition

<table>
<thead>
<tr>
<th>Sensory attribute</th>
<th>Reference composition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aromas</td>
<td></td>
</tr>
<tr>
<td>Woody/roasted</td>
<td>8 g oak chips maintained two days in 1 L of water</td>
</tr>
<tr>
<td>Red/black berries</td>
<td>80 mL cinnamon syrup (Monin) L⁻¹ water</td>
</tr>
<tr>
<td></td>
<td>80 mL green banana syrup (Monin) L⁻¹ water</td>
</tr>
<tr>
<td>Tastes and mouthfeel sensations</td>
<td></td>
</tr>
<tr>
<td>Acid</td>
<td>1 g citric acid L⁻¹ water</td>
</tr>
<tr>
<td>Bitter</td>
<td>0.08 g quinine chlorhydrate L⁻¹ water</td>
</tr>
<tr>
<td>Astringent</td>
<td>0.6 g tannic acid L⁻¹ water</td>
</tr>
<tr>
<td>Heat (alcohol)</td>
<td>70 mL ethanol L⁻¹ water</td>
</tr>
<tr>
<td>Pungent</td>
<td>–</td>
</tr>
<tr>
<td>Sweet</td>
<td>8 g sucrose L⁻¹ water</td>
</tr>
</tbody>
</table>

Data analysis

Data analysis was carried out as described by Meillon et al.28 for producing the TDS curves for each wine and the TDS curves of differences between CM and DS wines. Curves were produced by importing the Fizz data into the TimeSens software (www.timesens.com).

The dominant rates of the different attributes are calculated for each wine by dividing the number of citations of each attribute (over all assessors and replications) by the total number of evaluations (number assessors × number replications). Since an assessor can have only a single dominant attribute at each time, the sum of the dominance rates over attributes is equal to 1 at each time. The higher the dominant rate, the better is the agreement among assessors (i.e. if 10 of the 16 assessors had marked an attribute as dominant at the same time, the dominance rate of this attribute is 10/16, which indicates a better agreement than, for instance, five assessors coinciding in an attribute, so with a dominance rate of 5/16).

The dominance rates of each attribute are then smoothed along time to produce a time–dominance curve. The different curves for a given wine are then displayed on a graph that also includes ‘chance level’ and ‘significance level’ curves. The ‘chance level’ line represents the dominance rate that an attribute can obtain by chance (1/number of attributes). The ‘significance level’ line, based on a binomial test, expresses the smallest value of the proportion being significantly (P ≤ 0.10) higher than the ‘chance level’. When the curve of an attribute overcomes this significance level, it is considered as significantly dominant. In this manner, the sequence of the dominant sensations perceived in a product can be described.

In addition, TDS difference curves showing the attributes that are different between CM and DS wines were produced as described by Pineau et al.15 These curves are drawn by subtracting time by time dominance rates from one product to another one. TDS difference curves were plotted only when a significant (P ≤ 0.10) difference was observed between the average dominance rate of the four CM wines and the average dominance rate of the four DS wines.

The table composed of dominance durations of products by subjects as observations and attributes as variables was analysed by...
Canonical Variate Analysis (CVA). The first two canonical variates were displayed as a biplot with superimposition of the 90% confidence ellipses of product means. CVA was complemented by $T^2$ Hotelling tests to compare the products two by two multi-variateley based on their dominance durations. CVA was also carried out by using TimeSens software.

RESULTS AND DISCUSSION

Dynamic descriptions of the wines

The attributes selected to be evaluated in the RA wines of the present study (Table 2) did not fit, to a certain extent, the attributes previously reported for young red wines from Rioja Alavesa. It could be explained by the fact that TDS is a sensory approach different to the conventional descriptive analysis, which does not consider expressly the evolution of sensations. But it could also be explained in some sense by the cultural differences between panels from different regions (Basque Country and Burgundy in this case), as reported by several authors. In fact, Drake et al. reported differences in the usage of several terms to describe Cheddar cheeses among panels from Ireland, New Zealand and USA, and found some attributes that likely displayed distinct cultural influences. Also, Strauss and, specifically, red berry aroma. Indeed, Etaio et al. found that CM wines presented a significantly higher red berry aroma than DS wines (there were not significant differences for black berry aroma). Versini and Tomasi described CM wines as higher in strawberry and raspberry in comparison with non-CM wines as well. Also, the higher fruity character of CM wines reported by several authors has not been observed in the present study. The higher dominance for red/black berry aroma in DS wines could be explained for later and broader peaks over the significance line for this attribute in comparison with CM wines (Fig. 1). In this sense, the use of a dynamic approach seems to reveal a small time difference in the perception of this sensation as dominant, which could not be noticed when using the conventional descriptive analysis. This observation would support the interest of using both kind of analysis to better understand the sensations perceived in mouth when evaluating a food product.

Regarding taste and trigeminal sensations, heat, the unique attribute that resulted in being significantly dominant in the eight wines, did not present differences among DS and CM wines. Thus, this attribute contributed to describing the sensations elicited in mouth by these wines but not to discriminating among these two winemaking practices. In relation to heat sensation, Etaio et al. reported higher intensity for alcoholic sensation in CM wines in conventional descriptive analysis. No additional references about possible differences between CM and DS wines for this sensation (heat, alcoholic, burning) have been found.

In relation to astringency, DS wines presented an evident higher dominance, which extended throughout 25 s. There is no conclusive data about the differences in astringency between CM and DS wines, mainly due to the scarce scientific reports published (all of them using conventional descriptive analysis). In a study assessing wines made with Muscadine grape variety (Vitis rotundifolia Michaux) Carroll reported lower astringency for CM wines in comparison with DS wines, whereas Etaio et al. did not find differences in Tempranillo wines from Rioja Alavesa regarding these two winemaking practices.

CM wines presented a slight higher dominance for pungent and for acid sensations during a brief period of time (6 and 4 s, respectively), as reported by several authors. In fact, Drake et al. reported higher intensity for alcoholic sensation in CM wines in comparison with DS wines by using conventional descriptive analysis. No additional references about possible differences between CM and DS wines for this sensation (heat, alcoholic, burning) have been found.
Figure 1. Evolution of dominance of sensory perceptions resulting from TDS for carbonic maceration (CM) and destemming (DS) wines. Curves over the significance level ($P = 0.10$) mean that the attribute is significantly dominant.
Figure 2. Significant differences ($P \leq 0.10$) between TDS curves of carbonic maceration (CM) and destemming (DS) wines (upper curves express higher dominance rates for DS wines, and lower curves higher dominance rates for CM wines).

Table 3. CVA Hotelling table for carbonic maceration (CM) and destemming (DS) wines

<table>
<thead>
<tr>
<th>Sample</th>
<th>CM1</th>
<th>CM2</th>
<th>CM3</th>
<th>CM4</th>
<th>DS1</th>
<th>DS2</th>
<th>DS3</th>
<th>DS4</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM1</td>
<td>1</td>
<td>0.623</td>
<td>0.477</td>
<td>0.475</td>
<td>0.005</td>
<td>0.144</td>
<td>0.003</td>
<td>0.128</td>
</tr>
<tr>
<td>CM2</td>
<td>0.623</td>
<td>1</td>
<td>0.222</td>
<td>0.102</td>
<td>0</td>
<td>0.035</td>
<td>0</td>
<td>0.311</td>
</tr>
<tr>
<td>CM3</td>
<td>0.477</td>
<td>0.222</td>
<td>1</td>
<td>0.598</td>
<td>0.037</td>
<td>0.093</td>
<td>0.008</td>
<td>0.047</td>
</tr>
<tr>
<td>CM4</td>
<td>0.475</td>
<td>0.102</td>
<td>0.598</td>
<td>1</td>
<td>0.025</td>
<td>0.143</td>
<td>0.001</td>
<td>0.052</td>
</tr>
<tr>
<td>DS1</td>
<td>0.005</td>
<td>0</td>
<td>0.037</td>
<td>0.025</td>
<td>1</td>
<td>0.013</td>
<td>0.008</td>
<td>0.001</td>
</tr>
<tr>
<td>DS2</td>
<td>0.144</td>
<td>0.035</td>
<td>0.093</td>
<td>0.143</td>
<td>0.013</td>
<td>1</td>
<td>0.471</td>
<td>0.055</td>
</tr>
<tr>
<td>DS3</td>
<td>0.003</td>
<td>0</td>
<td>0.008</td>
<td>0.001</td>
<td>0.008</td>
<td>0.471</td>
<td>1</td>
<td>0.002</td>
</tr>
<tr>
<td>DS4</td>
<td>0.128</td>
<td>0.311</td>
<td>0.047</td>
<td>0.052</td>
<td>0.001</td>
<td>0.055</td>
<td>0.002</td>
<td>1</td>
</tr>
</tbody>
</table>

Shaded cells mean that there is significant difference between products ($P \leq 0.10$) and cells without shading mean that there is no significant difference between products ($P > 0.10$).

respectively). References of other authors about differences in pungent sensation between DS and CM wines have not been found. Regarding acid sensation, the mentioned slight higher dominance in CM wines agreed with the results of Etayo et al.\textsuperscript{14}

Bitter attribute presented a singular performance, since its dominance was slightly higher for DS (between seconds 8 and 11) and later, from seconds 30 to 40, higher for CM. No clear explanation of this observation can be formulated but it could be linked to the dominance/lack of dominance of other sensations instead of being a very different perception of bitterness in CM and DS wines.

With regards to the interval when dominance differences between DS and CM wines were significant, Fig. 2 shows that, in general terms, the main differences in attribute dominance took place from 15 to 44 s. So, it seems that it was necessary to have sufficient time after sipping the wine for the sensory differences to be clearly perceived.

A hotelling table from CVA and the corresponding bi-plot for wines and attributes are shown in Table 3 and in Fig. 3, respectively. The two axes represented in Fig. 3 explain 55.59 % of the variance. The main aspect observed in Fig. 3 and Table 3 is that CM wines were very close, overlapping all of them, with no significant ($P > 0.10$) wine-to-wine differences among them, and that, with some exceptions, they differed from DS wines. CM wines were related with attributes such as spicy aroma, bitter, banana aroma, sweet, pungent and, to a less extent, heat and acid. DS wines were more dispersed than CM wines in the bi-plot and there were also many significant wine-to-wine differences among DS wines (10 significant differences vs. two non-significant differences in Table 3). As shown in Fig. 3, wine DS1 was significantly different from the other six wines (with a very slight overlapping surface with CM3), wine DS3 was different from other six wines (the four CM wines and two DS wines), wine DS4 was different from wines DS1 and DS3, and wine DS2 only differed clearly from wine DS1. So, DS wines were more heterogeneous than CM wines regarding their dynamic sensory characteristics. Among DS wines, wine DS2 and wine DS3 were the closest ones, mainly described by astringent, red/blackberry aroma and woody aroma. On the projection over these first two axes, wine DS1, the most different from the others, was not clearly differentiated by any attribute dominance (just in a slightly manner by acid sensation) and wine DS4 was mainly related to heat, pungent and, to a certain extent, to sweet sensation.

CONCLUSIONS

Using TDS to describe red wines from Rioja Alavesa has provided new information about the evolution of the sensations perceived in these wines, which cannot be achieved by static descriptive
analysis. Results of the application of this method have shown that heat, red/black berries aroma, astringent, bitter, woody aroma, pungent and acid are the main attributes to describe the evolution of the sensations perceived in mouth, although attributes with significant dominance varied to a great extent depending on the wine. It has been also observed that there is a tendency for the aromas to dominate first, and the gustative and trigeminal sensations to dominate later, which constitutes an interesting aspect to be investigated in the future in relation to this method.

Analysis of wines by TDS has enabled the observation of significant differences in the evolution of the sensations in the mouth according to the winemaking used (CM vs. DS). CM wines showed higher dominance for woody and spicy aromas, and pungent and acid sensations, while DS wines showed higher dominance for red/black berry aroma and astringency. This information complements the scarce information available about the differences between wines made by these two winemaking processes, providing the wineries with additional data about the implications of using one winemaking process or the other one. Despite these results, additional studies are still necessary to confirm the observed dynamic differences due to winemaking process in these products. Besides, it would be interesting for further works to consider the cultural effect on the use of attributes to describe the sensations perceived in these kinds of wines.

ACKNOWLEDGEMENTS

The authors thank Christine Urbano, from Centre des Sciences du Goût et de l’Alimentation, for helping with the panel training and sample preparation.

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