



HAL
open science

Oxidation in wine: Does expertise influence the perception?

Ernesto Franco-Luesma, Carole Honoré-Chedozeau, Jordi Ballester,
Dominique Valentin

► To cite this version:

Ernesto Franco-Luesma, Carole Honoré-Chedozeau, Jordi Ballester, Dominique Valentin. Oxidation in wine: Does expertise influence the perception?. *LWT - Food Science and Technology*, 2019, 116, pp.108511. 10.1016/j.lwt.2019.108511 . hal-02296497

HAL Id: hal-02296497

<https://institut-agro-dijon.hal.science/hal-02296497>

Submitted on 20 Dec 2021

HAL is a multi-disciplinary open access archive for the deposit and dissemination of scientific research documents, whether they are published or not. The documents may come from teaching and research institutions in France or abroad, or from public or private research centers.

L'archive ouverte pluridisciplinaire **HAL**, est destinée au dépôt et à la diffusion de documents scientifiques de niveau recherche, publiés ou non, émanant des établissements d'enseignement et de recherche français ou étrangers, des laboratoires publics ou privés.



Distributed under a Creative Commons Attribution - NonCommercial 4.0 International License

1 **OXIDATION IN WINE: DOES EXPERTISE INFLUENCE THE PERCEPTION?**

2

3 Ernesto Franco-Luesma^{a*}, Carole Honoré-Chedozeau^b, Jordi Ballester^{ac}, Dominique

4 Valentin^{ad}

5 ^aCentre des Sciences du Goût et de l'Alimentation. Université de Bourgogne Franche Comté.

6 UMR 6265 CNRS, UMR 1324 INRA, France

7 ^bSICAREX Beaujolais, 210 Boulevard Victor Vermorel, 69400 Villefranche sur Saône,

8 France

9 ^cIUVV Jules Guyot, Université de Bourgogne, 1 rue Claude Ladrey, 21078 Dijon, France

10 ^dAGROSUP, Université de Bourgogne, 1 Esplanade Erasme, 21000 Dijon, France

11 ***corresponding author:** efrancolesma@gmail.com

12

13

14 **ABSTRACT**

15 Wines can develop off-odours that depreciate their quality. Among them, oxidation is one of
16 the most prevalent. The main objective of this work was to study the perception of wine
17 oxidation through the categorization of oxidized wines perceived as not-faulty/faulty
18 depending on the expertise of participants. For this purpose, one white wine and one red wine
19 were spiked with three volatile oxidation compounds (acetaldehyde, phenylacetaldehyde and
20 methional) in order to recreate twelve levels of oxidation in a controlled way. Samples were
21 submitted to orthonasal tasting for being categorized by wine experts and novices and coupled
22 to a free description task. Results demonstrated that experts were significantly more
23 consensual to categorize oxidized wines than novices. However, the difference between the
24 two groups was not of great magnitude. To find an explanation, *a posteriori* individual data
25 treatment was carried out. This analysis highlighted five particular behaviours as a function of
26 the samples' oxidation level, irrespective of the level of expertise. Results also highlighted
27 that for the experts, the frontier between the two categories (not-faulty/faulty) was
28 significantly clearer for the white wine than for the red wine. This same tendency was also
29 observed for the novices.

30 **Keywords:** wine oxidation; wine expertise; perception

31

32 1. INTRODUCTION

33 Wine quality is a complex and multidimensional concept (Jover, Montes, & Fuentes, 2004).
34 Previous research has shown that perceived quality of wine is based on both extrinsic (brand,
35 price, labelling, wine origin, variety, awards...) and intrinsic (organoleptic properties such as
36 flavour, colour or mouthfeel) cues (Charters & Pettigrew, 2007; Jover et al., 2004; Veale &
37 Quester, 2009). Among the intrinsic quality cues, the absence of negative odorants is of
38 utmost importance.

39 Many wines identified as faulty in oenological contests have off-odours associated to
40 deficient aging, in particular with oxidation (Ugliano et al., 2009). Oxidation is one of the
41 most widespread wine faults found in nearly all the winegrowing regions in the world. Wine
42 is in contact with atmospheric oxygen to a greater or lesser extent during operations occurring
43 before, during, and after the fermentation process. This contact extends to bottle ageing as a
44 result of the oxygen passing through the cork until its consumption (Karbowiak et al., 2009).
45 Then, if the management of the oxygen from the must to the glass is not well controlled,
46 oxidation off-odours could appear. Many of the oxidation compounds with relevant aroma
47 impact in wines are aldehydes. Different types of aldehydes can play an important role in
48 wine. However, acetaldehyde (Wildenradt & Singleton, 1974), phenylacetaldehyde (Silva
49 Ferreira, Hogg, & Guedes de Pinho, 2003) and methional (Escudero, Hernández-Orte, Cacho,
50 & Ferreira, 2000) have a significant and negative sensory impact. Acetaldehyde is a major
51 wine compound at levels of mg/L in oxidized wines and characterized by aromas of green
52 apple and nuts. With respect to phenylacetaldehyde and methional, both compounds
53 contribute with honey-like and boiled potato nuances respectively. Although these three
54 compounds are always present in aged wines and can contribute to the expected wine tertiary
55 aromas, at high concentrations, they may affect negatively the perception of wine quality.
56 However, on the other hand, for some wines, high concentrations of oxidation compounds are

57 expected and positively evaluated (e.g. Xerez wines, “*vin jaune*”). Therefore, the evaluation
58 of oxidation in wine is not straightforward, and can oscillate from positive to negative
59 depending on the concentration in oxidation compounds, the context, and the expertise level
60 of the participants.

61 On the other hand, identifying wine faults is an important activity for which wine experts are
62 often trained for. Although wine experts and novices seem to be equal in terms of olfactory
63 sensitivity (Bende & Nordin, 1997; Parr, White, & Heatherbell, 2004), they do not describe
64 their perceptions of wines in the same way. Indeed, experts use more technical and precise
65 terms than novices (Croijmans & Majid, 2016; Chollet & Valentin, 2000). Wine experts seem
66 to have also better odour recognition and memorization abilities than novices (Hughson &
67 Boakes, 2002). This superiority could be due to the level of wine knowledge and the way this
68 knowledge is organized and activated in memory (Ballester, Patris, Symoneaux, & Valentin,
69 2008; Hughson & Boakes, 2002). Repeated exposure to wines seems to have also an effect on
70 wine knowledge and mental representations (Honoré-Chedozeau, Lelièvre-Desmas, Ballester,
71 Chollet, & Valentin, 2017)

72 Taken together, the previous studies suggest that experts, through repeated exposure, formal
73 training and professional experience may have developed a common mental representation of
74 wine faults, allowing them to recognize and describe these off-odours in a more consensual
75 way. In agreement with this hypothesis, Tempère et al. (2016) reported that wine faults are
76 often better discriminated by wine experts in comparison with novices. However, another
77 study conducted by Tempère et al. (2014) showed a lack of consensus among wine experts
78 about red wines spiked with ethyl phenols. On the novice side, Schumaker et al. (2017)
79 showed that perception of *Brettanomyces* character in wine was influenced by the level of
80 wine knowledge of novices. Those studies suggest that the difference between wine experts’
81 and novices’ ability to detect and identify wine faults is far from being clear cut.

82 To our knowledge, there is so far no research that had explored the perception of wine
83 oxidation regarding to the expertise level. Then, the specific goal of this work was to explore
84 the perception of oxidation off-odours in red and white wines as a function of the level of
85 expertise of the participants. Based on the literature, we expected that experts would have a
86 clearer mental representation of wine oxidation than novices and so to identify oxidation
87 odours as a wine fault at lower concentrations than novices and in a more consensual way.

88 **2. MATERIAL AND METHODS**

89 **2.1. Reactives**

90 Ethanol used as solvent for preparing solutions of aldehydes was from Panreac (Barcelona,
91 Spain). Acetaldehyde, phenylacetaldehyde and methional (Food grade $\geq 99\%$) were
92 purchased from Sigma-Adrich (Gillingham, England).

93 **2.2. Wines**

94 One red and one white wine were used as base wines. These two wines were selected among
95 four commercial red wines made from Grenache/Syrah and four commercial white wines
96 made from Chardonnay for their absence of oxidative notes. The selection was made based on
97 a pre-test during which 16 participants (second year students of Viticulture and Oenology
98 from the University of Burgundy) described orthonasally the main aromas of the wines. The
99 chemical characterization of the two base wines was made by means of OenoFossTM wine
100 analyser (Foss Iberia, S.A. Barcelona, Spain). Alcoholic degree, volatile acidity, malic acid,
101 reducing sugars, free and total SO₂ and pH were in the common range for reds and white
102 wines. Information and basic compositional oenological parameters of the selected wines are
103 shown in **Table 1**.

104 The two base wines were spiked with increasing concentrations of a mixture of acetaldehyde,
105 phenylacetaldehyde and methional in order to create a twelve-samples oxidation gradient
106 (**Table 2**). These three aldehydes are very labile compounds, which can interact mainly with

107 SO₂ but also with other wine compounds. For this reason, wines were spiked 30 minutes
108 before the sensory sessions. The ratio chosen for these three compounds was within the
109 natural proportions of occurrence in commercial wines (Bueno, Carrascón, & Ferreira, 2016).
110 Detailed compositional data of samples are provided in **Table 2**.

111 **2.3. Participants**

112 Twenty nine (13 men and 16 women) experts were recruited according to the criteria
113 proposed in previous works (Bende & Nordin, 1997; Parr et al., 2004). All experts were from
114 the Beaujolais region. Their age ranged from 26 to 75 years old (average=48.7).

115 Thirty-two novices (10 women and 22 men) were recruited by means of a questionnaire
116 including questions about wine-tasting experience and drinking habits. The criteria used to
117 select wine novices were: not being under the legal drinking age of 18, drinking wine at least
118 once per month, not having professional wine experience and not having followed formal
119 training in wine-tasting or wine production. Novices age ranged from 32 to 77 years old
120 (average=49.6). The number of novices and experts selected in this study is in line with the
121 number of participants in most study investigating expertise effects (Ballester et al., 2008;
122 Giboreau, Navarro, Faye, & Dumortier, 2001; Hoek, van Boekel, Voordouw, & Luning,
123 2011; Honoré-Chedozeau et al., 2017; Lelièvre, Chollet, Abdi, & Valentin, 2009; Parr,
124 Valentin, Green, & Dacremont, 2010).

125 No information about the specific aim of the study was provided to the participants. They
126 were only informed about the fact that they would be participating in a “wine study”. They
127 were not paid for their participation in the study.

128 **2.4. Procedure**

129 Participants were served the twelve samples. They were asked to smell the samples and to
130 categorize them as faulty or not faulty. To clarify what we meant by faulty we asked them to
131 imagine a scenario in which they had to decide whether they would serve a wine to their

132 friends (i.e. a wine that has no fault) or not (i.e. a faulty wine). They received the following
133 instructions:

134 *“Imagine you have a dinner with friends. You want to serve them a glass of wine, you open
135 the bottle and you smell the wine. Then you have to decide if you can serve it to your friends.
136 You have to smell the following wines (without tasting them) and answer the next question: If
137 you were in the previous situation, would you serve the wine to your friends?”*

138 *You have to take into consideration that the twelve wines are Chardonnays from vintage
139 2015/ Côtes-du-Rhône from vintage 2016 (Grenache/Syrah) with a price under 7 euros.”*

140 They indicated their response choosing one of the two categories proposed by ticking “yes, I
141 would serve” or “no, I would not serve” in the answering sheet. They could also add free
142 comments to describe the samples if they wished.

143 **2.5. Experimental conditions**

144 Each participant participated in two sessions the same day, one session for the white wines
145 and the other for the red wines. Each session lasted about 20 min. Half of the participants
146 smelled the set of red wines first and the other half assessed the set of white wines first.
147 Twenty-millilitre wine samples were presented in trays of twelve samples according to a
148 predefined order from minor to major concentration of oxidation compounds. This order of
149 presentation of samples was chosen to avoid priming effect that could occur with a balanced
150 design.

151 **2.6. Data treatment**

152 Firstly, a global analysis by expertise was carried out. Then, an *a posteriori* individual
153 analysis was performed to better understand participants’ behaviour in the categorization task

154 **2.6.1. Global analysis**

155 Experts and novices were considered as independent groups. Logistic regression and student
156 t-tests were carried out for the categorization data (serving the wine/not serving the wine) and
157 frequency analysis for the free comments data.

158 Logistic regression, for both experts and novices and for both types of wines, was done with
159 the binary data as dependant variable (0 = I would serve the wine; 1= I would not serve the
160 wine) and the common logarithm of the ratio of the concentration of oxidation compounds as
161 independent variable. The proportion among the three compounds was always the same along
162 the scale of concentration of oxidation. The increasing factor between oxidation levels was
163 1.35. Thus, the common logarithm was applied to 1.00 corresponding to the level 1 of
164 oxidation, and to 1.35, 1.82, 2.46, 3.32, 4.48, 6.05, 8.17, 11.03, 14.89, 20.11, and 27.14 from
165 the level 2 until the 12 of the oxidation mixture respectively.

166 Student t-tests were carried out for comparing the slopes of the logistic regressions.

167 The free comments were transcribed including spelling mistakes. Words referring to the
168 intensity level were removed. Then, three wine researchers lemmatized the words and
169 grouped the words with similar meaning into odour categories. Once, the three wine
170 researchers had individually categorized the words; the consensus was evaluated by checking
171 whether their classifications were in agreement (Lawrence et al., 2013). Only those terms
172 cited by a minimum of 15% of the experts and novices were considered in the subsequent
173 statistical analyses. The frequency of occurrence of the final terms was computed for each
174 wine and each participant group giving rise to four contingency tables. Separate
175 Correspondence Analyses (CA) were performed on the four contingency tables.

176 In parallel, free comments were classified according to their valence (negative and
177 positive/neutral). A logistic regression was performed with the resulting binary data as
178 dependant variable (0 = positive/neutral terms; 1= negative terms) and the common logarithm
179 of the ratio of the concentration of oxidation compounds as independent variable.

180 2.6.2. A posteriori individual analysis

181 Individual graphs representing the categorization data of each participant as a function of
182 oxidation for each wine (red and white) were printed. Then, three wine researchers classified
183 the printouts based on what, in their opinion, were similar behaviours. The three
184 classifications were then compared to reach a consensual behavioural classification. The
185 frequency of occurrence of response behaviours was then computed for both groups of
186 participants. A Chi-square test was performed to evaluate the effect of expertise on the
187 categorization behaviour distribution. A logistic regression was also carried out to model the
188 different categorization behaviours.

189

190 **3. RESULTS AND DISCUSSION**

191 **3.1. Global results**

192 **3.1.1. Measuring consensus and boundary between categories in the perception of oxidized**

193 **wines**

194 **Fig. 1a** shows three different hypothetical models of the consensus among participants in the
195 categorization of wines. The slope reflects the degree of consensus of the participants at
196 passing from the not-faulty category (I serve the wine to my friends) to the faulty one (I do
197 not serve the wine to my friends) at the same average of oxidation level (level 6 in **Fig. 1a**).
198 High consensus level would typically be given by a curve, in which, from a certain level of
199 oxidation almost all participants would pass from one category to the other due to the
200 presence of the oxidation off-odour. Indeed, since having a clear-cut and strong shift from
201 not-faulty to faulty categories implies consensus at categorizing wines at the same level of
202 the oxidation gradient, we can consider that the higher the slope the more consensual the
203 participants. The increase in disagreement among participants would be translated by a
204 decrease in the value of the slope represented by medium and low consensus model curves.
205 This disagreement would reflect a wider range of oxidation levels in which participants move
206 from one category to the other.

207 In **Fig. 1b**, three different hypothetical models of participants' sensitivity to move from one
208 category to the other are presented (all of them showing similar consensus). Sensitivity to
209 change of category could be defined as the boundary (level of oxidation) at which exists more
210 than 50% of probability ($p(0.5)$) that an oxidized sample was perceived as faulty. In the high
211 sensitivity curve $p(0.5)$ corresponds to the level 3 of oxidation. This means that from level 3
212 there is more than 50% of probability that a sample was considered as faulty. The decrease in
213 the sensitivity would be given by $p(0.5)$ from low to high oxidation levels as for the medium
214 ($p(0.5)$ at level 6) and low sensitivity ($p(0.5)$ at level 9) model curves.

215 A logistic regression (**Fig. 2**) was carried out with the categorization data of experts and
216 novices for each of the wines as explained in section 2.5. For the white (**Fig. 2a** and **Table 3**)
217 and red wine (**Fig. 2b** and **Table 3**) slopes for experts were significantly higher than for
218 novices ($p < 0.05$). In contrast, values of sensitivity to move from one category to the other
219 were nearly similar for experts ($p(0.5)_{\text{white}} = 0.65$; $p(0.5)_{\text{red}} = 0.53$) and novices ($p(0.5)_{\text{white}}$
220 $= 0.63$; $p(0.5)_{\text{red}} = 0.52$) regardless of the wine matrix.

221 3.1.2. Analysis of free comments

222 Another approach to understand participant consensus and boundary between categories
223 towards oxidized wines is to analyse their free comments. CA on the frequencies of citation of
224 each term for each sample was carried out for each group of participants and type of wine
225 (**Fig. 3**).

226 For the white matrix, the first dimension of CA corresponding to the experts (**Fig. 3a**) and
227 novices (**Fig. 3b**) explained 42% and 29 % of the total variance and for both groups it was
228 significantly correlated to the level of oxidation (experts: $r = 0.91$, $p < 0.001$; novices: $r = 0.90$,
229 $p < 0.001$). Experts used 107 oxidation related terms for describing the samples whereas
230 novices used just 14. Nevertheless, novices used negative terms for describing the samples.

231 The first dimension corresponding to CA of red matrix explained 42% and 33% of the total
232 variance for experts (**Fig. 3c**) and novices (**Fig. 3d**). Again, the first dimension showed a
233 significant correlation with the oxidation gradient for experts ($r = 0.94$, $p < 0.001$) and novices
234 ($r = 0.88$, $p < 0.001$). The variance explained by the first dimension in the experts' CA for the
235 red matrix was lower compared to the white matrix meaning that experts used less oxidation
236 related terms for this matrix (74 oxidation related terms). This phenomenon was also observed
237 for novices, but in this case, they just used hedonic negative terms. Novices passed from using
238 44 negative hedonic terms for describing whites to 31 for reds, which was, as for experts, 30%
239 lower.

240 Finally, a hedonic categorization of terms in negative and positive/neutral was carried out (see
241 section 2.5.). Logistics regression with the categorized terms (Fig. 4) corresponded to the
242 same patterns that those of the regressions on the not-faulty/faulty categories towards
243 oxidized wines observed in Fig. 2. It was observed that the higher level of oxidation the more
244 negative terms used. Slopes obtained were 1.45 and 1.24 for the white, 0.47 and 0.43 for the
245 red for experts and novices, respectively. The comparison of the slopes did not show
246 significant differences between experts and novices, neither in the white samples nor in the
247 red ones.

248 **3.1.3. Comparison of experts' and novices' within-group consensus and verbalization**

249 The logit regression for experts yielded a steeper slope than for novices, which suggests that
250 experts were more consensual in their responses towards oxidation. However, both groups
251 were similar in terms of average oxidation level to change of category. If we compare the
252 curves from Fig. 2 with those of the models (Fig. 1), it can be noted that none of the four
253 curves from Fig. 2 resembled to the high consensus model curve, neither for experts nor for
254 novices. This showed a global lack of agreement in the responses of the participants,
255 regardless their expertise level. This result suggests that, despite the significant difference in
256 the consensus, the difference between experts and novices was not important.

257 The main difference coming from the analysis of free comments concerns the way the two
258 groups described the samples; experts used technical and accurate oxidation-related terms
259 while novices relied on negative hedonic terms to describe the same samples. The difference
260 would thus not be a perceptual difference but a lexical difference. This result is consistent
261 with previous research (Croijmans & Majid, 2016; Chollet & Valentin, 2000).

262 **3.2. Individual results**

263 **3.2.1. Definition of different behaviours towards oxidation**

264 To understand the small difference in terms of consensus between experts and novices we
265 looked at individual categorization behaviour. After classification (see section 2.5.), five
266 different behaviours (**Fig. 5**) emerged from the individual data:

267 **Behaviour A: “clear categorization”**: participants classified the samples as not-faulty up to
268 a certain concentration of oxidation compounds and then they moved suddenly to the faulty
269 category. This indicates that from a certain concentration (which may be different from one
270 participant to another) the fault was clearly identified. **Fig. 5a.**

271 **Behaviour B: “almost clear categorization”**: The participants categorized as not-faulty the
272 samples for the lowest concentrations and vice versa for the highest concentrations. They had
273 a period of hesitation for the intermediate concentrations, illustrated by a successive change of
274 category. This period of hesitation suggests a less clear mental representation of oxidation
275 than for behaviour A. **Fig. 5b.**

276 **Behaviour C: “clear categorization after hesitation”**: As for the previous behaviour, a
277 period of hesitation was observed, but it appeared only for the lowest concentrations. On the
278 other hand, from a certain concentration, the oxidation seemed to be clearly perceived and the
279 samples were clearly classified in the faulty category. **Fig. 5c.**

280 **Behaviour D: “Oxidation fan”**: As for profile C, the participants initially hesitated and then,
281 from a certain concentration (which may be different from one participant to another), the
282 samples were classified as not faulty. This suggests a positive representation of oxidation.
283 **Fig. 5d.**

284 **Behaviour E: “Undecision”**: The participants seemed to answer randomly; this was
285 exemplified by a successive change between the not-faulty/faulty categories. **Fig. 5e.**

286 Nine individual response graphs (white wine: one novice and three experts; red wine: two
287 novices and three experts) did not follow any of the precedent patterns of behaviours. They
288 were deleted from further analyses.

289 **Fig. 6** represents the logistic regressions done with the categories chosen by participants
290 (experts and novices together) belonging to each pattern of behaviours for the white matrix
291 (similar results for the red wine; data not shown). Participants from behaviour A presented the
292 highest consensus towards oxidation (slope = 5.6). Although these participants did not show
293 any period of hesitation the fact that they changed from not-faulty to faulty categorization at
294 different levels of oxidation was reflected by a more gradual slope than the steep slope of the
295 hypothetical high consensus model curve showed in **Fig. 1a**. The curve obtained for the
296 behaviour B had a lower slope (slope = 4.6) compared to behaviour A (slope = 5.6), but
297 higher than C (slope = 1.5). Behaviour B was characterized by a hesitation period that did not
298 appear in behaviour A. This period of hesitation was more important in participants from
299 behaviour C than those of behaviour B, which was translated in the difference between the
300 two slopes. The logistic regression done with the categorization data of participants with
301 behaviour E, characterized by a successive change between the two categories, was close to
302 zero (slope = 0.6), although a tendency to consider the highest oxidation levels as faulty was
303 observed. For behaviour D, the negative value of the slope (slope = -1.9) was indicative that
304 these participants categorized the most oxidized wines as not-faulty, contrary to the
305 participants of behaviours A, B and C.

306 The distribution of the number of experts and novices for each type of behaviour for the white
307 and for the red is shown in **Table 4**. The distribution in the different categorization behaviour
308 was independent of the expertise (chi-square =3.54; p=0.47) and each type of behaviour can
309 be found in both experts and novices, with the exception of behaviour D for white wine,
310 where no expert followed this behaviour.

311 **3.2.2. Exploring the different behaviours towards oxidation**

312 As previously mentioned, we expected higher consensus among experts. We also expected
313 that once an expert categorized samples with a certain level of oxidation in the faulty category

314 he/she would do the same with higher oxidized samples. However, the five behaviours that
315 emerged from the individual responses of experts and novices showed that it was not
316 systematically the case. The distribution of the number of experts and novices for each one of
317 the behaviours was quite similar, with the exception of behaviour D for the white wine. The
318 categorization of highly oxidized samples in the not-faulty category, could be explained by
319 the ambivalent character of oxidation. Oxidation differs from other off-odours in the fact that
320 oxidation compounds can provide positive aromas if they are well-integrated (Gambutì,
321 Rinaldi, Ugliano, & Moio, 2012; Ugliano, 2013).

322 Our results revealed a heterogeneity of behaviours in the categorization of oxidized wines, for
323 both experts and novices, which was in agreement with the lack of consensus observed in the
324 global results (see section 3.1.). The small, but significant, difference previously observed in
325 the consensus considering experts and novices as independent groups could be due to several
326 reasons. The first one can be the higher number of novices in the behaviour D with regard to
327 the experts' number for both matrices. Another plausible reason could be just that experts
328 following behaviours A, B and C were slightly more consensual than novices at choosing the
329 oxidation level at which they clearly categorized samples in the faulty category.

330 Even though the consensus among experts was better than among novices, it remains rather
331 low. The low consensus among experts may be due to the heterogeneity of their backgrounds
332 as Tempère et al. (2014) have observed.

333 **3.3. White matrix vs. red matrix**

334 In the **Fig. 2** and **Table 3**, it can be seen that both groups of participants exhibited greater
335 slopes for the white wine than for the red one. Experts showed significantly more consensus
336 to categorize white than red samples (2.82 vs. 1.93, $p < 0.05$). This difference was not
337 significant for novices although a tendency was observed. This result would reflect a higher
338 consensus among experts for the white matrix. On the other hand, experts showed more

339 variability and hesitation in the categorization of red samples. This clearly suggests a different
340 perception of oxidation for whites and reds. The reason behind this difference in the
341 consensus could be that, with the exception of some styles of oxidized white wines like, Xerez
342 wines or Jura wines (“*vin jaune*”), oxidation is mostly considered negative in whites. Thus,
343 the experts’ mental representation about white wines would be associated to fresher wines
344 than reds, meaning that at a certain level of oxidation, white wines would be more likely to be
345 perceived as faulty. On the contrary, there are many red wines in the market with oxidation
346 nuances that are considered positive. It is more common for red wines to stay in the bottle
347 during years developing oxidation aromas that, if well integrated and expected, give to the
348 wine complexity and increase their quality. This could explain why the frontier between not-
349 faulty/faulty categories towards oxidation would be less clear-cut in the case of red wines.
350 Another explanation for the difference in the experts’ consensus between both types of wine
351 could also be due to a matrix effect. Interactions between molecules, synergies and other
352 chemical and physiological phenomena would lead to a different perception of the three
353 spiked compounds in the two matrices. Both explanations are not mutually exclusive.

354 **4. Conclusion**

355 Although a clear-cut difference between experts and novices towards the perception of
356 oxidation as wine fault was expected, our results have demonstrated that differences between
357 both groups were quite small. Experts as well as novices showed low consensus at
358 categorizing oxidized wines. However, experts were slightly, but significantly more
359 consensual than novices. On the other hand, no difference in the boundary between not-
360 faulty/faulty categories was found between the two types of participants.

361 Five different behaviours in the categorization of oxidation in wine emerged. Contrary to
362 what previous studies on wine expertise suggest, the “wine expert” label hides a wide
363 variability of experiences and hence, of sensory responses. Taking wine experts as an *a priori*

364 homogeneous group is a rather simplistic approach that should be completed by an individual
365 analysis if the objective is to better understand participants' behaviour.

366

367 **ACKNOWLEDGEMENTS**

368 E. Franco-Luesma acknowledges the financial support of *Fundación Alfonso Martín Escudero*
369 for its postdoctoral fellowship. Authors also thank Francine Griffon and Méven Otheguy for
370 their help and *SICAREX Beaujolais* for the use of their facilities.

371

372

373

374

375

376 **REFERENCES**

- 377 Ballester, J., Patris, B., Symoneaux, R., & Valentin, D. (2008). Conceptual vs. perceptual wine spaces:
378 Does expertise matter? *Food Quality and Preference*, *19*, 267-276.
- 379 Bende, M., & Nordin, S. (1997). Perceptual learning in olfaction: professional wine tasters versus
380 controls. *Physiology & Behavior*, *62*, 1065-1070.
- 381 Bueno, M., Carrascón, V., & Ferreira, V. (2016). Release and formation of oxidation-related aldehydes
382 during wine oxidation. *Journal of Agricultural and Food Chemistry*, *64*, 608-617.
- 383 Croijmans, I., & Majid, A. (2016). Not all flavor expertise is equal: The language of wine and coffee
384 experts. *PloS one*, *11*, e0155845.
- 385 Culleré, L., Cacho, J., & Ferreira, V. (2007). An assessment of the role played by some oxidation-
386 related aldehydes in wine aroma. *Journal of Agricultural and Food Chemistry*, *55*(3), 876-881.
- 387 Charters, S., & Pettigrew, S. (2007). The dimensions of wine quality. *Food Quality and Preference*, *18*,
388 997-1007.
- 389 Chollet, S., & Valentin, D. (2000). Le degré d'expertise a-t-il une influence sur la perception olfactive?
390 Quelques éléments de réponse dans le domaine du vin. *L'année Psychologique*, *100*, 11-36.
- 391 Escudero, A., Hernández-Orte, P., Cacho, J., & Ferreira, V. (2000). Clues about the role of methional
392 as character impact odorant of some oxidized wines. *Journal of Agricultural and Food*
393 *Chemistry*, *48*, 4268-4272.
- 394 Gambuti, A., Rinaldi, A., Ugliano, M., & Moio, L. (2012). Evolution of phenolic compounds and
395 astringency during aging of red wine: effect of oxygen exposure before and after bottling.
396 *Journal of Agricultural and Food Chemistry*, *61*, 1618-1627.
- 397 Giboreau, A., Navarro, S., Faye, P., & Dumortier, J. (2001). Sensory evaluation of automotive fabrics:
398 the contribution of categorization tasks and non verbal information to set-up a descriptive
399 method of tactile properties. *Food Quality and Preference*, *12*, 311-322.
- 400 Guth, H. (1997). Quantitation and sensory studies of character impact odorants of different white
401 wine varieties. *Journal of Agricultural and Food Chemistry*, *45*, 3027-3032.
- 402 Hoek, A. C., van Boekel, M. A., Voordouw, J., & Luning, P. A. (2011). Identification of new food
403 alternatives: how do consumers categorize meat and meat substitutes? *Food Quality and*
404 *Preference*, *22*, 371-383.
- 405 Honoré-Chedozeau, C., Lelièvre-Desmas, M., Ballester, J., Chollet, S., & Valentin, D. (2017).
406 Knowledge representation among assessors through free hierarchical sorting and a semi-
407 directed interview: Exploring Beaujolais wines. *Food Quality and Preference*, *57*, 17-31.
- 408 Hughson, A. L., & Boakes, R. A. (2002). The knowing nose: the role of knowledge in wine expertise.
409 *Food Quality and Preference*, *13*, 463-472.
- 410 Jover, A., Montes, F., & Fuentes, M. (2004). Measuring perceptions of quality in food products: the
411 case of red wine. *Food Quality and Preference*, *15*, 453-469.
- 412 Karbowiak, T., Gougeon, R. D., Alinc, J.-B., Brachais, L., Debeaufort, F., Voilley, A., et al. (2009). Wine
413 oxidation and the role of cork. *Critical Reviews in Food Science and Nutrition*, *50*, 20-52.
- 414 Lawrence, G., Symoneaux, R., Maitre, I., Brossaud, F., Maestrojuan, M., & Mehinagic, E. (2013). Using
415 the free comments method for sensory characterisation of Cabernet Franc wines:
416 Comparison with classical profiling in a professional context. *Food Quality and Preference*, *30*,
417 145-155.
- 418 Lelièvre, M., Chollet, S., Abdi, H., & Valentin, D. (2009). Beer-trained and untrained assessors rely
419 more on vision than on taste when they categorize beers. *Chemosensory Perception*, *2*, 143-
420 153.
- 421 Parr, W. V., Valentin, D., Green, J. A., & Dacremont, C. (2010). Evaluation of French and New Zealand
422 Sauvignon wines by experienced French wine assessors. *Food Quality and Preference*, *21*, 56-
423 64.
- 424 Parr, W. V., White, K. G., & Heatherbell, D. A. (2004). Exploring the nature of wine expertise: what
425 underlies wine experts' olfactory recognition memory advantage? *Food Quality and*
426 *Preference*, *15*, 411-420.

- 427 Schumaker, M. R., Chandra, M., Malfeito-Ferreira, M., & Ross, C. F. (2017). Influence of
428 Brettanomyces ethylphenols on red wine aroma evaluated by consumers in the United States
429 and Portugal. *Food Research International*, *100*, 161-167.
- 430 Silva Ferreira, A. C., Hogg, T., & Guedes de Pinho, P. (2003). Identification of key odorants related to
431 the typical aroma of oxidation-spoiled white wines. *Journal of Agricultural and Food*
432 *Chemistry*, *51*, 1377-1381.
- 433 Tempère, S., Cuzange, E., Schaaper, M., De Lescar, R., De Revel, G., & Sicard, G. (2014). "Brett
434 character" in wine: Is there a consensus among professional assessors? A perceptual and
435 conceptual approach. *Food Quality and Preference*, *34*, 29-36.
- 436 Tempere, S., Schaaper, M., Cuzange, E., De Lescar, R., De Revel, G., & Sicard, G. (2016). The olfactory
437 masking effect of ethylphenols: Characterization and elucidation of its origin. *Food Quality*
438 *and Preference*, *50*, 135-144.
- 439 Ugliano, M. (2013). Oxygen contribution to wine aroma evolution during bottle aging. *Journal of*
440 *Agricultural and Food Chemistry*, *61*, 6125-6136.
- 441 Ugliano, M., Kwiatkowski, M. J., Travis, B., Francis, I. L., Waters, E. J., Herderich, M. J., et al. (2009).
442 Post-bottling management of oxygen to reduce off-flavour formation and optimize wine
443 style. *Australian and New Zealand Wine Industry Journal*, *24*, 24-28.
- 444 Veale, R., & Quester, P. (2009). Do consumer expectations match experience? Predicting the
445 influence of price and country of origin on perceptions of product quality. *International*
446 *Business Review*, *18*, 134-144.
- 447 Wildenradt, H., & Singleton, V. (1974). The production of aldehydes as a result of oxidation of
448 polyphenolic compounds and its relation to wine aging. *American Journal of Enology and*
449 *Viticulture*, *25*, 119-126.

450

451

Figure 1. Hypothetical logistic regression models in the categorization of oxidized wines as not-faulty/faulty. **(a)** Models of logistic regression for high (full lines), medium (broken lines) and low (dotted lines) consensus panel. **(b)** Models of logistic regression for high (full lines), medium (broken lines) and low (dotted lines) sensitivity to change of category panel.

Figure 2. Logistic regression with the categorization data of wines. Probability of categorizing in faulty *versus* the common logarithm of the concentration of oxidation compounds for experts (triangles) and novices (squares). **(a)** white wine; **(b)** red wine.

Figure 3. Correspondence Analysis (CA) done with the categorization of the terms given for the description of wines. **(a)** white wine for experts; **(b)** white wine for novices; **(c)** red wine for experts; **(d)** red wine for novices.

Figure 4. Logistic regression with the negative categorized terms in function of the common logarithm of the ratio of the concentration of oxidation compounds for experts in white (full triangles), novices in white (full squares), experts in red (open triangles) and novices in red (open squares).

Figure 5. Illustration of the panellists' responses categorized in five behaviours. **(a)** behaviour A; **(b)** behaviour B; **(c)** behaviour C; **(d)** behaviour D; **(e)** behaviour E.

Figure 6. Logistic regression for each one of behaviours (A, triangles; B, squares; C, circles; D, diamonds; E, crosses) found in white wine, considering experts and novices together, in function of the common logarithm of the concentration of oxidation compounds.

Fig.1a

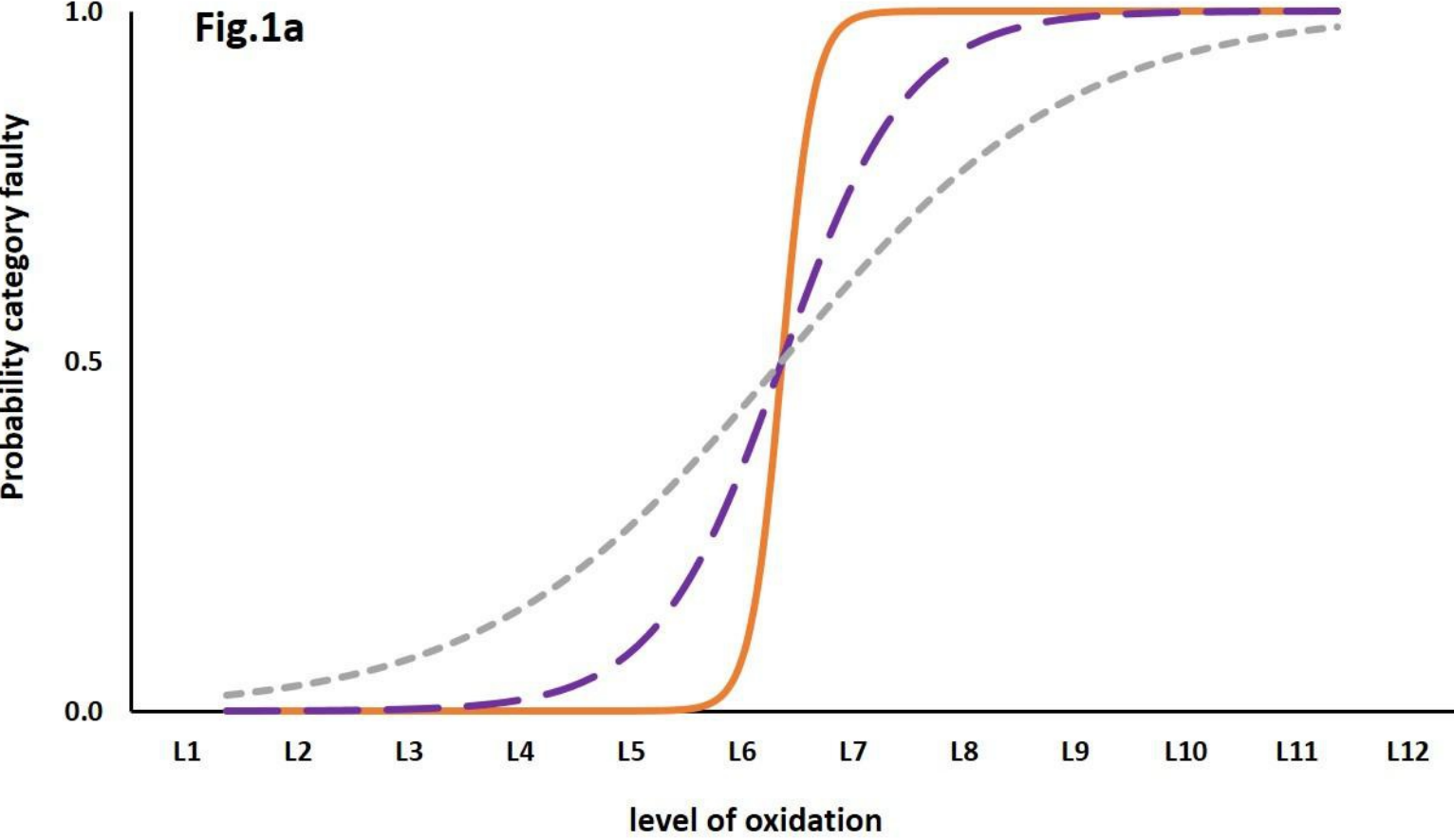


Fig.1b

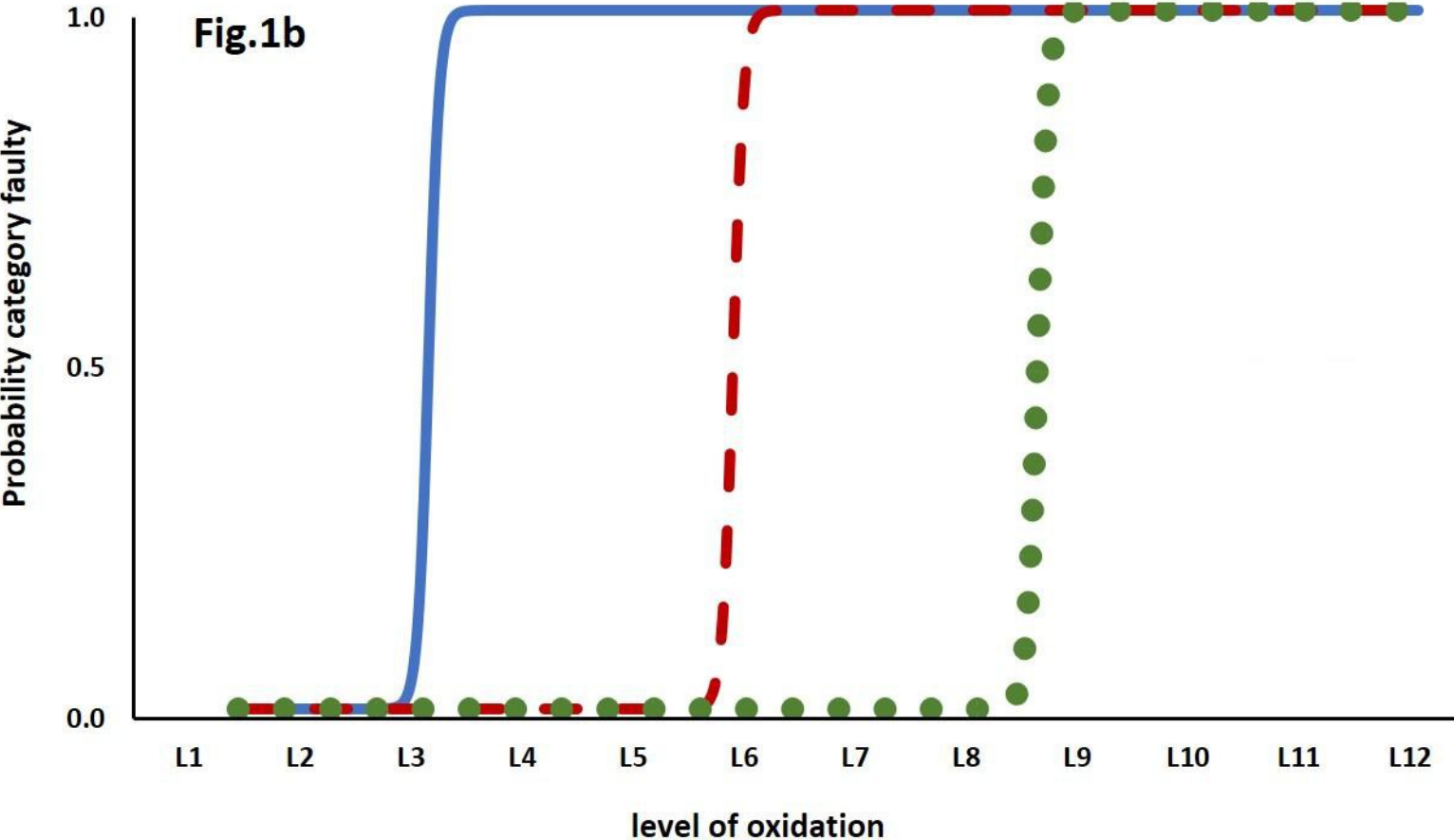
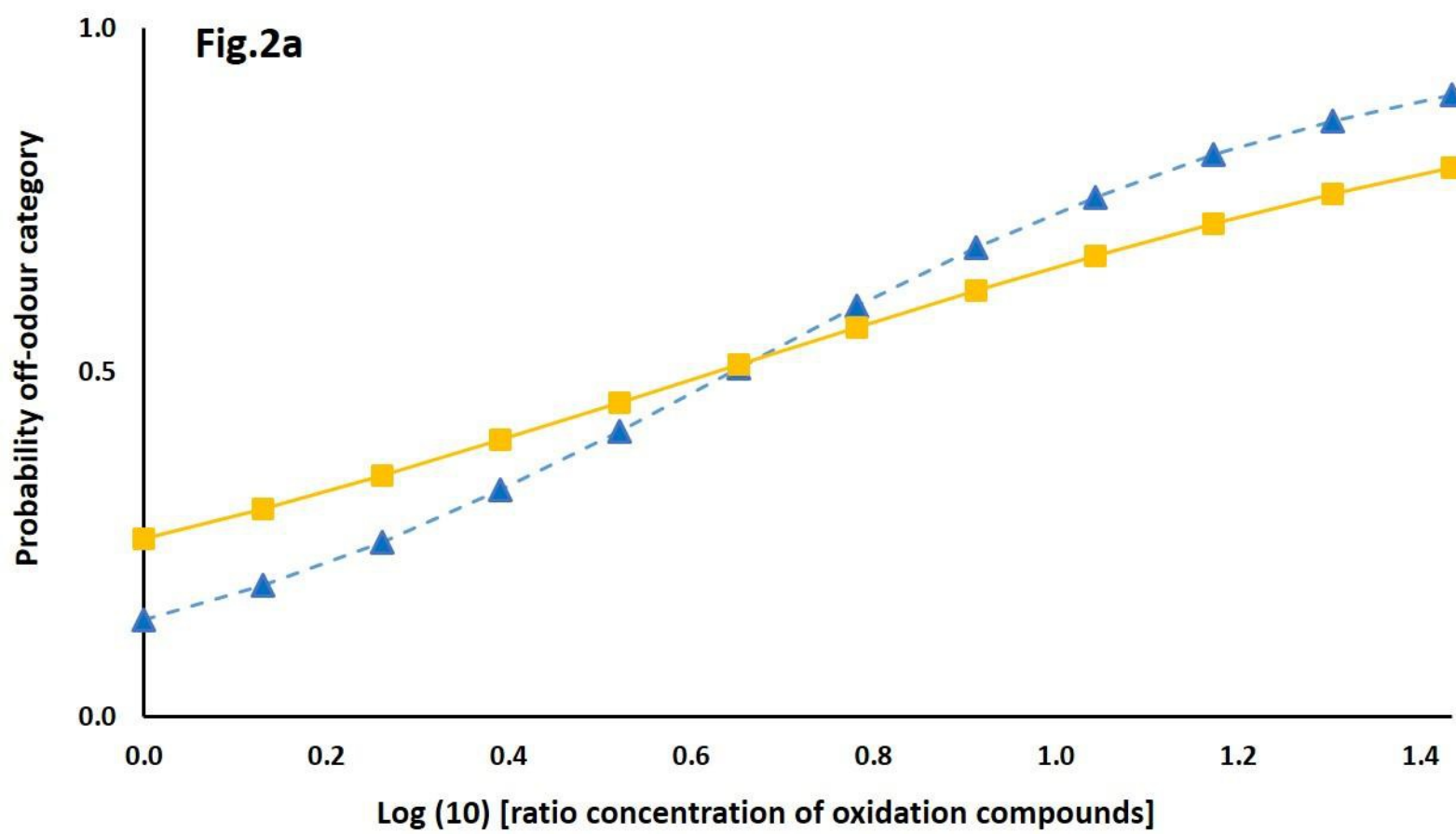
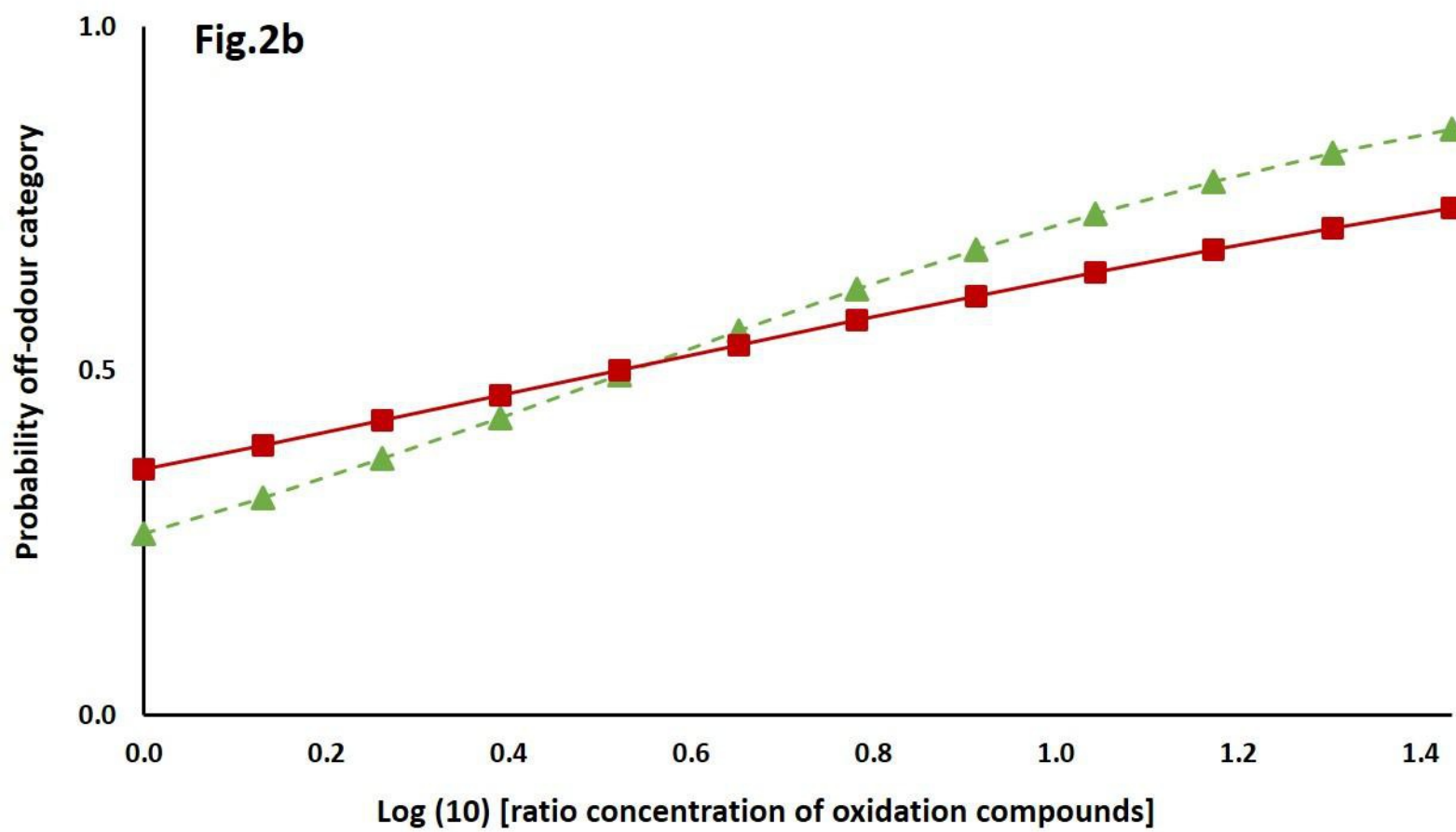


Fig.2a**Fig.2b**

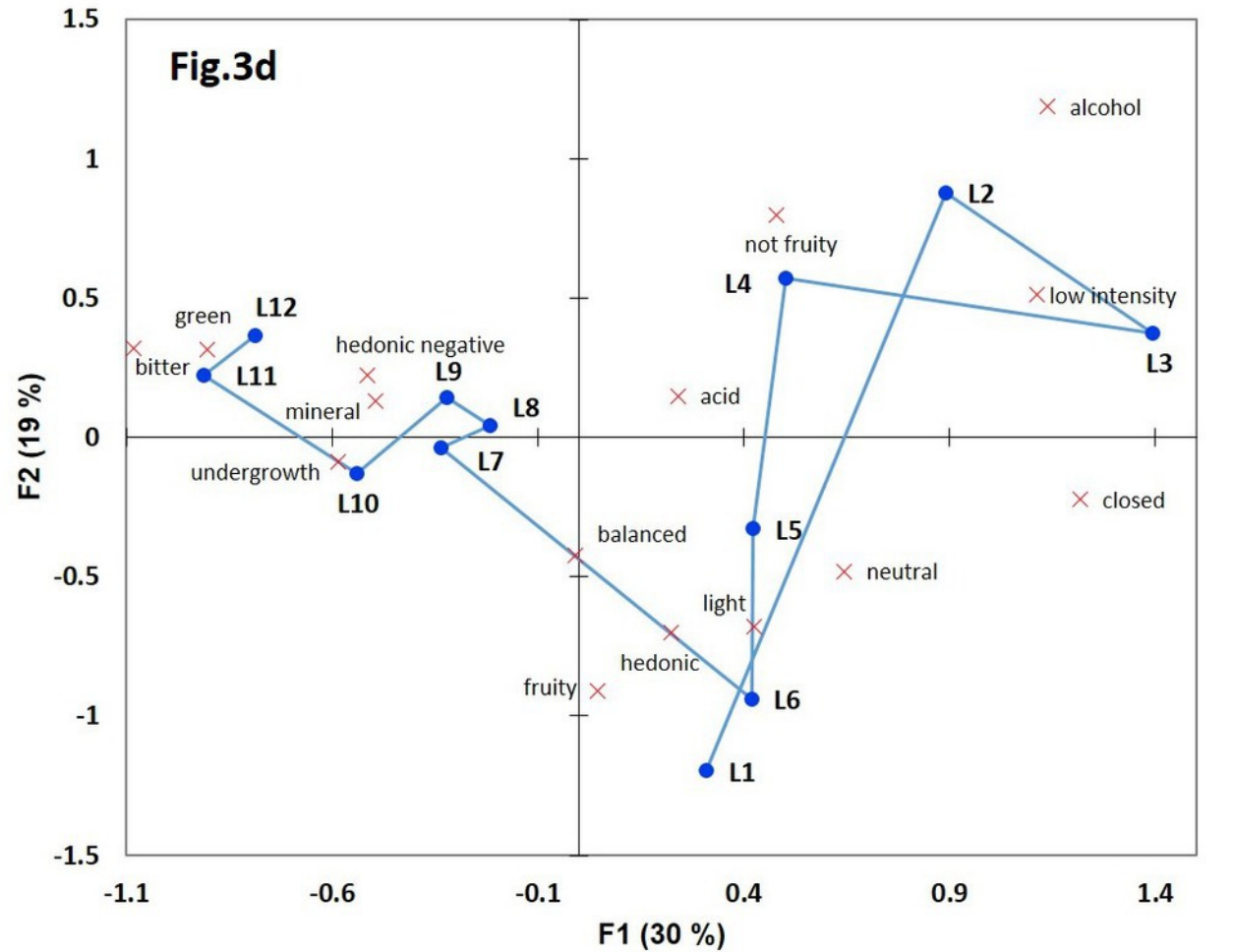
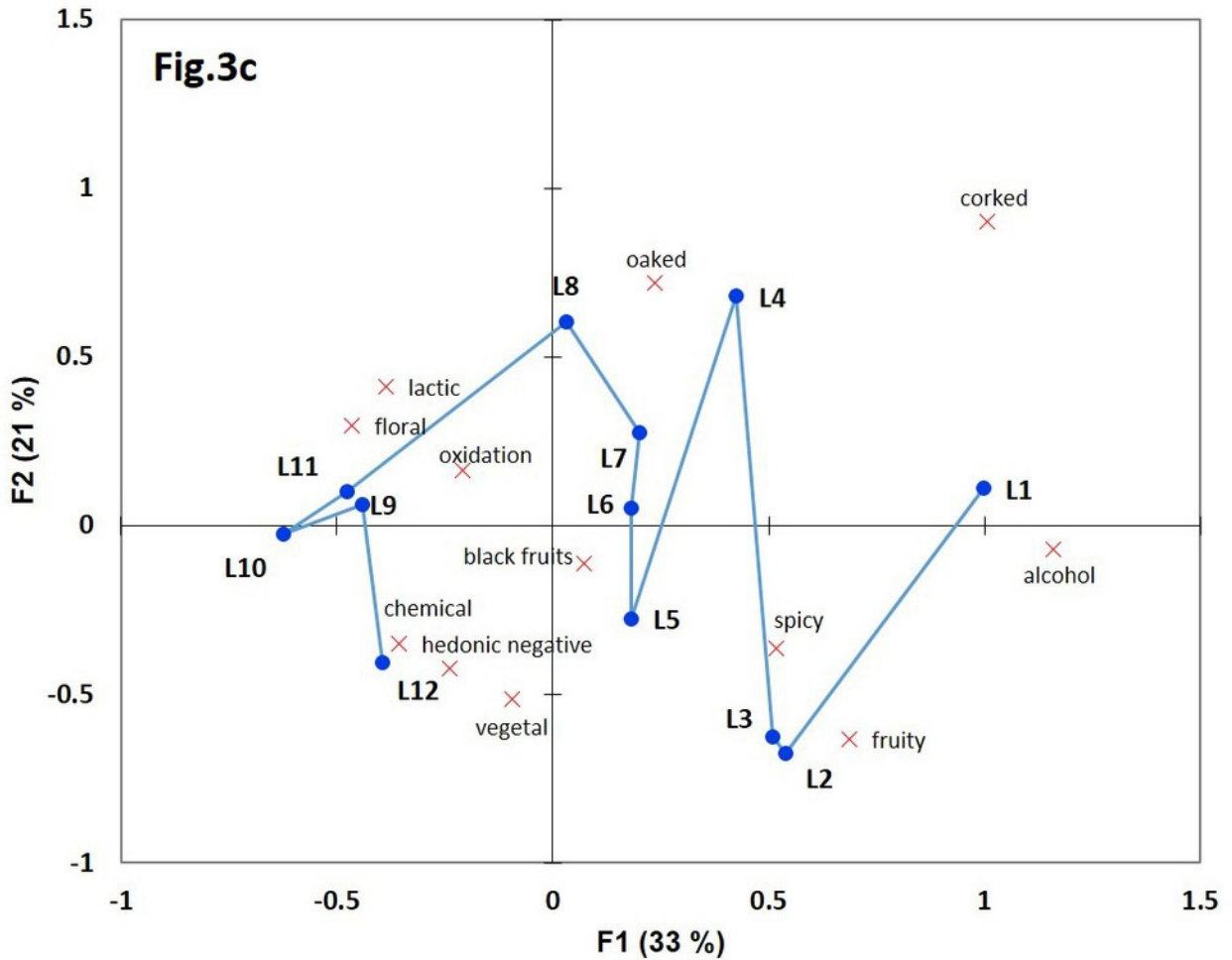
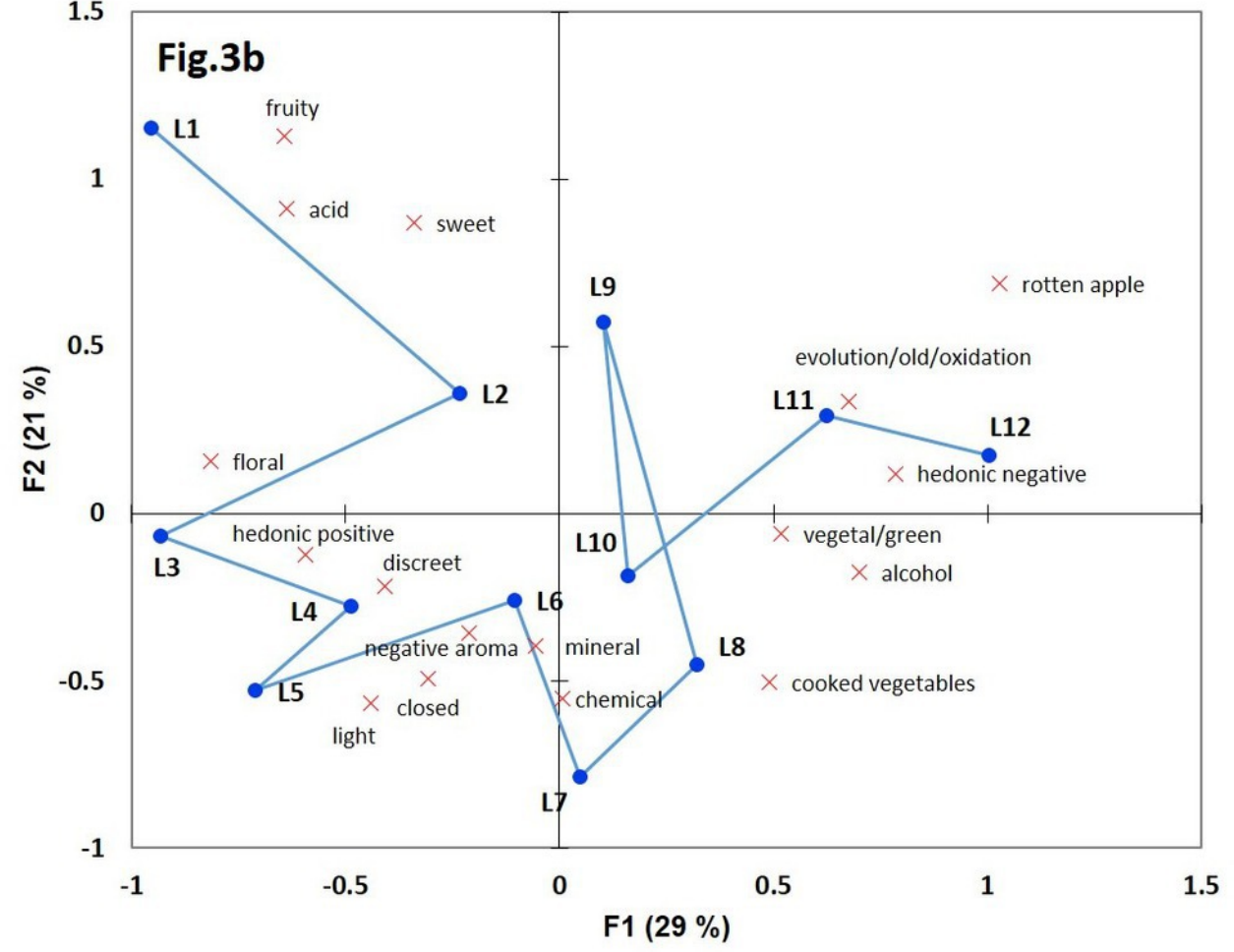
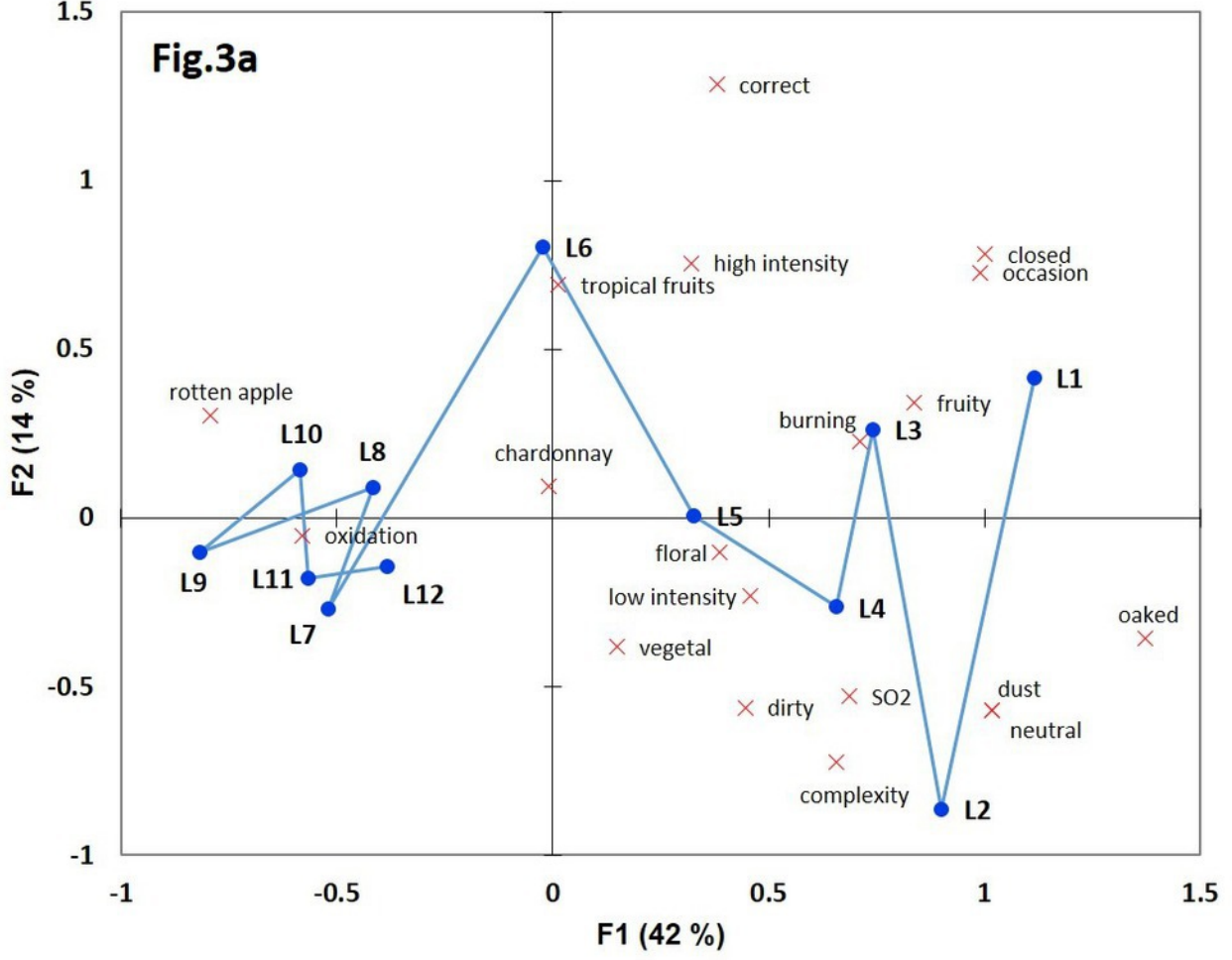
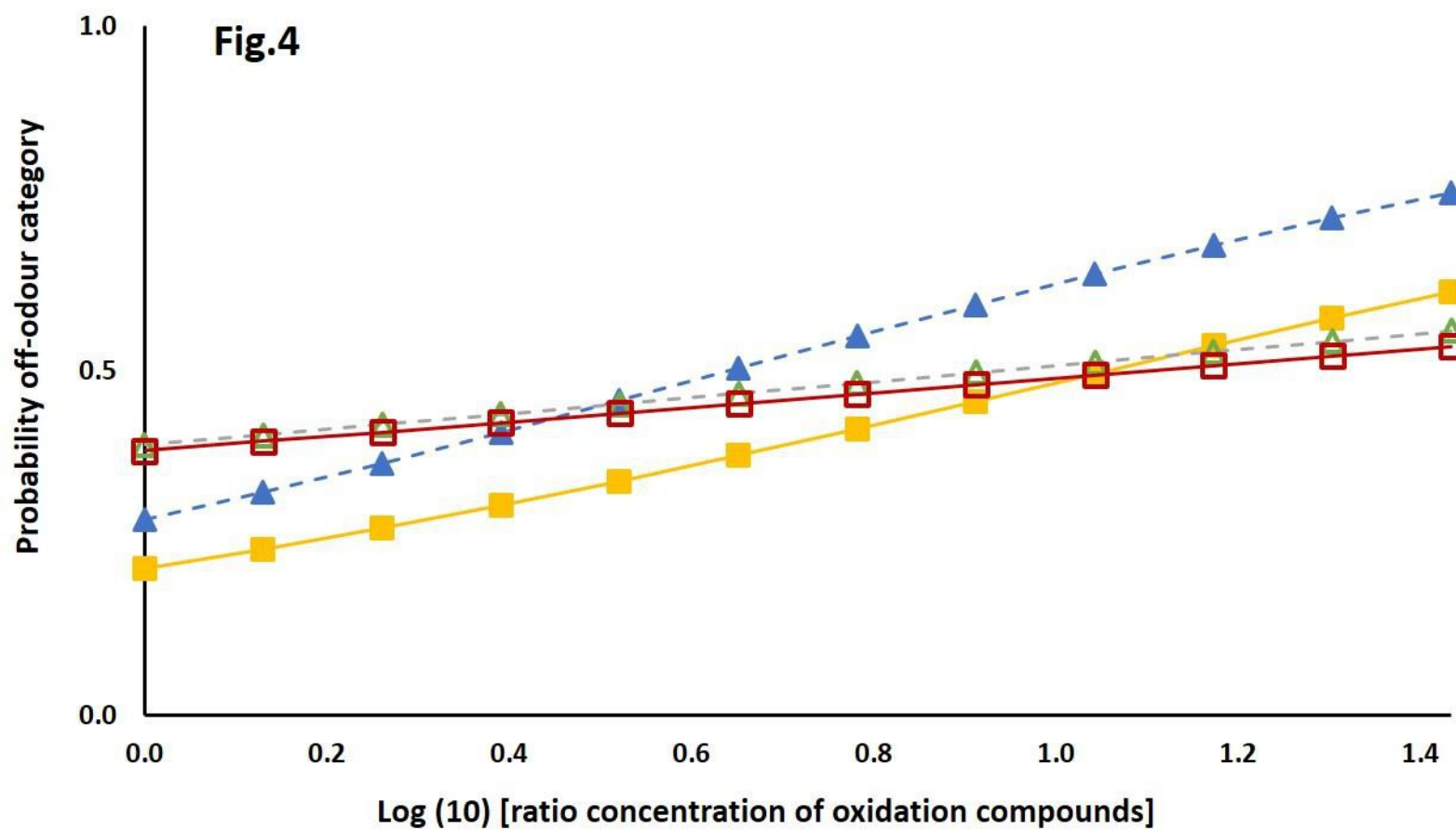


Fig.4



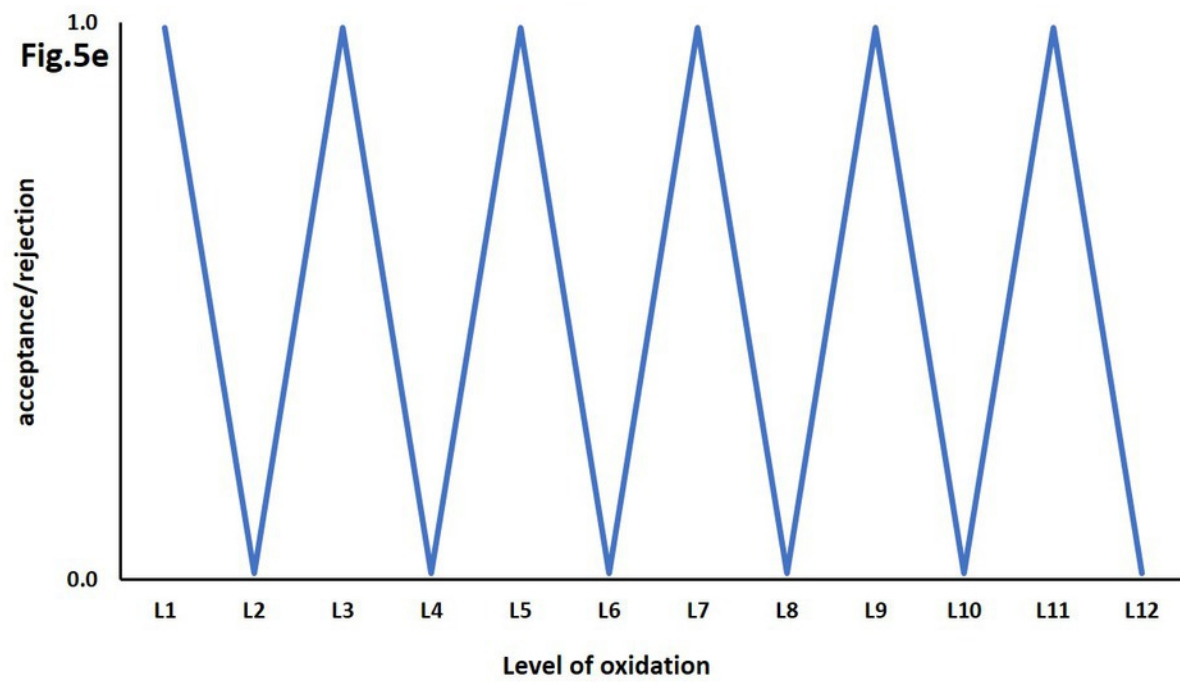
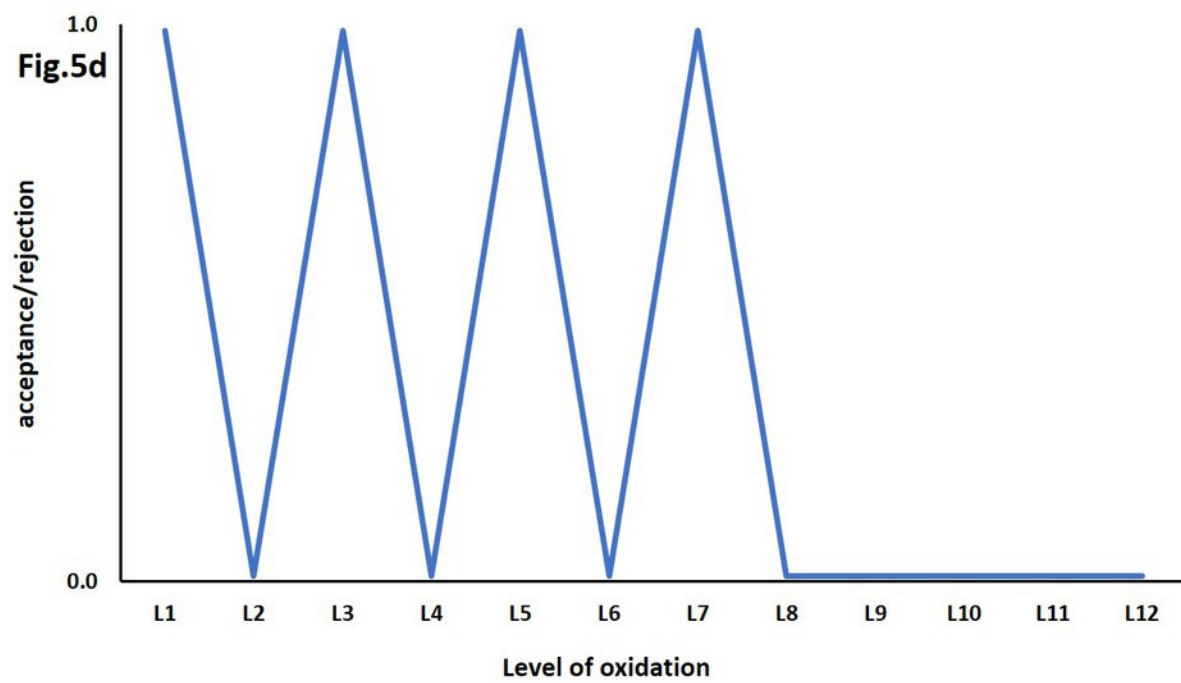
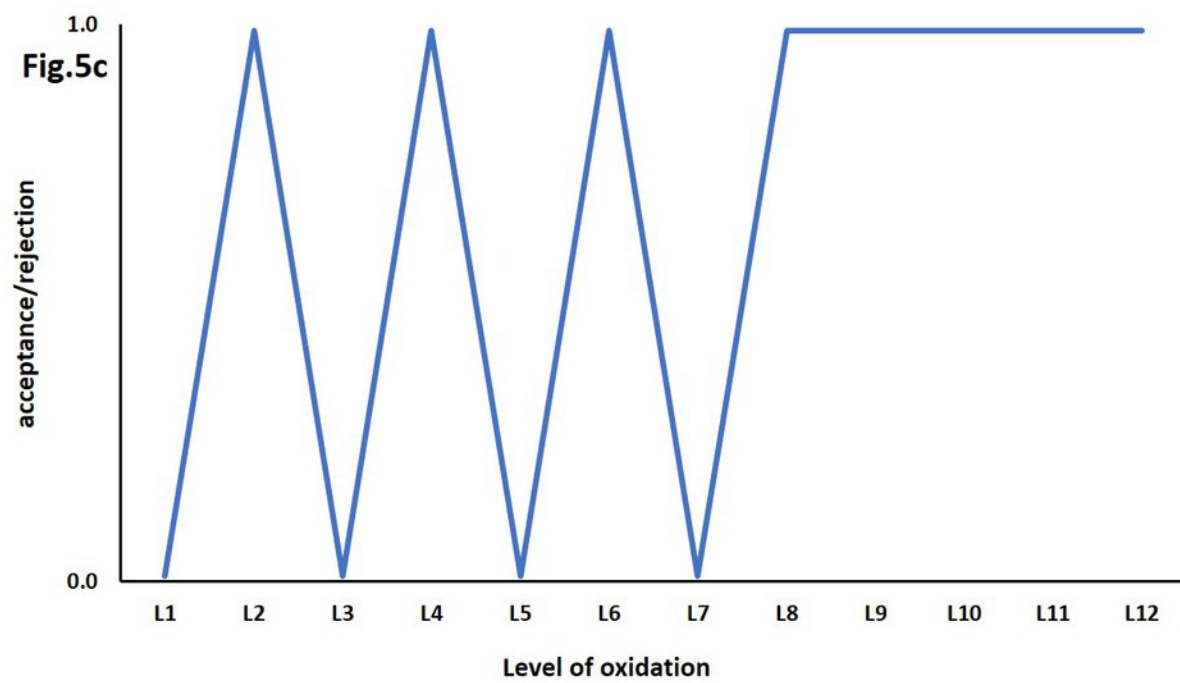
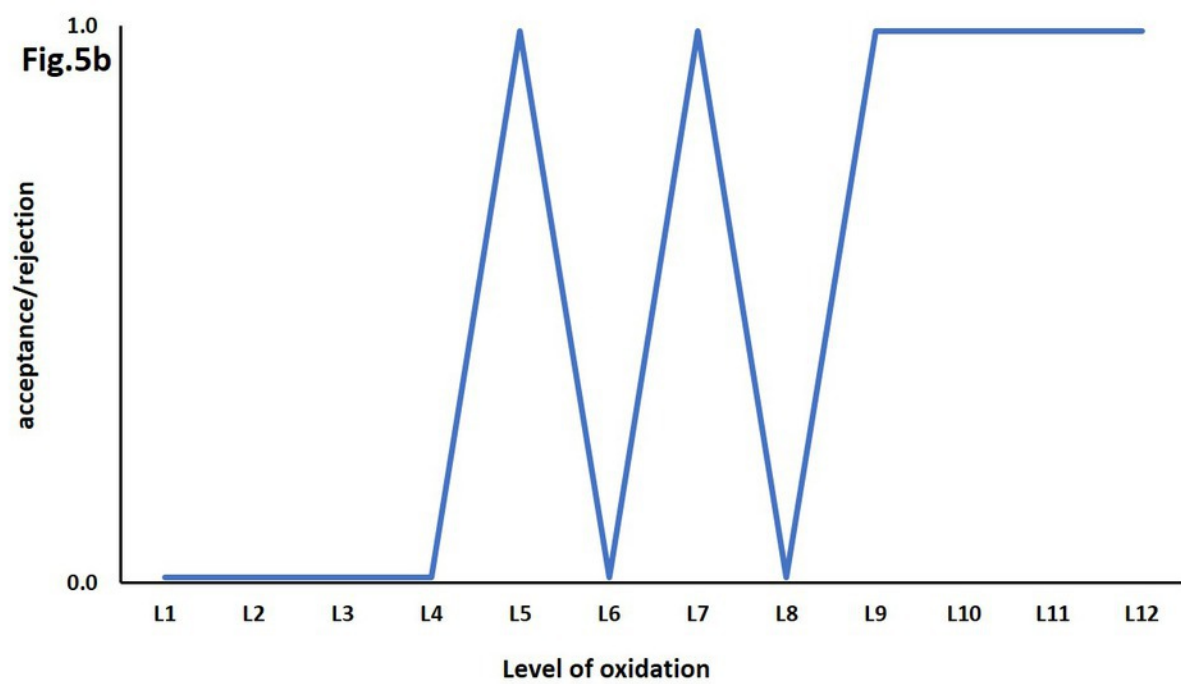
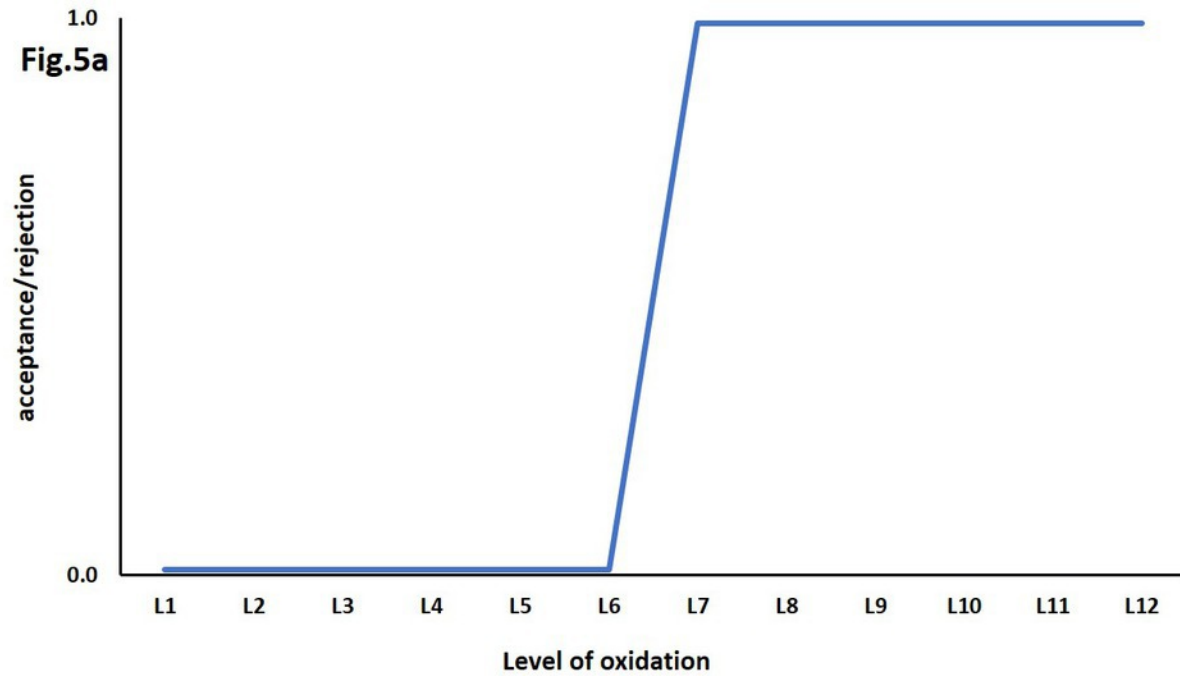
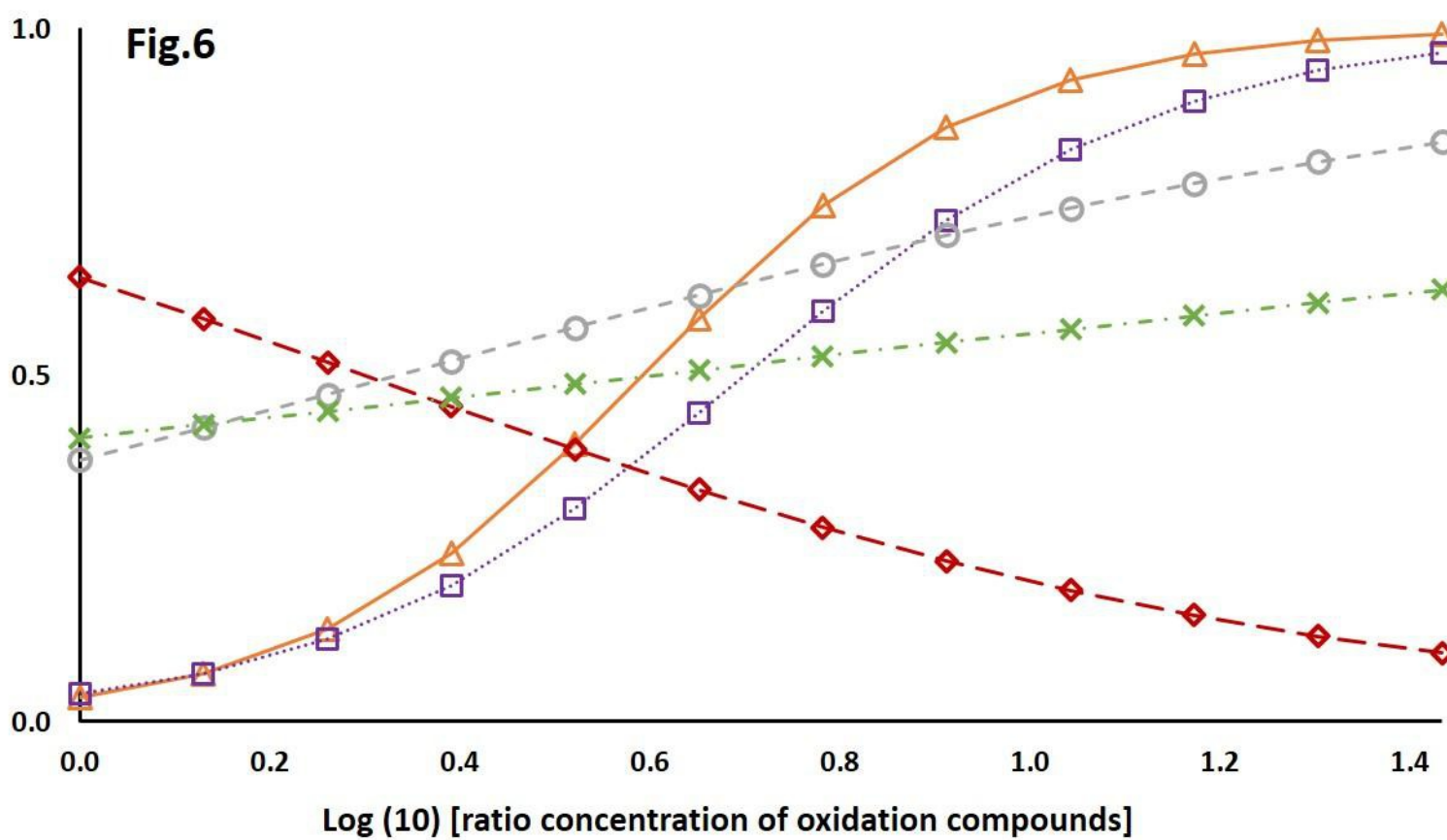


Fig.6

Probability off-odour category



Information and Compositional data	Wine	
	Red wine	White wine
Protected Designation of Origin (PDO)	Côtes du Rhône (France)	Val de Loire (France)
Vintage year	2016	2015
grape variety	Grenache/Syrah	Chardonnay
alcohol % (v/v)	12.58 ± 0.03	11.78 ± 0.13
pH	3.55 ± 0.01	3.35 ± 0.01
Free SO ₂	22.4 ± 0.07	41.6 ± 0.09
Total SO ₂	43.2 ± 2.7	99.2 ± 3.1
Volatile acidity (g/L)	0.39 ± 0.035	0.25 ± 0.030
Malic acid (g/L)	nd	2.25 ± 0.040
Glucose+Fructose (g/L)	0.56 ± 0.010	3.47 ± 0.48

Table 1. Mean results with standard error of some basic compositional parameters of base wines, also including origin, age and varietal composition. nd, not detected.

Levels of oxidation	Compound		
	Acetaldehyde (mg/L)	Phenylacetaldehyde (µg/L)	Methional (µg/L)
L1	1.8	7.4	3.7
L2	2.5	9.9	5.0
L3	3.4	13.4	6.7
L4	4.5	18.1	9.1
L5	6.1	24.5	12.2
L6	8.3	33.0	16.5
L7	11.2	44.6	22.3
L8	15.1	60.2	30.1
L9	20.3	81.3	40.6
L10	27.4	109.7	54.9
L11	37.0	148.1	74.1
L12	50.0	200.0	100.0
Odor threshold	0.5	1.0	0.5

Table 2. Concentration of acetaldehyde (mg/L), phenylacetaldehyde (µg/L) and methional (µg/L) for each one of the oxidation levels (Ln). Odor threshold for acetaldehyde (Guth, 1997), phenylacetaldehyde (Culleré, Cacho, & Ferreira, 2007) and methional (Escudero, Hernández-Orte, Cacho, & Ferreira, 2000).

Matrix	Level of expertise	Slope			Intercept		
		value	Pr(Khi ²)	SE	value	Pr (Khi ²)	SE
White	Novices	1.69	<0.001	0.26	-1.06	<0.001	0.21
	Experts	2.82	<0.001	0.32	-1.81	<0.001	0.25
Red	Novices	1.13	<0.001	0.24	-0.59	<0.01	0.20
	Experts	1.93	<0.001	0.28	-1.03	<0.001	0.22

Table 3. Slope and intercept with their probability of Khi² (Pr (Khi²)) and standard error (SE) for the logistic regression of categorization data for both experts and novices and red and white wine.

Matrix	Level of expertise	Behaviours towards oxidation in wine				
		A	B	C	D	E
White	Novices	7	10	5	4	5
	Experts	7	7	7	0	5
Red	Novices	6	5	10	7	2
	Experts	6	4	11	4	1

Table 4. Distribution of the number of novices and experts in each type of behaviour for white and red wine.