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Is the typicality of “Provence Rosé wines” only a matter of color?

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Abstract

Aims: Given the diversity of French dry Rosé wines, Provence Rosé producers (France) wish to evaluate the typicality of their wines in order to better identify their typical characteristics. A clear pink color is one of them but they would also like to identify some specific odors and aromas. Here, we address these issues by: (i) assessing whether the identity of Provence Rosé wines is perceptible by tasting and shared by professionals based on specific odors and aromas (disregarding color as indicator using black glasses), and (ii) evaluating the impact of color on Provence Rosé wine typicality.

Methods and results: Complementary methods were used: exemplarity measurements by a panel of wine professionals, sensory evaluation by a trained expert panel, and color assessment. It was confirmed that Provence Rosé wine typicality is based on color because the clearest wines were found to be more typical. However, typicality in odors and aromas was also demonstrated. Using black glasses, wine professionals from Provence agreed on ‘citrus fruit’, ‘exotic fruit’ and ‘fresh floral’ odors and aromas being typical attributes of Provence Rosé wines. Next, when using transparent glasses, the color of the wines clearly modified the perception of exemplarity.

Conclusion: There is no single sensory profile of typical Provence Rosé wines. Variability within the sensory profiles of this specific Rosé wine area was observed, but some common aromatic and visual characteristics were identified.

Significance and impact of the study: These results could be used as a marketing tool to better highlight the specific intrinsic characteristics of Provence Rosé wines. It will now be interesting to investigate the Provence area further in order to evaluate potential sub-area specificities linked to “terroir” factors.

Keywords: sensory analysis, descriptive profile, exemplarity, French rosé wines

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Introduction

For the past 10 years the production and consumption of Rosé wines has continued to progress worldwide (Pouzalgues *et al.*, 2013). France is the world's leading producer (7.6 million hectoliters produced in 2014) and consumer (8.1 million hectoliters consumed in 2014) of Rosé wines (OIV, 2015). However, these wines suffer from the lack of a unique, shared definition and are often mixed together with red wines in economic data (OIV, 2015).

In this context, wine producers are seeking to increase the quality of Rosé wines and identify their specificity better (Masson and Schneider, 2009). The technicality and know-how of the wine producers from a specific area can lead to a qualitative development and specific characteristics of wines related to a specific "terroir" called typicality (OIV, 2010). The value of the wines, as perceived by consumers, can be increased by a strong link with a territory conferring a specific typicality (Boncinelli *et al.*, 2016). Using scientific methodologies to enhance knowledge of the intrinsic attributes of typicality can lead to better communication about wines (Passebois-Ducros and Trinquecoste, 2013) and thus increase consumer satisfaction.

Only a few recent scientific works have focused on Rosé wine characteristics. They studied the composition (more specifically the volatile compounds), color, and sensory characteristics as well as the preference of wine professionals. Their results indicated a large diversity in flavor and color among Rosé wines. Relationships between sensory profiles and wine composition have been explored for Rosé wines (Wang *et al.*, 2016a). These authors investigated the characteristics of Australian Rosé wines for the first time. They were described by 'green' and 'citrus' aromas with some 'tropical fruit' and 'floral' aromas. Some wines were 'oaky' and 'spicy' but with 'fruity' and 'floral' characters. Some wine professionals preferred Rosé wines with less residual sugar, which exhibited 'red fruit', 'floral', 'confectionery' and 'honey' characters (Wang *et al.*, 2016b). Masson and Schneider (2009) identified several major volatile compounds in the French Provence Rosé wine aroma as being responsible for some sensory characteristics. Additionally, Rosé wines are well known for their color. A wide range of colors is observed in Rosé wine, both in France and all over the world. Color measurement in a large sample set of Rosé wines from several countries showed colors from very pale to more saturated red. Within French Rosé wines, disparities of color appear from one area to another. An analysis of the international Rosé wine collection (Centre du Rosé & Union des Œnologues de France) showed that Provence Rosé wines are among the clearest in the world while Rosé wines from Bordeaux and South-West France are darker and redder.

Despite some identified sensory characteristics, no study has been conducted on the typicality of Rosé wines. By contrast, numerous works have focused on the typicality of other wines (Cadot *et al.*, 2012; Canuti *et al.*, 2017; Gomes *et al.*, 2016; Llobodanin *et al.*, 2014; Loison *et al.*, 2015; Perrin and Pagès, 2009). In these works, authors evaluated the typicality of specific red or white wines from different Protected Designation of Origin (PDO) or grape varieties. They aimed to identify the main sensory characteristics of typical or not typical wines in a category or find the chemical composition related to typicality. None of them included the impact of color on the perceived typicality.

This typicality concept is supported by the existence of a common memorized prototype, which represents the image of all the previous experiences of the wine type (Casabianca *et al.*, 2006; Maitre *et al.*, 2010). The typicality assessment method proposed by Ballester *et al.* (2008) has been used by several authors (Loison *et al.*, 2015; Perrin and Pagès, 2009). It is based on the evaluation of the product by connoisseurs, generally wine professionals from diverse backgrounds (Loison *et al.*, 2015). This methodological approach can detect if a group of tasters share the same perception of typicality for a specific category of products and identify the sensory attributes and chemicals related to it.

In general, research on typicality has focused on flavor perception and has been performed using dark INAO glasses. However, Cadot *et al.* (2010) and Perrin and Pagès (2009) worked with transparent glasses and found a significant impact of color intensity on the typicality of wines from Anjou Village Brissac. Recently, Valentin *et al.* (2016) worked with dark and clear glasses in order to identify the impact of color on the judgment of wine quality and typicality. They concluded that color characteristics (hue and intensity) were independent of quality and typicality in the case of Pinot Noir from France and New Zealand.

The aim of the present work was to characterize the typicality of Provence Rosé wines. When disregarding color by using black glasses, is the identity of Provence Rosé wines perceptible by tasting and shared by professionals due to specific odors and aromas? Then, what is the impact of tasting wine in a transparent glass; in other words, what is the impact of color on wine typicality? For this, complementary methods were used: exemplarity measurements, sensory evaluation and color assessment.

Materials and methods

1. Wine sample selection

The six main Rosé-producing areas in France were considered: Provence (PRO), Languedoc (LAN), Loire (VDL), Rhône (RHO) (more specifically wines from the PDO of Tavel), Bergerac (BGC) and Bordeaux (BDX) (Table 1). A maximum of seven dry (< 5 g/L of residual sugars) Rosé wines (01 to 07) of the vintage '2014' (to avoid the impact of aging) were jointly selected from each area, in the spring 2015, by an independent wine expert of the area (within each area) and the technicians of the 'Rosé Wine Experimentation and Research Center' located in Provence. They focused on PDO wines. The selected wines were chosen to be representative on one hand of the sensory diversity and typicality (whatever the vintage effect) of the Rosé wines produced within the considered area and on the other hand of the volume of wines available on the market. Seven wines were selected from the PRO, LAN, VDL, RHO and BGC areas and six wines from the BDX area. A total of 41 wines were evaluated.

2. Tasting conditions

For both methodologies described below, tasting took place in June 2015, in a sensory room with individual computerized booths, at 21 °C ± 1 °C. Wine samples (30 mL) were served in AFNOR dark and clear wine glasses labeled with random three-digit numbers. Wines were served at 11 °C ± 1 °C. Rinsing between samples was done with mineral water and white bread. The 41 samples were presented in a sequential monadic way and their order was based on a William Latin-square arrangement.

3. Typicality assessment and free description using a professional panel

3.1 Panel composition

The panel was composed of 41 wine professionals of the Provence area [established winemakers (19), wine-science researchers and engineers involved in wine-making and wine evaluation (22)]. They were selected for their good familiarity with the characteristics of Provence Rosé wines. The panel was not trained together prior to the wine tasting since the exemplarity evaluation is based on the individual perception of wine typicality.

3.2 Protocol

Assessors were instructed as follows: "For each wine presented, you must answer the following question: do you think this wine is a good example or a bad example of what a 'Provence Rosé' wine is?". These instructions were derived from the method proposed by Ballester *et al.* (2005). Assessors were asked to rate the wine sample's exemplarity on a continuous scale, anchored on the left by "very bad example" (score 0), and on the right by "very good example" (score 10). The scores were collected by FIZZ (version 2.10; Biosystèmes, Couternon, France). The assessors were also asked to specify in writing the sensory characteristics of each wine using a free description (Lawrence *et al.*, 2013).

After the first evaluation in a dark glass, each taster had to pour the wine into a transparent INAO glass and evaluate the typicality again, now integrating the

Table 1. Areas studied with the main varieties used and the color potential taking into account anthocyanin contents and CIELAB coordinate a.

Areas	Main varieties (according to PDO regulations)	Anthocyanins (mg malvidin-3-glucoside eq./L)	a (CIELAB coordinates)	
			Average (standard deviation) of the wine data set	From Masson *et al.* (2008)
Provence	Grenache, Syrah, Cinsault, Mourvèdre, Tibouren	15 (5)	3 (1)	5
Languedoc	Grenache, Syrah, Mourvèdre	24 (10)	7 (3)	11
Val de Loire	Cabernet franc, Grolleau, Cabernet-Sauvignon, Gamay, Pinot noir, Malbec/Côt, Pineau d'Aunis	31 (9)	9 (3)	8
Rhône (Tavel)	Grenache, Cinsault, Carignan, Syrah, Bourboulenc, Calitor, Mourvèdre, Picpoul	55 (8)	22 (4)	11 (all Rhône vineyard)
Bergerac	Merlot, Côt, Cabernet franc, Cabernet-Sauvignon	36 (14)	11 (5)	16 (all South-West vineyard)
Bordeaux	Merlot, Côt, Petit Verdot, Cabernet franc, Cabernet-Sauvignon, Carmenère	41 (8)	14 (5)	15

color. They were not allowed to modify their previous dark-glass typicality score.

The evaluations were performed during two sessions per assessor.

4. Descriptive sensory analysis using an expert panel and color measurement

A quantitative descriptive analysis (QDA®; Stone and Sidel, 2004) was performed by the trained sensory panel of the 'Rosé Wine Experimentation and Research Center'. The panel was composed of 12 paid judges including 8 men and 4 women aged 36-71 years. Each year, these judges receive intensive training (30 h) to characterize Rosé wines using individual tasks and group sessions and performance tests are regularly carried out. According to the method described in the ISO 13299:2003 standard, and after subsequent discussions within the trained panel, a consensus vocabulary of 36 attributes to describe Provence Rosé wines was generated (Table 2). This task was based on a large pre-established list previously generated by the center to describe Rosé wines. Olfactory and gustatory standards were used for specific training on these 36 selected attributes. Assessors were asked to rate each attribute on a continuous intensity scale from "low" to "high" and convert them into scores from 0 to 10. The scores were collected by FIZZ (version 2.10; Biosystèmes, Couternon, France).

5. Color measurement

CIELAB color coordinates (L, a, b, C and H) were measured for each wine using a spectrophotometer (Lambda 20 Perkin Elmer, USA): L: lightness to darkness, a: redder to greener, b: yellower to greener, C: brighter to duller and H: hue. These parameters enable the color of wines to be measured in the same conditions as those found in the visual color assessment by a panel but with more precision (Sáenz Gamasa *et al.*, 2009).

6. Statistical processing

6.1 Exemplarity measurements

Two-way (wine, assessor) ANOVAs were performed to analyze the exemplarity scores. Next, pairwise mean comparisons were made using Fisher's Least Significant Difference (LSD) test ($\alpha = 0.05$). In addition, the consensus among the professionals was evaluated using a Principal Component Analysis (PCA) based on the correlation matrix. The assessors were considered the variable and the wines the individuals. The professionals' loadings on the first principal component (PC1) reflected their inter-individual consensus. We also used Kendall's coefficient of concordance and the Intraclass Correlation Coefficients (ICC) considering the consistency (C) and the agreement (A) according to Loison *et al.* (2015).

After recoding the free description of each wine by the professionals, the frequency of the free attributes was noted and a contingency table was built to calculate overall Chi-square and Chi-square per cell (Lawrence *et al.*, 2013; Symoneaux *et al.*, 2012). This analysis was performed only for some specific wines depending on the cluster analysis when additional information was needed to better understand the typicality perception of professionals.

6.2 Descriptive analysis by a trained panel

Variance analyses (ANOVA) were used to analyze the scores for each attribute. Two models were applied: the first considering the area and judge factors and the second considering the wine and judge factors. Only the discriminant attributes (threshold: $\alpha = 0.20$) for either the wine factor or the area factor were taken into account in the subsequent analyses.

A PCA was performed; the data were averaged according to the wine and normalized. Next, a Hierarchical Ascendant Classification (HAC) using Ward criteria and Euclidian distance was carried out on the first 10 components of the PCA to cluster wines based on their sensory similarity. Two levels of cutting were arbitrarily chosen: four clusters and nine clusters.

Then, two-way ANOVAs considering the cluster and judge factors were carried out. The analysis was completed by pairwise mean comparisons using Fisher's LSD test ($\alpha = 0.05$) to link sensory characteristics to each cluster. All the attributes whose p-value was less than 0.02 for the V-Test (difference between the average in the class and the overall average) were used to characterize the clusters. All analyses were done using XLStat-pro software (v.2009.2; Addinsoft, Paris, 2009) and the R program with the FactoMineR package (Lê *et al.*, 2008).

6.3 Relationship between sensory descriptors and typicality levels

Partial Least Squares Regression (PLS-R) analyses were used as an explanatory model to link sensory descriptors (X-variables) and typicality levels (Y-variable, PLS1). An overall PLS-R was performed considering the 41 wines. The model is considered significant when $Q^2 > 0.097$ (Tenenhaus *et al.*, 2005). The optimal number of PLS components was chosen by the leave-one-out cross-validation correlation coefficient, calculated from the Predicted Residual Sum of Squares (PRESS) referred to as the model's predictive ability and the multiple correlation coefficient (R2), which provides estimates of the model fit. The optimal model presented a reasonable balance between the model's fit and predictive ability. The Variable Importance for the Projection (VIP) was calculated. Variables are regarded as important for the prediction if VIP > 0.8 (Tenenhaus *et al.*, 2005). All analyses were done using the R program with the PLS package (Mevik and Wehrens, 2007).

Results

1. Typicality assessment: consensus among wine professionals

1.1 Evaluation in dark glass

The professionals of Provence shared a common perception of the Provence Rosé wine exemplarity based on odor and flavor, when wines were served in a dark glass. The agreement among the 41 tasters evaluating 41 wines was high. The loading of the assessors on the two principal components (PC1 and PC2) of the PCA performed on the typicality scores is shown in Figure 1a. These principal components explain 36.7% and 7.7%, respectively, of the total variance. All the professional tasters were loaded on the positive side of the first axis, highlighting the fact that they tended to score the typicality of the wines in a similar way. The low proportion of total variance explained on the first components was due to the use of many wines and tasters. Kendall's coefficient of concordance was 0.33 (p-value < 0.001), the ICC(C) was 0.31 and the one considering the agreement, ICC(A), was 0.28 showing a good consensus among wine professionals (Loison *et al.*, 2015).

The 41 selected wines were perceived with very different levels of exemplarity. The average typicality scores for each wine varied between 0.9 and 6.7, with an overall average for all wines of 4.04 (Table 2). All the Provence Rosé wines (PRO) had a level of exemplarity higher than this overall average. Five of the seven Provence wines were the five best examples. The other two were among the twelve best examples. These results were observed when analyzing the averages per area. The average and LSD groups were: PRO: 6.1 (a), LAN: 4.9 (b), VDL and BDX: 3.7 (c), BGC: 3.3 (cd) and RHO: 2.5 (d).

1.2 Evaluation in transparent glass

There was an impact of color on the judgment of exemplarity. When wines were poured into transparent glass, the perceived typicality of the majority of the wines changed in different ways. Eleven wines had a decrease in exemplarity of more than 0.5 while fifteen wines had an increase of more than 0.5. Interestingly, no wines with an exemplarity mean score in dark glass of more than 5 received a lower score in transparent glass, except BDX3 (-0.08). In parallel, no wines with a mean score of less than 3 in dark glass had a higher score in transparent

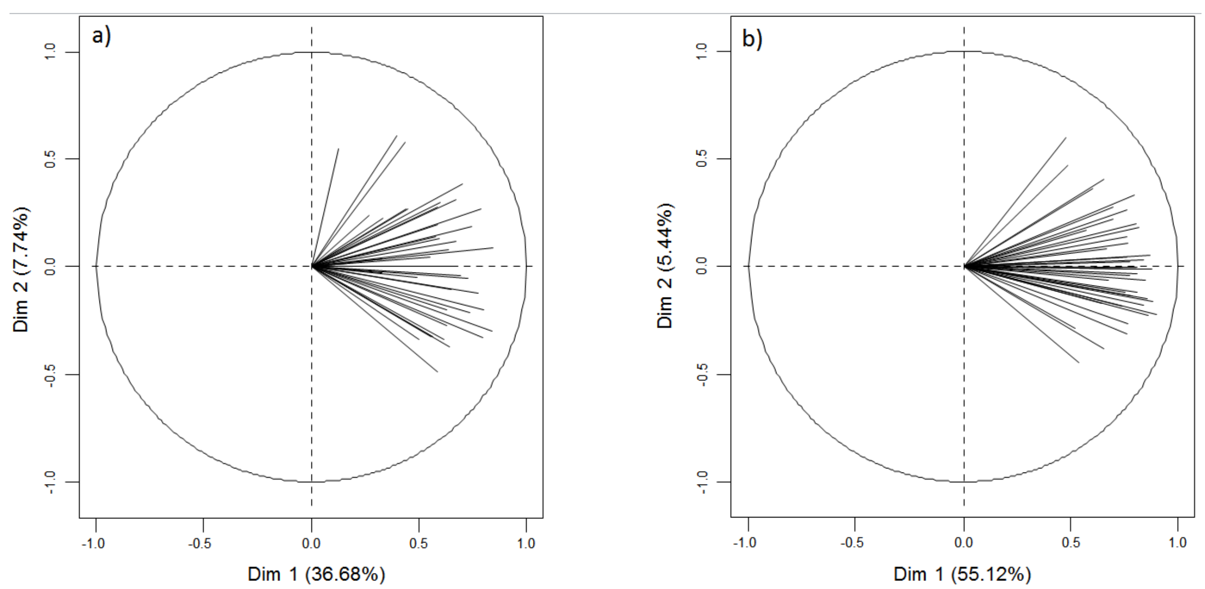

Figure 1. Correlation circles of Principal Component Analysis presenting the typicality assessment between judges in dark glass (a) and transparent glass (b).

Table 2. Averages of the exemplarity scores evaluated by 41 professionals (scores between 0 "very bad example of a Provence Rosé wine" and 10 "very good example of a Provence Rosé wine") and CIELAB color coordinates (L, a, b, C and H) of the 41 Rosé wines studied.

Wines	Exemplarity average (n=41)			Color measurements				
	In dark glass	In transparent glass	Difference between both	L	a	b	C	H
PRO5	6,69	7,06	0,37	97,5	2	4,7	5,1	67,4
PRO2	6,69	7,4	0,72	96,9	2,9	4,4	5,3	56,5
PRO4	6,65	7,32	0,67	97,3	2,5	3,9	4,6	57,1
PRO7	6,41	7,02	0,6	96,3	2,8	5,8	6,4	64,4
PRO6	6,41	7,04	0,63	96,8	2,2	5,6	6	68,5
LAN6	6,27	7,19	0,91	96	3,7	5,3	6,5	55,4
LAN4	5,57	6,09	0,52	93,9	7	6	9,2	40,9
BDX6	5,4	6,14	0,74	94,3	6	6,7	9	48
BDX3	5,24	5,16	-0,08	89,6	11,4	8,9	14,5	38,1
PRO1	5,05	5,63	0,58	94,1	5,4	7,8	9,5	55,6
BGC5	4,89	5,71	0,82	95,1	5,4	5,9	8	47,8
PRO3	4,85	5,45	0,6	95,8	4,7	5,4	7,1	48,7
LAN2	4,85	5,42	0,57	94,6	5,5	4,9	7,4	41,6
VDL5	4,74	5,02	0,29	92	9,1	6,6	11,2	36,3
LAN1	4,66	4,63	-0,03	91,7	9,2	7,8	12	40,2
LAN3	4,55	4,93	0,38	92,2	8,8	7,8	11,7	41,5
LAN7	4,34	5,23	0,89	96,3	3	6,6	7,2	65,4
VDL2	4,26	4,36	0,1	91,9	7,6	9,3	12	50,7
LAN5	4,26	3,78	-0,48	89,4	12,4	8,6	15,1	34,9
BGC2	4,24	5,5	1,26	94,6	5	7,5	9	56,5
VDL7	4,17	5,21	1,04	94,8	5	4,9	7	44,8
VDL3	3,75	3,69	-0,06	90,4	10,8	7,4	13,1	34,6
BGC3	3,4	3,84	0,44	93,5	7,2	8,2	10,9	48,6
RHO3	3,37	2,05	-1,32	84,4	17,8	11,7	21,3	33,3
VDL1	3,35	3,84	0,49	92,2	7,8	7,9	11,1	45,4
BDX1	3,35	2,69	-0,66	88,6	14,7	8,4	16,9	29,7
VDL4	3,28	3,95	0,67	92,2	8	7,9	11,3	44,6
BDX7	3,09	2,26	-0,83	86,8	14	12,3	18,7	41,3
RHO1	3,01	1,64	-1,38	83,3	18,3	10,9	21,3	30,7
BGC4	3,01	2,43	-0,58	89,4	11,7	10,8	15,9	42,9
BGC7	2,97	2,1	-0,87	86,3	17,6	8,8	19,7	26,7
RHO2	2,91	1,71	-1,2	80,9	23,8	8,8	25,4	20,4
RHO6	2,84	2,4	-0,44	84,4	17,7	11	20,8	31,8
BDX5	2,81	2,77	-0,04	89,5	13,3	7,8	15,4	30,3
VDL6	2,43	1,94	-0,49	86,5	14	10,6	17,6	37
BGC1	2,31	2,06	-0,25	88,6	15	7,7	16,9	27
RHO5	2,3	1,18	-1,12	77,5	24,9	13,5	28,3	28,5
RHO4	2,29	1,44	-0,85	81,3	21,5	12,5	24,8	30,2
BGC6	2,16	1,62	-0,54	88,6	15,7	6,3	16,9	22
BDX4	2,09	1,38	-0,71	82	22,5	13,8	26,4	31,5
RHO7	0,86	0,59	-0,27	76,8	27,3	13,7	30,6	26,7

glass. In the range between 3 and 4, the exemplarity increased, decreased or stayed stable depending on the wine. In relation to these observations, there was a high correlation (R = 0.96) between the average typicality score in dark and transparent glass.

As for the evaluation in dark glass, a PCA with judges as variables and wines as individuals was carried out (Figure 1b). The consensus was higher with transparent glass as indicated by the higher percentage of inertia explained on the first two components (60.56% for clear glass against 44.42% for dark glass). The Kendall’s coefficient, the ICC(C) and the ICC(A) also indicated a higher agreement among subjects: 0.53, 0.5 and 0.46, respectively.

2. Descriptive sensory analysis: some specific characteristics of typical Provence Rosé wines

2.1 Discriminative sensory attributes

The trained judges generated and selected 36 attributes (14 odors and corresponding aromas, and 8 flavors) to define the sensory properties of the studied Rosé wines. Values of the Fisher statistics of the analysis of variance (ANOVA) and p-values for the area and wine factors are given in Table 3. The effect of the wine factor was found to be significant for 18 attributes (p-value < 0.05). The effect of the area factor was found to be significant for 17 attributes (p-value < 0.05). Four attributes (‘yellow fruit’ aroma and odor, ‘dried fruit’ odor and ‘bitterness’) were not taken into account in the subsequent analysis since they were not discriminant for either the wine factor or the area factor (p-value > 0.20).

2.2 Clustering of wines depending on sensory attributes

The 41 studied wines could be optimally grouped into four distinct clusters (C1 to C4) and nine subgroups thanks to the HAC (Figure 2). The description of each cluster was carried out based on the LSD results (Table 4) and V-Test analysis per cluster considering the 32 attributes taken into account.

Cluster C1 contained a single Provence Rosé wine (PRO04). This wine was considered very typical (6.7) by the group of professional tasters. It was distinguished from the others by a significantly higher intensity of ‘exotic fruit’ and ‘vegetal’ odors and aromas. It also presented slight ‘animal’ and ‘mineral’ notes significantly higher than the others but still low. In addition, it had a significantly less intense ‘ripe fruit’ aroma.

Cluster C2 contained 19 wines including four Provence Rosé wines evaluated as good examples by professional tasters. The mean typicality of this cluster was 4.79 but with a large diversity from 2.3 to 6.69. This cluster was clearly characterized by ‘fresh floral’ odors and aromas combined with some ‘citrus and exotic fruit’ notes. These wines were slightly less astringent than those in C3 and C4. Three subgroups were observed. Cluster C2.1 wines were more intense in ‘exotic fruit’, ‘citrus’ and ‘amylic’ odors and less intense in ‘red fruit’, ‘vegetal’ and ‘spicy’ notes and ‘dried fruit’ odor. These wines had a good exemplarity (mean = 5.71). C2.2 and C2.3 wines were slightly less intense in ‘citrus fruit’ notes. C2.2 wines presented more ‘red fruit’ and ‘smoked’ and less ‘exotic fruit’ flavors. Their average exemplarity was 4.31. However, the RHO5 wine within this group was significantly less typical with an exemplarity score of 2.3. Variance analysis of the sensory data of the three wines grouped within Cluster C2.2 (RHO5, LAN5 and BDX3) gave no significant results. The lowest p-value was for ‘red fruit’ aroma (p-value = 0.133) and RHO5 was slightly more intense in this attribute. In parallel, the analysis of the free descriptions of the professionals revealed that RHO5 was evaluated more often as unbalanced and three tasters mentioned ‘cherry’ notes (data not shown). Finally, the seven wines in C2.3 presented ‘vegetal’ and ‘spicy’ nuances. The exemplarity of this group was 4.41 but with a maximum of 6.69 and a minimum of 3.09. Two of the seven wines (LAN4 and PRO2) had a higher exemplarity. These two wines were more ‘alcoholic’ than the other five. In parallel, the analysis of the free descriptions of the professionals showed that two more exemplary wines received proportionally more citations for ‘alcohol’, ‘finesse’ and ‘citrus fruit’ whereas the five others had more citations for ‘vegetal’, ‘heavy’, ‘sour’ and ‘mature’. These nuances were not perceived by the trained panel apart from ‘alcohol’.

Cluster C3 was composed of 11 products including two Provence Rosé wines (grouped in C3.2). The mean exemplarity of this group was lower (3.80) than the two previous ones but still with some variation between subgroups. C3 wines were significantly more ‘sourer’ and ‘astringent’, slightly more ‘salty’ and less ‘round and sweet’, ‘amylic’, ‘fresh floral’ and ‘exotic fruit’. The three subgroups were not very different from a sensory point of view. C3.1 contained seven wines with a low exemplarity (mean = 3.18). These were characterized by the

Table 3. F ratios and P-values of the variance analysis (ANOVA) for two models of variance analysis (area+judge and wine+judge) based on 41 Rosé wines studied and 41 judges, for each sensory attribute.

	Area factor (n=6) (Model 1: Area + Judge)		Wine factor (n=41) (Model 2: Wine + Judge)	
	F	P-Value	F	P-Value
Amylic odor	5,777	< 0,0001	1,982	0,001
Animal odor	1,585	0,163	1,509	0,027
Citrus fruit odor	1,804	0,111	0,849	0,732
Dried fruit odor	1,184	0,316	1,111	0,301
Exotic fruit odor	3,18	0,008	1,423	0,049
Fresh floral odor	2,021	0,074	1,311	0,103
Mineral odor	2,183	0,055	1,164	0,233
Mushroom odor	1,016	0,407	1,937	0,001
Red fruit odor	5,203	< 0,0001	1,587	0,015
Ripe fruit odor	3,168	0,008	1,557	0,019
Smoked odor	3,819	0,002	1,788	0,003
Spicy odor	2,677	0,021	1,174	0,222
Vegetal odor	2,196	0,054	1,429	0,048
Yellow fruit odor	0,636	0,673	1,054	0,385
Amylic aroma	2,653	0,022	1,613	0,012
Animal aroma	1,12	0,349	2,155	< 0,0001
Citrus fruit aroma	2,99	0,011	1,564	0,018
Dried fruit aroma	1,495	0,19	0,939	0,581
Exotic fruit aroma	2,554	0,027	2,043	< 0,0001
Fresh floral aroma	2,265	0,047	1,739	0,004
Mineral aroma	1,755	0,121	1,079	0,348
Mushroom aroma	1,369	0,235	1,339	0,086
Red fruit aroma	7,791	< 0,0001	2,072	< 0,0001
Ripe fruit aroma	4,76	< 0,0001	1,322	0,096
Smoked aroma	3,053	0,01	2,074	< 0,0001
Spicy aroma	1,704	0,132	1,208	0,186
Vegetal aroma	2,902	0,014	1,829	0,002
Yellow fruit aroma	1,378	0,231	0,926	0,602
Alcohol	5,064	< 0,0001	1,636	0,01
Sparkling	2,336	0,041	2,013	< 0,0001
Sourness	3,397	0,005	1,305	0,106
Sweetness	1,914	0,091	1,063	0,372
Bitterness	1,072	0,375	1,102	0,313
Astringency	0,776	0,567	1,349	0,081
Roundness	1,481	0,194	1,155	0,244
Salty	1,928	0,088	1,045	0,4

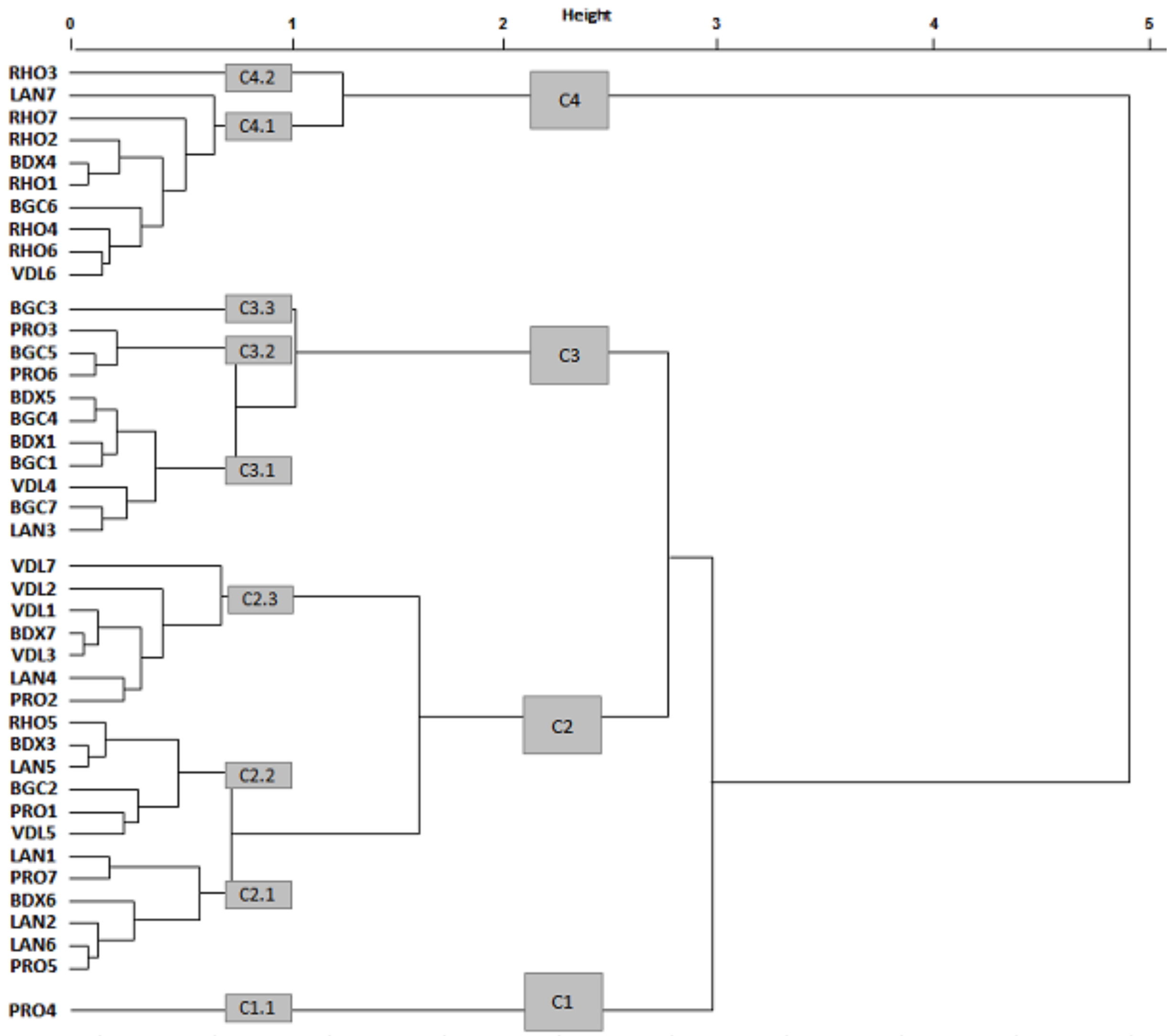

Figure 2. Clustering of the 41 Rosé wines studied based on a Hierarchical Ascendant Classification.
Four clusters and nine sub-clusters are considered (grey labels)

lower ‘alcoholic’ mouth feel and the lower ‘citrus fruit’ intensity. Three wines in C3.2 had a higher exemplarity level (mean = 5.38). They differed from the others in the higher ‘alcoholic’ sensation and ‘citrus’ notes, and slightly more intensity in ‘amylic’ but less ‘mineral’ aroma. Finally, a single wine formed the C3.3 group with a low exemplarity of 3.4. This wine was perceived as sparkling and less ‘round’. It presented slight notes of ‘mushroom’ and ‘animal’ and few positive attributes (‘floral’, ‘amylic’, ‘exotic fruit’ or ‘red fruit’).

The odor and flavor of 10 wines in Cluster C4 were clearly perceived as not typical by Provence professionals. Their average typicality was 2.63. C4 contained six wines originating from the Rhône Valley (Tavel PDO) and none from Provence. The 10 wines were very close. They presented higher notes of ‘ripe fruit’, ‘amylic’, ‘smoked’ and ‘red fruit’ than all the other wines. They were also more ‘alcoholic’, ‘round’ and ‘sweet’. In contrast, they had fewer ‘citrus fruit’, ‘mineral’ and ‘vegetal’ notes. Cluster analysis into subgroups separated one wine (RHO3) with a higher ‘mushroom’ note.

Clusters or sub-clusters share the same letter if they are not statistically different from each other (ANOVA, post-hoc LSD tests, threshold 5%).

3. Prediction of typicality according to sensory attributes

3.1 Various sensory specificities for the most typical wines

PLS-R enabled the level of exemplarity to be predicted from the sensory discriminant attributes

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considering all 41 wines. It can be considered consistent with a Q^2 of 0.538 > 0.097, an R^2 of 0.644 and an RMSE of 0.855 (scale between 0 and 10). Figure 3 presents the 15 attributes showing scores higher than 0.8 from the VIP analysis. These were therefore considered indicators of typicality or non-typicality. Seven attributes had a positive impact on the level of Provence exemplarity: 'mineral' aroma, 'citrus fruit', 'exotic fruit', and 'fresh floral' odors and aromas. In contrast, eight attributes had a negative impact: 'red fruit', 'smoked', 'ripe fruit' odors and aromas, 'dried fruit' odor and 'spicy' aroma.

These results are related to the wines with the highest and lowest exemplarity scores identified in the different sensory subgroups. The majority of typical wines (over 5) were in C1, C2.1 and C3.2. The description of these groups enabled some common sensory characteristics shared by these wines to be identified manually. They appeared to have 'exotic fruit' and 'citrus fruit' notes. On the contrary, the least typical wines were in C4, with 'ripe fruit', 'red fruit' and 'smoked' notes.

3.2 Impact of color on sensory typicality

Wine typicality was scored again after pouring the wines into a transparent glass after each evaluation. Correlations between the average typicality scores in both conditions and all physical measurements of color were highly significant (Table 2). First, it should be noted that all color measurements (L, a, b, C, H) were correlated (p-value < 0.0001). In the selected Rosé wines, the clearest wines were very pale with a low level of saturation and a more orange hue while the darkest wines had more saturated and red colors. Then, there were significant correlations between the color parameter and typicality even in dark wines. Based only on the flavor perception, the wines with higher typicality were paler and more orange whereas the least typical ones were more red and saturated. When the wines were poured into a transparent glass, the contrast in typicality was stronger. The wines with high luminance were perceived as more typical than when they were in a dark glass, whereas the other wines were perceived as less typical. Thus, the correlation between color parameters and the difference between the exemplarities in dark and transparent glasses was also highly significant (data not shown).

Discussion

This work aimed to identify the sensory typicality of one specific area, here Provence, compared to other French areas based on odor, aroma and mouth feel characteristics, first without the influence of color

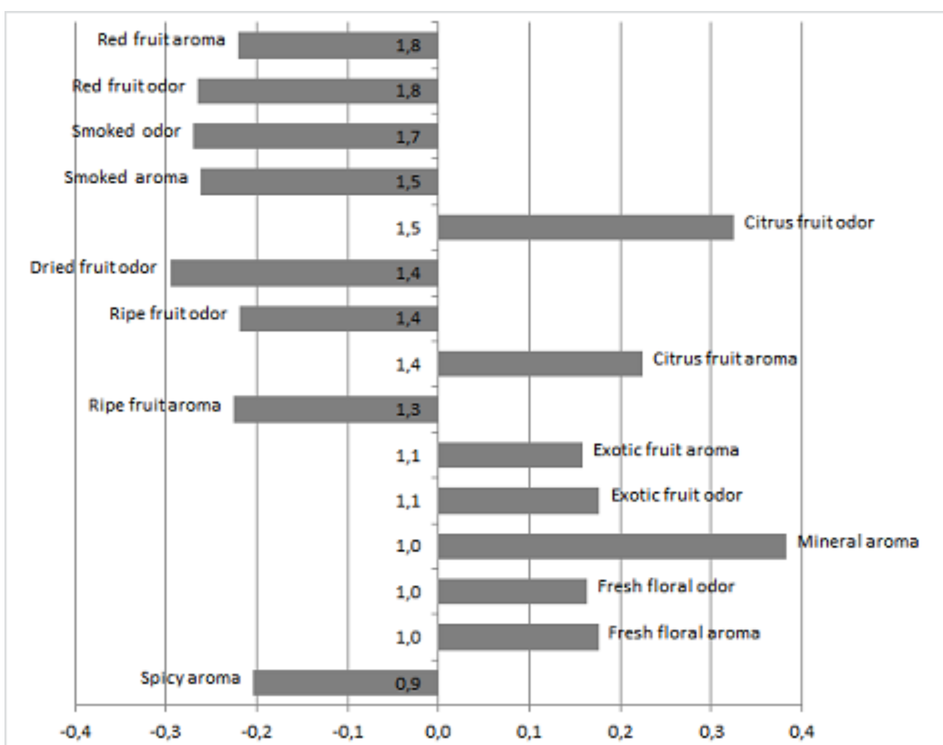

Figure 3. PLS-R coefficients for sensory attributes with a VIP > 0.8.

Table 4. Description of each cluster and sub-cluster based on the LSD results and V-Test analysis considering the 32 discriminant sensory attributes.

Attributes	C1	C2	C3	C4	F	p-value	C1.1	C2.1	C2.2	C2.3	C3.1	C3.2	C3.3	C4.1	C4.2	F	p-value
Fresh floral odor	1,64 ab	2,20 a	1,45 b	1,7 ab	8,77	< 0,0001	1,64 abc	2,09 ab	2,26 a	2,25 a	1,44 bc	1,57 abc	1,21 c	1,70 abc	1,42 bc	3,47	0,0007
Amylic odor	2,38 bc	2,72 b	2,29 c	3,34 a	12,63	< 0,0001	2,38 b	2,84 ab	2,65 ab	2,67 ab	2,33 bc	2,43 b	1,63 c	3,38 a	3,01 ab	5,33	< 0,0001
Citrus fruit odor	4,55 a	4,67 a	4,53 a	4,11 b	3,82	0,0101	4,55 ab	4,92 a	4,66 ab	4,47 ab	4,41 ab	4,74 a	4,69 ab	4,13 ab	3,95 b	2,09	0,0357
Exotic fruit odor	3,93 a	2,43 b	2,10 c	2,27 bc	6,25	0,0004	3,93 a	2,90 b	2,15 c	2,27 c	2,15 c	2,06 c	1,89 c	2,26 c	2,35 bc	3,82	0,0002
Red fruit odor	4,34 b	4,64 b	4,75 b	5,48 a	8,01	< 0,0001	4,34 b	4,38 b	4,9 ab	4,64 b	4,90 ab	4,49 b	4,54 b	5,57 a	4,64 b	4,25	< 0,0001
Ripe fruit odor	2,34 b	3,14 b	3,12 b	3,92 a	11,53	< 0,0001	2,34 c	3,12 bc	2,919 bc	3,34 b	3,09 bc	3,25 bc	2,88 bc	3,89 a	4,25 a	4,93	< 0,0001
Vegetal odor	3,03 a	1,53 b	1,51 b	1,05 c	8,6	< 0,0001	3,03 a	1,13 c	1,61 b	1,80 b	1,59 b	1,28 bc	1,60 b	1,01 c	1,33 bc	4,67	< 0,0001
Mushroom odor	0,58 a	0,22 a	0,35 a	0,36 a	2,07	0,1034	0,58 bc	0,17 cd	0,15 d	0,32 cd	0,33 cd	0,19 cd	0,92 b	0,23 cd	1,48 a	7,12	< 0,0001
Spicy odor	1,86 a	1,83 a	1,79 a	1,88 a	0,16	0,9245	1,86 ab	1,38 b	1,88 ab	2,17 a	1,85 ab	1,67 ab	1,78 ab	1,93 ab	1,44 b	3,36	0,0009
Smoked odor	3,88 b	3,99 b	4,15 b	4,75 a	9,21	< 0,0001	3,88 b	3,86 b	4,4 ab	3,81 b	4,28 ab	3,91 b	3,93 b	4,81 a	4,24 ab	5,07	< 0,0001
Animal odor	1,00 a	0,15 b	0,23 b	0,17 b	12,31	< 0,0001	1,00 a	0,14 c	0,197 c	0,13 c	0,23 c	0,11 c	0,57 b	0,17 c	0,18 c	5,8	< 0,0001
Mineral odor	0,88 a	0,30 b	0,23 b	0,25 b	6,37	0,0003	0,88 a	0,38 b	0,31 bc	0,24 bc	0,21 c	0,23 bc	0,36 bc	0,25 bc	0,23 bc	2,87	0,0039
Fresh floral aroma	1,91 a	2,12 a	1,46 b	1,87 a	8,69	< 0,0001	1,91 abc	1,91 abc	2,06 ab	2,34 a	1,40 c	1,63 bc	1,43 c	1,91 abc	1,57 bc	4,19	< 0,0001
Amylic aroma	2,38 ab	2,64 a	2,16 b	2,87 a	7,32	< 0,0001	2,38 abc	2,82 a	2,6 ab	2,5 ab	2,06 bc	2,50 ab	1,81 c	2,93 a	2,30 abc	3,92	0,0002
Citrus fruit aroma	5,52 a	5,42 a	5,39 a	4,64 b	9,72	< 0,0001	5,52 ab	5,38 ab	5,476 ab	5,4 ab	5,18 b	5,87 a	5,42 ab	4,66 c	4,39 c	4,53	< 0,0001
Exotic fruit aroma	4,27 a	2,46 b	1,80 c	2,36 b	15,25	< 0,0001	4,27 a	2,40 bc	2,26 bc	2,68 b	1,73 c	1,94 c	1,90 c	2,39 bc	2,08 bc	6,36	< 0,0001
Red fruit aroma	4,15 b	4,84 b	4,88 b	5,76 a	10,64	< 0,0001	4,15 d	4,47 cd	5,28 abc	4,78 bcd	5,00 abcd	4,64 bcd	4,73 bcd	5,80 a	5,45 ab	5,43	< 0,0001
Dried fruit aroma	1,36 a	1,46 a	1,81 a	1,77 a	2,44	0,064	1,36 ab	1,32 b	1,51 ab	1,55 ab	1,93 a	1,49 ab	1,97 a	1,70 ab	2,31 a	1,67	0,1025
Ripe fruit aroma	1,96 c	2,80 b	2,72 bc	3,56 a	11,38	< 0,0001	1,96 d	2,96 abc	2,98 abc	2,50 cd	2,68 bcd	2,83 bc	2,62 bcd	3,59 a	3,28 ab	5,11	< 0,0001
Vegetal aroma	3,17 a	1,64 b	1,47 bc	1,23 c	8,98	< 0,0001	3,17 a	1,32 c	1,51 bc	2,02 b	1,55 bc	1,22 c	1,63 bc	1,22 c	1,33 bc	5,24	< 0,0001
Mushroom aroma	0,52 a	0,21 b	0,31 ab	0,39 ab	2,56	0,0547	0,52 bc	0,20 bc	0,25 bc	0,18 c	0,4 bc	0,13 c	0,58 b	0,30 bc	1,15 a	4	0,0001
Spicy aroma	1,98 a	2,14 a	2,18 a	2,33 a	0,83	0,4788	1,98 ab	1,84 b	2,10 ab	2,44 a	2,21 a	2,04 ab	2,42 a	2,38 a	1,84 ab	2,06	0,0384
Smoked aroma	3,71 b	3,82 b	4,06 b	4,53 a	10,23	< 0,0001	3,71 bc	3,93 bc	4,03 abc	3,53 c	4,20 ab	3,68 bc	4,22 ab	4,58 a	4,09 abc	5,88	< 0,0001
Animal aroma	0,92 a	0,13 b	0,18 b	0,14 b	20,45	< 0,0001	0,92 a	0,12 b	0,15 b	0,12 b	0,20 b	0,11 b	0,23 b	0,14 b	0,13 b	7,95	< 0,0001
Mineral aroma	0,95 a	0,46 b	0,43 bc	0,27 c	4,21	0,0059	0,95 a	0,43 b	0,48 b	0,47 b	0,51 b	0,28 b	0,31 b	0,24 b	0,57 ab	2,25	0,0227
Sparkling	1,45 a	1,52 a	1,79 a	1,69 a	2,37	0,0698	1,45 b	1,51 b	1,45 b	1,59 b	1,73 b	1,39 b	3,42 a	1,68 b	1,76 b	6,37	< 0,0001
Sourness	4,25 b	4,65 b	5,12 a	4,64 b	6,01	0,0005	4,25 d	4,50 cd	4,58 bcd	4,83 abcd	5,17 ab	4,90 abc	5,42 a	4,65 bcd	4,50 cd	2,96	0,0031
Sweetness	1,88 ab	2,00 a	1,74 b	2,16 a	4,74	0,0029	1,9 bc	2,13 ab	2,09 bc	1,81 bc	1,68 bc	1,89 bc	1,63 c	2,11 abc	2,58 a	3,11	0,002
Roundness	2,68 ab	2,58 ab	2,33 b	2,87 a	4,74	0,0029	2,68 abc	2,59 bc	2,61 bc	2,55 bc	2,28 c	2,70 abc	1,57 d	2,82 ab	3,33 a	3,31	0,0011
Alcohol	5,28 b	5,35 b	5,49 ab	5,78 a	6,49	0,0003	5,28 c	5,24 c	5,44 bc	5,35 bc	5,35 bc	5,80 ab	5,55 abc	5,76 ab	5,93 a	3,58	0,0005
Salty	1,51 b	1,65 ab	1,96 a	1,73 ab	3,72	0,0115	1,51 b	1,53 b	1,53 b	1,86 b	1,87 b	1,96 b	2,58 a	1,75 b	1,51 b	3,37	0,0009
Astringency	3,02 c	3,68 bc	4,21 a	3,98 ab	6,3	0,0003	3,02 b	3,62 ab	3,55 ab	3,85 a	4,21 a	4,19 a	4,22 a	4,02 a	3,57 ab	2,8	0,0048
Exemplarity																	
average	6,651 a	4,790 b	3,803 c	2,631 d	91,76	< 0,0001	6,651 a	5,714 b	4,306 c	4,412 c	3,184 d	5,384 b	3,398 d	2,549 e	3,371 d	55,56	< 0,0001
n	1	19	11	10			1	6	6	7	7	3	1	9	1		
min	-	2,3	2,31	0,86			-	4,66	2,3	3,09	2,31	4,85	-	0,86	-		
max	-	6,69	6,41	4,34			-	6,69	5,24	6,69	4,55	6,41	-	4,34	-		

Clusters or sub-clusters share the same letter if they are not statistically different from each other (ANOVA, post-hoc LSD tests, threshold 5%).

(blind tasting in dark glass) and then with color as indicator (clear glass). Wine professionals from this area shared a common perception of which wines are typical or not typical from a flavor point of view. They agreed about the characteristics that Provence Rosé wines should have. In the literature, the consensus observed among tasters from a specific area varies depending on the number of products tested, the number of tasters and the sensory space selected to analyze the perceived exemplarity. It also depends on the sensory variability in the studied area and the existence of a shared perception of typicality. With 41 wines and 41 tasters, the present study has the largest number of products and tasters reported in the literature. This could have had an impact on the statistical indicators, artificially decreasing the percentage of inertia on the PCA due to a higher number of components. However, the percentage of inertia explained on the first two components (44%) and other coefficients such as ICC(A), ICC(C), and Kendall's coefficient were high indicating high agreement among tasters. Thus, there is a consensus among the professionals ; they have a common representation of what Provence Rosé wines shouldbe.

Based on the sensory characteristic of each wine or clusters and sub-clusters, there is no single sensory profile of Provence Rosé wines. The more typical wines were included in different clusters of the HAC performed on the sensory attribute scores. Nevertheless, the present methodology and the PLS coefficients enabled the sensory attributes impacting the Provence Rosé wine typicality to be identified and hierarchized. Fruity 'citrus fruit' and 'exotic fruit' odors and aromas as well as 'fresh floral' odors and aromas and 'mineral' aroma had a positive impact on the exemplarity of Provence Rosé wines. These positive attributes are in accordance with other studies about the main volatile compounds characterizing Provence Rosé wines (Masson and Schneider, 2009 ; Pouzalgues *et al.*, 2013). These wines contained mainly ethyl esters and higher alcohol acetates at the origin of the 'fruity' and 'amylic' notes ; two thiols : β-mercaptohexanol (3MH) and 3-mercaptohexyl acetate (A3MH) linked to 'citrus' and 'exotic fruit' notes ; two furanic compounds : furaneol and homofuraneol having a synergic action for 'fruity' and 'caramel' notes (Ferreira *et al.*, 2002) ; and one C13 norisoprenoid : β-damascenone having a positive influence on 'dried fruit', 'black fruit' and 'roasted' notes and exerting a suppressing effect on 'red fruit' (Callejón *et al.*, 2012 ; Ferreira *et al.*, 2016). It would be interesting to analyze the volatile compounds from the wines of the present study in order to identify those markers responsible for 'dried, roasted and red fruit'. In fact, some other attributes penalized the exemplarity : the fruity attributes 'red fruit' and 'ripe fruit' odors, the 'dried fruit' odor as well as 'smoked' and 'spicy' aromas.

The typicality of Provence Rosé wines perceived by professionals is based mainly on the odor and aromatic characteristics. In fact, no mouth feel and taste attributes were significant in the PLS. Cluster C3 was 'sourer' and 'astringent', but wines with more 'amylic' and 'citrus fruit' notes were more typical (C3.2.). This does not mean that these characteristics are not important in Provence Rosé wines, but aromatic characteristics dominate. Finally, it seems that two other sensory properties ('alcohol' and 'balance') could play a role in the exemplarity score even if these were not significant in the PLS. Products in group C3.2 had a higher 'alcoholic' sensation while in group C2.3, LAN4 and PRO2 were perceived as more 'alcoholic' and had higher exemplarity scores than other wines in this group. On the other hand, professionals penalized 'unbalanced' wines (e.g. RHO5). The concept of 'balanced' or 'unbalanced' wine is an abstract quality little used by expert panels but frequently mentioned by professionals (Picard *et al.*, 2015 ; Valentin *et al.*, 2016). These two characteristics should be investigated further in other experiments in order to better understand how to explain 'balanced' based on trained panel evaluation as well as the role of 'alcoholic' perception in Provence Rosé wine exemplarity.

Before discussing the impact of color on Provence Rosé wine typicality, it should be noted that even using dark glass there was a significant correlation between color parameters and typicality. Provence Rosé wines are characterized by their light color (Flanzy *et al.*, 2009). Color analysis (CIELAB) revealed that the clearest wines were more typical whereas the reddest wines, i.e. with a high 'a' value (e.g. RHO1, BDX4 or RHO6), were the least typical. The color of Rosé wines is impacted by the date of harvest and the duration of the skin contact (Flanzy *et al.*, 2009 ; Institut Technique de la Vigne et du Vin, 2006). In Provence, wines can be less colored due to i) the type of variety used : local varieties like Tibouren and Cinsault have less anthocyanins in their skin than other varieties, ii) the early date of harvesting during fresh conditions at nights and iii) the duration and temperature of the skin contact, lower in the Provence area (Flanzy *et al.*, 2009). This enological process leads to a specific color that also impacts the aromatic characteristics due to a different volatile composition (Callejón *et al.*, 2012). The same authors highlighted the highest concentration of β-damascenone for the highest skin contact duration while Lukić *et al.* (2017) observed the lowest concentration using cold-pre-fermentation but no results are available specifically for Rosé wines. β-Mercaptohexanol and 3-mercaptohexyl acetate, revealing 'citrus' notes, are mainly produced by yeast metabolism (Swiegers *et al.*, 2007). Producers of Provence Rosé wines use cold temperatures before alcoholic fermentation to minimize oxidation and color extraction. In this way, there is a relationship between the odor and aromatic characteristics and the color obtained. Further scientific studies are needed to characterize the specificities of each area concerning the enological processes.

In relation to this result, the color of the wines clearly modified the perception of exemplarity when they were poured into transparent glasses. The color is an important part of Provence Rosé wine typicality, which increases following the decrease in luminance and in 'a' and 'b' color parameters. The significant increase in agreement among judges when wines were presented in clear glass shows how determinant this parameter is for Provence wine producers. Professionals from the Provence area agree that clear and more orange wines are more typical than darker and redder wines.

It has to be said that, for practical reasons, the methodology used was not totally satisfactory to underline this point. There was a high dependence between the two typicality scores since they were recorded one after the other by just changing the glass. To better estimate the contribution of color to the perceived typicality of Rosé wines, another experiment is proposed for the next study. It would be based on the methodology used by Valentin *et al.* (2016), who asked tasters to evaluate independently a set of wines served with different codes in both types of glass. Moreover, due to the observed correlation between aromatic and color characteristics, it would also be pertinent to use food colorant to change the color of wines and to make color and aromatic characteristics independent.

Finally, in such studies of PDO typicality, the selection of wines is determinant. Which wines are compared to answer which questions? As in Cadot *et al.* (2010) and Perrin and Pagès (2009), it would have been possible to focus on a selection of wines closer from a sensory point of view. In the present experiment, it was decided to select wines from the six main Rosé areas in order to represent better the diversity of sensory characteristics present on the French market. This gave access to how wine professionals from the same specific area define the main characteristics of their wines compared to others. The focus here was on the perception of Provence Rosé wine exemplarity by Provence wine professionals. The same experiment could be done with tasters from outside the area to identify if wine professionals from other areas in France share the same vision of Provence sensory characteristics. In addition, the same methodology could be used to ask professionals from other areas to evaluate the typicality of their area and, in this way, identify and communicate better about the different profiles of Rosé wines throughout France.

Further studies are also required to characterize the sensory properties of the wines. Characterization of wine typicality will include volatile composition considering Odor Activity Values that take into account odor and aroma sensory thresholds as suggested by Sáenz-Navajas *et al.* (2015).

Finally, it would be interesting to focus within a specific area and consequently identify the "terroir" specificity within the areas. The sensory results of the present study show some nuances among the seven Rosé wines selected as representative of the area's diversity. However, for example this area is composed of sub-appellations (e.g. Lalonde, Sainte Victoire PDO). The same methodology carried out with wines and professionals from each sub-area would reveal if wines from specific areas have common and specific characteristics linked to "terroir" factors such as soil, climate, vine development, grape composition and enological practices. Like family members, they may have similar traits because they are from the same area, but they could be differentiated by some elements if professionals from a specific subarea share a common sensory definition of their wines due to "terroir" factors (soil, climate, etc.) or human factors.

Conclusion

This work is the first study of Rosé wine typicality on a national scale, focusing on the typicality of one of the most productive areas: the Provence area. The main objective was to see whether the exemplarity of Provence Rosé wines could be explained by criteria other than color. The results confirm that Provence Rosé wine typicality is based on color because the clearest wines are the most typical. Nevertheless, color is not the only factor; odors and aromas are also involved in the typicality of Provence Rosé wines. Wine professionals from Provence agreed on 'citrus fruit', 'exotic fruit' and 'fresh floral' odors and aromas being typical attributes sought in Provence

Rosé wines. Beyond this overall result, there is no single sensory profile of typical Provence Rosé wines. The more typical wines are included in different clusters of the HAC performed on sensory attribute scores. This means that variability in the sensory profiles is observed within the areas with some common characteristics that distinguish Provence Rosé wines from other French Rosé wines.

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