Chapter 13

Novel Memory-Based Sensory Approach to Assess Large-Scale Typicality: The Case of Mainland Portugal Red Wines

Anibal Jose-Coutinho, Patricia Avila and
Jorge M. Ricardo-da-Silva

Additional information is available at the end of the chapter

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Abstract

Twenty professional wine experts were asked to describe their prototypical construct of a representative young red wine from each of the 12 Protected Geographical Indications (PGI) of mainland Portugal. No samples were assessed; the experiment was based on memory alone by completion of 12 extended self-reported sensory questionnaires. Four large-scale areas were differentiated, the typicality being statistically validated and described from a sensory standpoint. Alcohol, acidity, bitterness, and astringency were cross-linked; the respective variations were correlated with published literature and expressed as key factors for the regional macroscale area differentiation. Bitterness and astringency were found to be sensory different and related on a geographical scale, as bitterness was primarily affected by inland/coastal influence; while astringency confirmed its customary north/south dependence that finding is to be considered a new understanding. Moreover, with the proposed methodology, it was possible to achieve a novel nationwide sensory characterization of PGIs, overcoming present day limitations on macroscale sensory research and sample representativeness. Results by uncalibrated prototypical memory assessment of single PGI Beira Atlântico were compared with the outcome of calibrated wine sampling assessment by local experts, using the same sensory questionnaire, and were found significantly correlated. The need for a calibration stage was found uneven regarding the overall group of scrutinized wine descriptors.

Keywords: red wine, sensory, typicality, astringency, bitterness

1. Introduction

The geographical origin of wine as well as its price has a strong impact on consumers. Wine is a product in which the concept of typicality is prevalent, especially in Europe [1]. Protected geographical indications (PGI) and protected designation of origin (PDO) products are the base of European artisan production, maintaining sensory characteristics, assuring consumer confidence, and preserving market position [2].

A large number of sensory methodologies are based on the use of professional tasters to show the sensory properties of a wine category (wine variety or PDO). Scientists have tested different sensory approaches, but the perceptual sample-tasting methods may be considered the most commonly used. These approaches work correctly, if the samples are grouped in well-separated regions; however, in more complex distributions, their classification power becomes poor [3]. Concerns regarding the scarcity and representation of samples that are assessed have always undermined typicality research. A recent study stated that a sample-tasting panel did not discriminate among the wines for astringency and bitterness, probably because the samples were inexpensive wines with very similar phenolic contents [4].

The role of expertise, as well as the importance of experience and long-term memory (LTM) for extraordinary performance, is widely documented. Wine professionals (wine-makers, wine journalists, etc.) are often nonavailable for testing [5]; hence, our experts were not formally trained, as usually done in quantitative descriptive analysis (DA). Due to their high level of long-term professional expertise, we hypothesized that the abstraction of sensory prototypes is memorized and could be considered as a synthesis of all previous wine tasting experiences from the category. Descriptions stored in LTM can be used to generate images of objects and scenes [6]. Recognition of meaningful stimuli such as words or objects rapidly activates conceptual information and leads to the retrieval of additional relevant information from LTM [7]. Neuroscience research stated that new information can come from different sources, including sensory stimuli (SS) or LTM; however, no (brain) regions were found to be more active during updating from SS than updating from LTM [8]. In the case of sensory analysis, flavor may be processed by tasters as a psychological construct, the data being more consistent with a perceptual/cognitive process rather than a consequence of rating strategies [9].

Our nationwide study, a novel macroscale approach on wine sensory typicality, was built on the case that senior experts have common mental representations of typical wines from each PGI, resulting in a feasible assessment of predetermined attributes and respective lexicon [10] which can be used to describe the sensory characteristics of a typical exemplar of the category or prototype. Clear agreement between experts concerning typicality scores [11] and existence of shared cognitive constructs of typicality [12] has been demonstrated. The literature does not always clearly delineate what constitutes training and what is experience. Experience relates to a familiarity with a product class resulting from long-term exposure to a wide variety of members representing that class [13]. Qualitative methods can be used to enhance quantitative studies, and with time, labor or financial limitations, may be considered a valid substitute for quantitative methods with heavy training/calibration requirements. Sensory methods are constantly evolving, becoming simpler, faster, and highly reviewed [14–20]. If neuroscience and sensory science results suggest that expertise may be more a cognitive skill rather than a

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perceptual one, and if all of the perceptually based techniques have a persistent low wine sampling hazard due to the logistical and/or time-consuming factors, then why are conceptual techniques, based on the long-term memory from professional wine experts and *keepers of memory* [1], not accepted as a sensory methodology?

Currently, there are 12 Protected Geographical Wine Indications (PGI) in mainland Portugal (**Figure 1**). For such a small country, does the actual range of 12 PGI's offer 12 single and

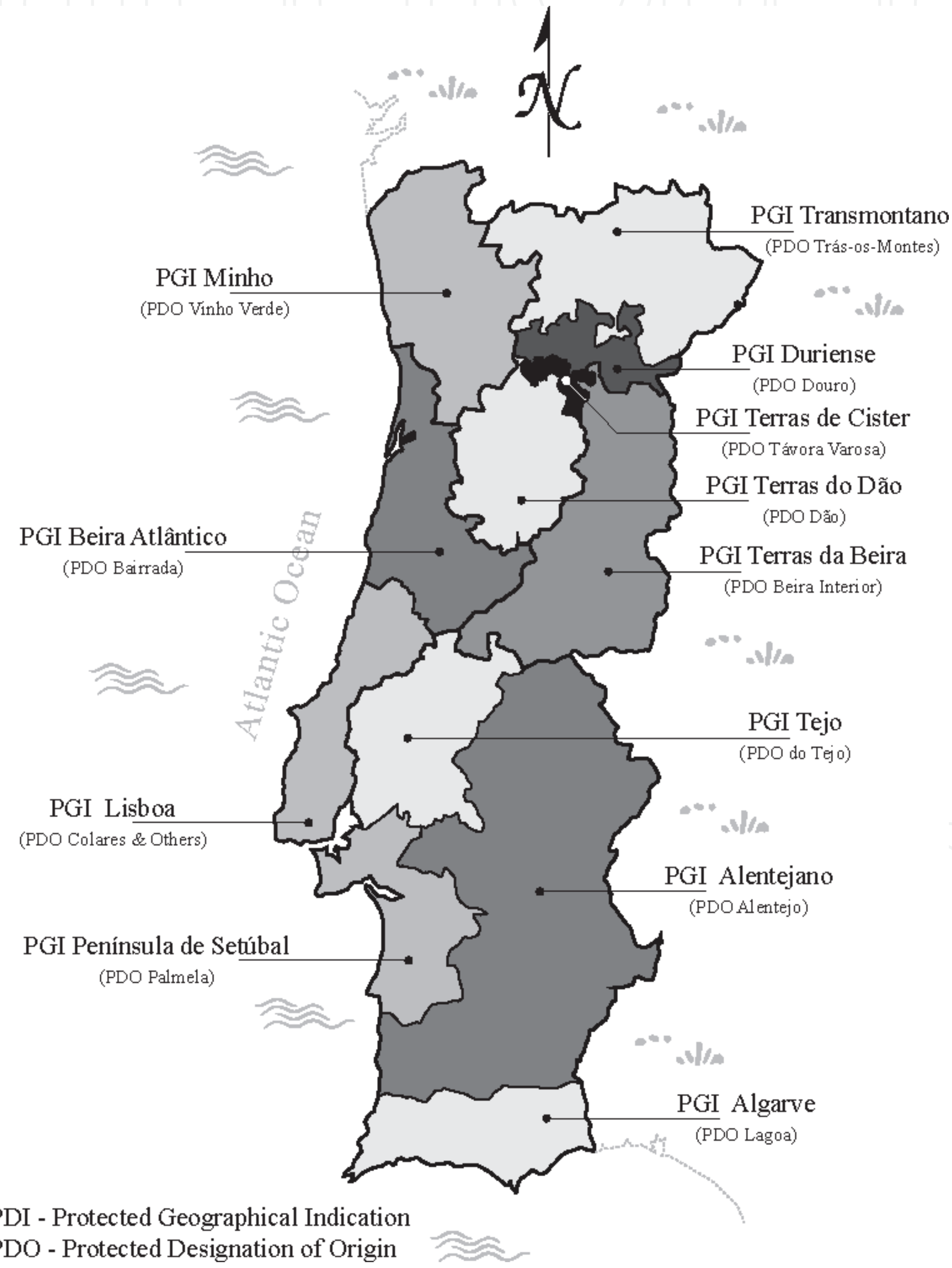

Figure 1. Protected geographical indications (and respective inner protected designations of origin) in mainland Portugal.

typical wine sensory profiles, so different from one another that typicality governs consumers on their purchasing decisions?

This study builds on the suggestion, which is commonly expressed in Portuguese and Anglophone wine press, that typicality assessment of PGI-certified still red wines of mainland Portugal does not match 12 exclusive sensory profiles, 1 for each Geographical Indication [21]. The supporting evidence of typicality similitude among certain PGIs can be found in bioclimatic [22–24] and biogeographical zoning studies [25]. Moreover, the phenolic composition [26, 27] and aroma [28] exhibited zonal differences.

Following our recently published white wine nationwide study [29], encompassing a novel memory-based DA, each member of our panel of professional experts was asked to mentally retrieve and assess his prototypical sensory profile of each of the 12 mainland Portugal PGI-certified young red wines. To our knowledge, this is the first macroscale sensory study covering a whole wine-producing country.

Finally, the outcome of our sample-free and uncalibrated DA methodology was compared with the results of a classic sampling DA single PGI study [30] assessed by a calibrated panel of PGI Beira Atlântico local experts, both studies sharing the same sensory questionnaire.

2. Materials and methods

2.1. Subjects

When compared with previous studies [31], rigorous selection criteria were applied, as the definition of a wine expert considered the following categories:

- Renowned wine-makers with tasting activity of >4 times per week in more than one Portuguese wine region;
- Oenology researchers and scholars who were regularly involved in wine-making and/or wine evaluation;
- Wine professionals (e.g., *Master of Wine*, wine judges, wine writers, wine buyers);
- Wine experts with an extensive (more than 15 years) history of wine involvement.

As this method is mostly dependent on indisputable knowledge brought by well-known senior Portuguese professionals, graduate wine students, wine consumers and enthusiasts, even with a long-term wine involvement, were not eligible for group of wine experts. The sensory raw data of this work was generated by 20 renowned wine-makers, referenced scholars and professional opinion leaders, wine buyers, and distributors from the Portuguese wine industry. Recent literature showed that the number of panelists is well above average to ensure a statistically robust outcome [4].

2.2. Questionnaire

The questionnaire was designed according to the classical three-tier sensory method of assessment: visual, aromatic, and gustatory/tactile descriptors (full questionnaire in supporting information). With the exception of hue, the questionnaire used an 11-integer point rating scale. On the left was written: "no trace of the attribute" (score 0) and on the right was written: "extreme intensity of the attribute" (score 10).

The color was assessed in its intensity and hue. Results from this last descriptor were standardized to match the same scale because the previously reported research justified the use of a 4-integer point scale with 1—Violet-Purple, 2—Purple-Ruby, 3—Ruby-Garnet, and 4—Garnet-Brick [32]. The aroma was evaluated with 1 overall intensity measure and 18 aromatic categories that summarize a significant amount of scientific research [33], much of which has already been used in the form of aroma wheels [34]. The taste of red wines was evaluated using 14 measures, including essential tastes (sour, sweet, salty, and bitter), mouthfeel categories resulting from the various types of astringency [35], prickling, weight, persistence, and mouthcoat sensation [10].

2.3. Procedure

Respondents were invited and briefed by the same experimenter. They received oral instructions on how to fill the questionnaire. The experts were told to quantify their prototypical memory activated by the following question: "How would you sensory assess a typical young commercial red wine (released during the first year following harvest) from this particular PGI?" Despite some reasonable doubts on similar cognitive construct within the panel, no training phase or leveling pre-stage was performed. No wine samples were assessed. All experts independently completed individual self-reported questionnaires by scoring several sensory attributes that characterized their own expert construct for what is a typical PGI young red wine of each of the 12 Portuguese wine regions.

2.4. Statistical data analysis

Descriptive statistics (central tendency and dispersion) were computed for each sensory attribute, using IBM SPSS Statistics 20.0. Using the same software, bivariate statistics such as one-way ANOVA were performed in order to analyze the relation between the sensory attributes and 12 PGIs. Moreover, this tool reveals whether or not significant differences are found and also the strength of the association. This was followed by the completion of principal components analysis (PCA) with a Varimax rotation which sought to explore the possibility of reducing the initial amount of sensory variables into fewer dimensions—the principal components (PC). PCA of sensory data permitted the differentiation among geographic areas [28]. The number of retained components was based on the Kaiser criterion—according to which the components with an eigenvalue greater than or equal to 1 are retained—and occasionally, the next principal component was also retained. Latent variables encompassing different initial variables found to be highly correlated on each PC were estimated, named accordingly, and new descriptive statistics (mean and standard deviation) were computed on the basis of such aggregate variables (three initial variables were kept isolated: color intensity, color tonality (hue), and aromatic intensity).

Given that the central hypothesis of this study anchored on similarity of several PGIs typical wine sensory profiles, global research of this proximity was assessed by hierarchical cluster analysis (HCA), which is an exploratory data analysis tool that aims at sorting different objects (the 12 PGIs) into groups in a way that the similarity between two objects is maximal if they belong to the same group and minimal otherwise. The squared Euclidean distance was used as measure of proximity, and the complete linkage method algorithm was applied to group the PGIs. Raw data from the above-mentioned three initial sensory variables excluded from the PCA, as well the means of the latent sensory variables that emerged from the PCA outcome, were lined up as the HCA input.

3. Results and discussion

Twelve Protected Geographical Indications, memory assessed by the typicality of their respective young commercial red wines, were sensory validated, since all PGIs showed differences with significant statistical meaning (at least in 1 attribute) which was verified by the ANOVA method, considering one fixed factor: the Geographical Indication. Relative standard deviation, also known as coefficient of variation [36], showed a lower percentage for the majority of the sensory attributes, which indicates low variability in the data set means (**Table 1**).

3.1. Representation of aroma and taste

Except for the aromatic intensity assessment, the 18 initial aroma attributes were grouped into 5 principal components (**Table 2**) that were named according to the previously reported literature on aromatic series: **PC1 *Aredfruitwoody*, PC2 *Aripefruit*, PC3 *Agreenchemical*, PC4 *Aoverripeness* and PC5 *Aflorcitrusmineral*.**

It was possible to find an aggregate sensory measurement that explained 66.7% of the total variance. The simplification procedure that was based on the expert panel assessments may be optimal for macroscale area profiling purposes in contrast to the previously reported use of highly specific, isolated, and less obvious sensory descriptors.

The application of PCA to all tactile/textural and mouthfeel categories simplified the characterization of the taste of the PGI young red wines.

The 14 initial taste attributes were grouped into 4 principal components (**Table 3**) that were named according to the classical tastes and contributing research on mouthfeel perceptions, reported above: **PC1 *Tdryastringent*, PC2 *Tsweetviscous*, PC3 *Tbittersalty* and PC4 *Tfullpersistent*.**

We found an aggregate sensory measurement that explained 75% of the total variance, again supporting the role of the simplified procedure on the tannins tactile range of descriptors [35].

		Hue	Color intensity	Aroma intensity	(PC1) Aredfruitwoody	(PC2) Aripefruit	(PC3) Agreenchemical	(PC4) Aoverripeness	(PC5) Aflor citrusmineral	(PC1) Tdryastringent	(PC2) T sweetviscous	(PC3) T bittersalty	(PC4) T fullpersistent
Algarve	Mean	3.00	6.19	6.13	4.50	5.77	2.80	2.84	2.77	3.31	6.48	1.54	5.38
	SD	0.37	0.98	1.02	1.69	1.52	1.18	1.61	1.35	1.58	0.56	0.98	0.85
Alentejano	Mean	2.70	7.30	7.15	4.79	6.95	3.48	3.85	2.87	3.43	6.68	1.57	6.00
	SD	0.47	0.73	0.88	1.45	1.10	1.31	1.90	1.06	1.05	0.72	0.97	1.04
Beira Atlântico	Mean	2.00	5.65	5.30	4.07	3.28	4.93	3.33	3.80	5.73	3.24	3.12	5.60
	SD	0.46	1.39	1.08	1.13	1.22	1.51	1.40	1.25	1.34	0.63	1.43	0.95
Duriense	Mean	1.65	7.55	6.95	4.71	6.04	3.81	3.48	4.77	4.61	5.66	1.58	7.05
	SD	0.59	1.00	0.89	1.34	1.15	1.48	1.35	1.63	1.26	0.81	1.09	0.81
Lisboa	Mean	1.82	6.35	5.35	4.25	4.13	4.31	2.91	3.61	5.18	4.18	2.63	5.35
	SD	0.64	1.46	0.79	1.36	1.17	1.25	1.28	1.58	1.12	0.89	1.05	0.70
Minho	Mean	1.11	8.58	5.84	2.93	3.24	5.26	1.89	3.35	6.43	2.43	3.79	5.03
	SD	0.32	1.64	1.71	1.19	1.39	1.73	1.14	1.81	1.43	0.87	1.45	1.52
Península Setúbal	Mean	2.76	6.24	6.12	4.84	5.46	3.87	3.56	3.47	3.66	5.93	2.31	5.50
	SD	0.44	0.90	0.86	1.38	1.44	1.53	1.69	1.73	1.33	0.69	1.49	0.85
Tejo	Mean	2.84	6.32	6.05	4.73	5.09	3.95	2.95	3.32	4.26	5.37	1.79	5.47
	SD	0.37	0.58	0.91	1.35	0.92	1.48	1.61	1.68	1.64	0.62	1.25	0.75
Terras da Beira	Mean	2.32	6.16	5.74	4.13	4.21	3.96	3.08	4.39	5.07	4.52	1.95	6.08
	SD	0.67	1.17	0.93	1.22	1.13	1.57	1.56	1.42	1.28	0.76	1.22	0.69
Terras de Cister	Mean	2.60	5.10	5.20	3.74	3.45	3.73	2.70	3.77	5.03	3.94	2.20	5.55
	SD	0.52	0.99	1.03	1.19	1.14	1.08	0.98	1.24	1.42	0.67	1.04	0.76
Terras do Dão	Mean	2.00	6.60	6.90	4.57	4.19	3.94	3.63	5.23	5.03	4.52	1.92	6.70
	SD	0.46	1.10	1.02	1.47	1.56	1.30	1.64	1.62	1.11	0.73	1.18	0.83
Transmontano	Mean	2.38	6.25	5.38	3.98	4.91	3.91	3.66	3.83	4.63	4.71	1.88	6.00
	SD	0.50	0.86	0.81	1.45	1.19	1.42	1.71	1.50	1.20	0.77	1.06	0.89
Total	Mean	2.23	6.60	6.07	4.29	4.77	4.02	3.18	3.79	4.71	4.82	2.19	5.84
	SD	0.73	1.38	1.20	1.43	1.68	1.52	1.58	1.64	1.57	1.44	1.36	1.07
	% RSD	33%	21%	20%	33%	35%	38%	50%	43%	33%	30%	62%	18%

Table 1. Mean and standard deviation of scores on all final sensory attributes by PGI, after PCA. Includes relative standard deviation.

AROMA	**Principal component (PC)**				
	PC1	**PC2**	**PC3**	**PC4**	**PC5**
Woody	**0.814**	0.054	0.085	0.151	0.111
Spicy	**0.674**	0.02	0.236	0.154	0.206
Red fruit	**0.644**	0.139	0.088	−0.253	0.346
Bread and pastry	**0.595**	0.185	0.012	0.426	0.04
Caramelized	**0.492**	0.442	0.083	0.433	−0.219
Black fruit	0.058	**0.846**	−0.131	−0.14	0.249
Stone fruit	−0.027	**0.809**	0.054	0.167	0.048
Dried fruit	0.251	**0.717**	−0.092	0.351	−0.23
Jam and jelly fruit	0.513	**0.65**	−0.2	0.203	−0.086
Chemical	−0.036	0.064	**0.757**	−0.026	−0.095
Vegetable	0.292	−0.192	**0.742**	−0.157	0.177
Animal	−0.012	−0.024	**0.733**	0.307	0.109
Herbal	0.231	−0.16	**0.709**	0.094	0.243
Dry flowers	0.157	0.058	0.189	**0.763**	0.234
Nut fruit	0.118	0.206	−0.009	**0.691**	0.216
Floral	0.304	0.046	−0.079	0.077	**0.784**
Mineral	0.11	−0.091	0.218	0.208	**0.697**
Citrus fruit	−0.001	0.177	0.381	0.29	**0.574**
Variance explained (cumulative)	**15.2 (15.2)**	**15.1 (30.3)**	**14.1 (44.5)**	**11.2 (55.6)**	**11.1 (66.7)**

Major loadings on each PC are highlighted in bold.

Table 2. Loadings of 18 aromatic attributes in the first 5 principal components named PC1 *Aredfruitwoody*, PC2 *Aripefruit*, PC3 *Agreenchemical*, PC4 *Aoverripeness* and PC5 *Aflorcitrusmineral*.

Wine phenolic compounds may either taste astringent, bitter or both [37]. Furthermore, mutual suppression is a fundamental property among all tastes. However, this does not occur with astringency [38] because this tactile sensation plays a strong role as a key sensory profiler. Despite the close relationship between bitterness and astringent [39], our panel of professional experts placed major factor loadings for each one in different principal components, hence endorsing the greater sensitivity and lingual acuity of our super tasters [40]. Although the significant grouping of the originally segmented terms may lead to doubt about their usefulness for providing quality data regarding the astringency of the wines [35], our results suggest that the variation in the PC1 *Tdryastringent* that was elicited by the red wines can be differentiated and rated.

3.2. Sensory differentiation

Multivariate statistical methods showed that evidence of sensory aggregations between PGIs and extended geographical clusters or macroscale areas with similar sensory profile was

Taste	Principal component (PC)			
	PC1	PC2	PC3	PC4
Grain (Mouthfeel)	**0.879**	−0.073	0.071	0.122
Rough (Mouthfeel)	**0.862**	−0.216	0.154	0.075
Astringent (Global)	**0.812**	−0.341	0.186	0.165
Dry (Mouthfeel)	**0.787**	−0.045	0.247	−0.186
Sweet	−0.071	**0.886**	0.071	−0.092
Alcohol	−0.299	**0.799**	−0.113	0.168
Smooth (Mouthfeel)	−0.163	**0.787**	−0.045	0.206
Oily (Mouthcoat)	0.044	**0.622**	−0.166	0.583
Acid (Sour)	0.492	−**0.621**	0.363	0.187
Salty	0.084	0.025	**0.864**	0.009
Bitter	0.393	−0.011	**0.715**	0.053
Bubbly	0.167	−0.395	**0.572**	−0.209
Length	0.188	−0.107	0.077	**0.862**
Full body	−0.078	0.466	−0.1	**0.714**
Variance explained (cumulative)	**24.2 (24.2)**	**24.1 (48.3)**	**13.6 (61.9)**	**13.1 (75.0)**

Major loadings on each PC are highlighted in bold.

Table 3. Loadings of 14 tactile/textural and mouthfeel descriptors in the first 4 principal components named PC1 *Tdryastringent*, PC2 *Tsweetviscous*, PC3 *Tbittersalty* and PC4 *Tfullpersistent*.

proposed. The experts' typicality construct for the PGI red wines from mainland Portugal led to a sensory aggregation around four clusters (**Figures 2** and **3**) that were named according to their respective geography and a combination of geomorphological and bioclimatic characteristics [22]:

- **Cluster #1: SOUTHERN** (PGI Pen. Setubal (PS) + PGI Tejo (T) + PGI Alentejano (AL) + PGI Algarve (AG))
- **Cluster #2: CENTRAL VALLEYS** (PGI Duriense (D) + PGI Terras do Dão (TD))
- **Cluster #3: CENTRAL COAST and PERIPHERAL VALLEYS** (PGI Beira Atlântico (BA) + PGI Lisboa (L)) and (PGI Terras Beira (TB) + PGI Transmontano (TM) + PGI Terras Cister (TC))
- **Cluster#4: (Single) PGI MINHO (M)**

Clustered groups were, finally, sensory described on the basis of mean scores comparison as the ANOVA results confirmed the statistical robustness of our design (**Table 4**). A radar chart of such means is presented, such representation being straightforward and relatively effortless to analyze (**Figure 4**).

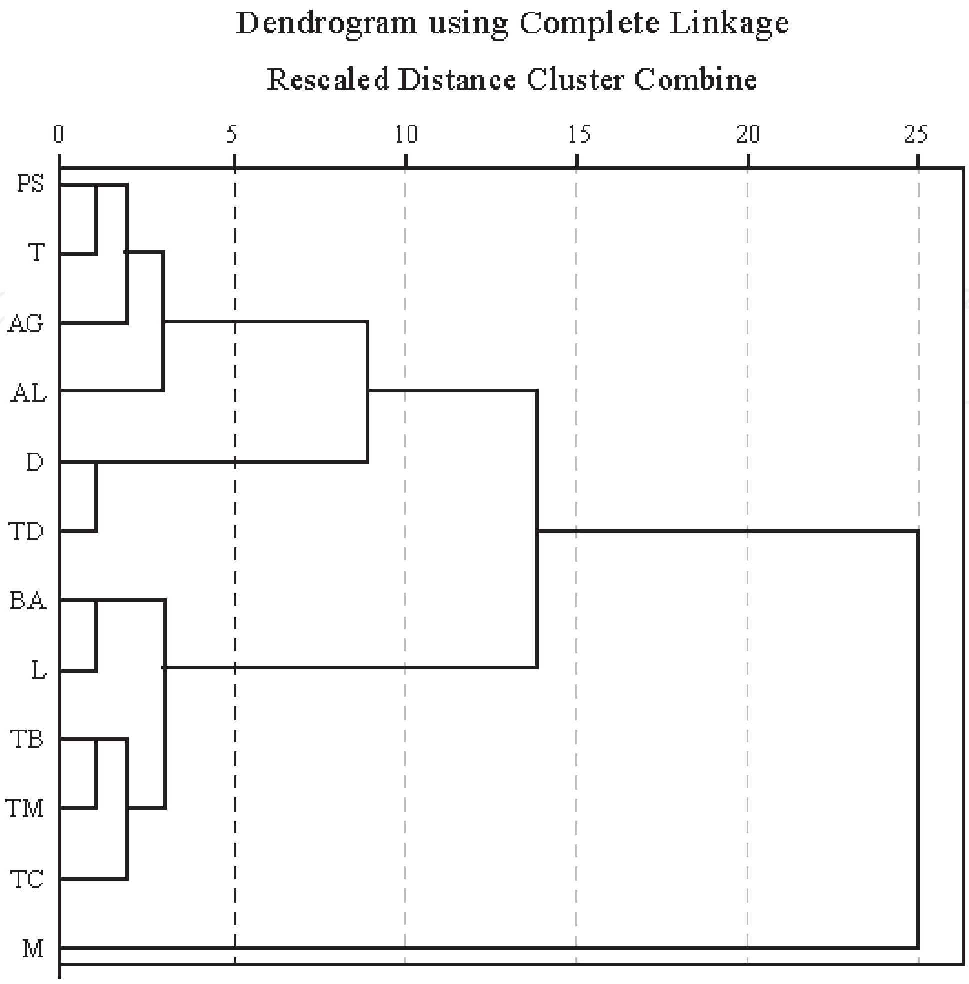

Figure 2. Dendogram showing the distance between PGIs (PS, peninsula de Setubal; T, Tejo; AG, Algarve; AL, Alentejano; D, Duriense; TD, Terras do Dão; BA, Beira Atlântico; L, Lisboa; TB, Terras da Beira; TM, Transmontano; TC, Terras de Cister; M, Minho).

3.3. Typical wine profiles of the new-found macroscale areas

3.3.1. Typical young red wine profile of the SOUTHERN macroscale area

The final sensory attributes reveal some characteristics that sustain the fast clustering dynamics that encompass the four SOUTHERN PGIs (PGI Peninsula de Setubal, PGI Tejo, PGI Alentejano and PGI Algarve), thus enabling the creation of a typical sensory profile for this macroscale area (**Figure 4**). In agreement with our results, similar geoviticultural (temperate hot climate, temperate warm nights and a moderately strong drought) and sensory analysis (high alcohol content and intense aromatic ripe fruity wines) groupings were reported for these same four PGIs [41].

The color hue got the highest assessment (**Table 4** and **Figure 4**), indicating a Ruby-Garnet hue, and color intensity rated second lowest. Temperatures of 30°C and higher might lead to lower anthocyanin synthesis [42]. Lower acidity levels are usually correlated with higher grape pH, although the relation is affected by potassium accumulation, which is itself temperature dependent. At a higher pH, the chalcone form (slightly yellow) increases progressively over

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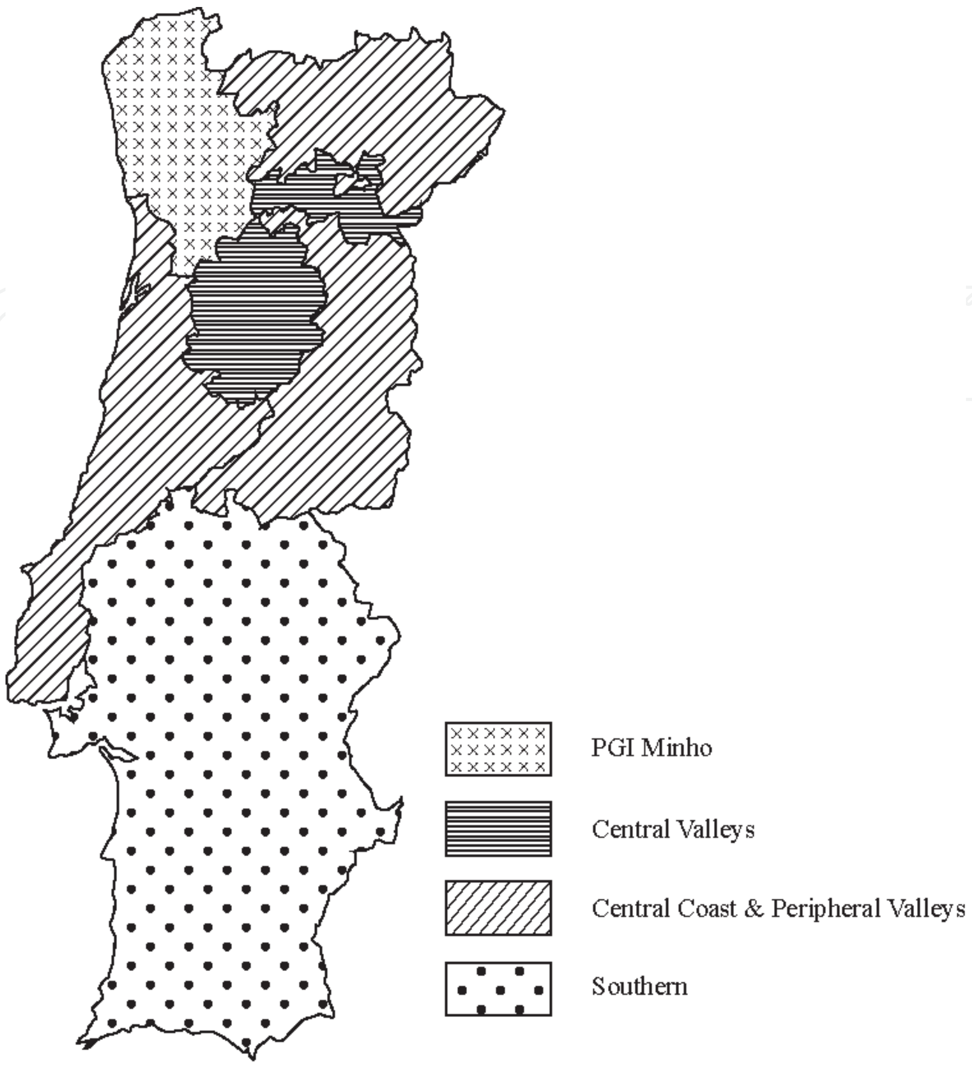

Figure 3. Four large-scale clusters in mainland Portugal originated from experimental design on sensory typicality.

the hemiketal (colorless), the quinoidal (blue) and the flavylium cation (red) anthocyanin structures [43, 44]. One study showed that raisining decreased the lightness and increased the color saturation and hue [45]. These findings may explain the ruby-garnet dominant hue and the low color intensity of typical young red wines from the SOUTHERN macroscale area.

For the aroma, the lowest assessments were given to PC3 *Agreenchemical* and PC5 *Aflorcitrusmineral*. Inversely, PC1 *Aredfruitwoody* and PC2 *Aripefruit* received higher scores (**Table 4** and **Figure 4**). Published results indicate that a masking effect of vegetative aromas by fruit aromas may occur [46].

The aroma profile showed an intense raisiny and jammy character with dominant black and stone fruit; however, the experts noted that the aromas were also woody, spicy, and of young yeasty red fruits. Red wine fruitiness may correlate directly with the ethanol enhancement because studies on red wine aroma have confirmed that when ethanol is enhanced, the intensity of the fruity odor increases [47]. Additionally, the existence of inodorous constituents in red grape skins, which are extractible by ethanol and transformed by yeasts, produced a

Final clustered zonings vs. final sensory attributes		Hue*	Color intensity	Aroma intensity	(PC1) Aredfruitwoody	(PC2) Aripefruit	(PC3) Agreenchemical	(PC4) Aoverripeness	(PC5) Aflor citrusmineral	(PC1) Tdryastringent	(PC2) Tsweetviscous	(PC3) Tbittersalty	(PC4) Tfullpersistent
Southern	Mean	**6.09**	6.51	6.36	**4.71**	**5.82**	*3.52*	3.30	*3.11*	*3.67*	**6.11**	1.80	5.59
CENTRAL VALLEYS	Mean	2.75	7.08	**6.93**	4.64	5.11	3.88	**3.55**	**5.00**	4.82	5.09	*1.75*	**6.88**
Central coast and peripheral valleys	Mean	4.08	*5.90*	*5.39*	4.03	3.99	4.17	3.13	3.88	5.12	4.12	2.35	5.72
PGI MINHO	Mean	*0.35*	**8.58**	5.84	*2.93*	*3.24*	**5.26**	*1.89*	3.35	**6.43**	*2.43*	**3.79**	*5.03*
Univariate ANOVA results (By Attribute)	Sigma	0.001	0.010	0.003	0.000	0.031	0.049	0.047	0.001	0.001	0.002	0.016	0.002
	Eta Squared	0.806	0.641	0.730	0.910	0.518	0.459	0.466	0.810	0.818	0.770	0.599	0.754

*Hue was standardized to encompass the 0–10 points integer scale.
Minimal scores in italic; maximal scores in bold.
Summary of ANOVA results.

Table 4. Mean scores of final sensory attributes regarding the four clustered zonings of mainland Portugal.

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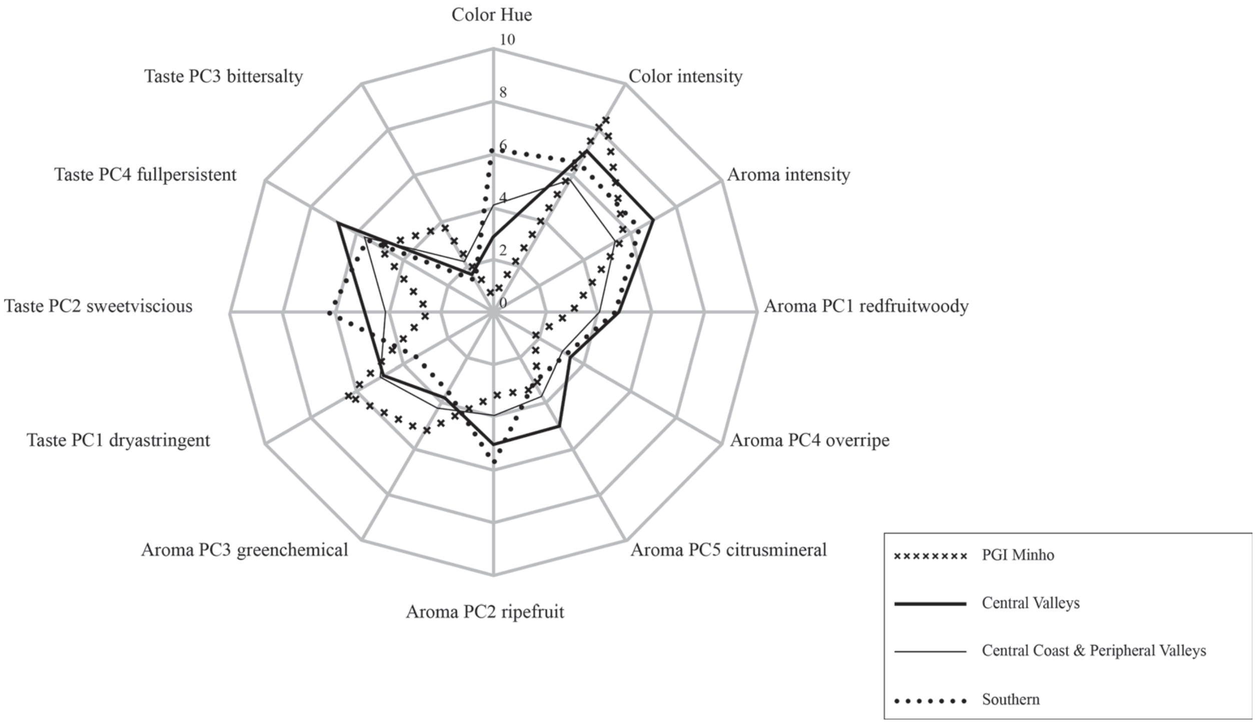

Figure 4. Radar chart of the red wine sensory aggregate attribute means per immediate cluster.

specific aroma of red-berry and black-berry fruit in the finished wines [48]. The SOUTHERN macroscale area ranked second on the aromatic intensity scale and received the lowest scores for mineral, floral, and citrus fruit. Chemical and vegetable notes were almost nonexistent.

For the taste, the lowest assessment was given to PC1 *Tdryastringent*, and the highest assessment was given to PC2 *Tsweetviscous* (**Table 4** and **Figure 4**). The taste characterization demonstrated a clear typicality for the sweet and oily intensive textures, which are higher alcohol-driven tactile sensations, with a weakness in the fresh acidic taste and tannin smoothness. Lower levels of dry, astringent, rough, and grain tannin-related mouthfeels are frequent in these medium-bodied immediate southern red wines. An oily viscosity enhancement results in a smoother palate texture [49] and reduces the astringency [38]. Wines with high levels of polysaccharides tend to decrease the impact of the bitterness and astringency [50]. The phenolic composition may be due to macroscale area differentiation because the amount of epigallocatechin (EGC) was negatively correlated with the perceived astringency [51] and could decrease the coarse perception [52]. PC2 *Tsweetviscous* encompassed alcohol, sweet taste, smooth mouthfeel, and oily mouthcoat sensations as positively correlated; however, other published results indicate that ethanol and glycerol do not significantly contribute to viscous mouthfeel [53].

3.3.2. Typical young red wine profile of the CENTRAL VALLEYS macroscale area

A portion of inner center-northern Portugal was sensory-zoned. PGI Terras do Dão and PGI Terras do Douro were immediately clustered and named CENTRAL VALLEYS because of their centered geography on the mountainous continental plateau (**Figure 4**).

The CENTRAL VALLEYS macroscale area was presented as an immediate clustering output. According to the cluster analysis method and based on the related isolated and aggregate means, the sensory profile has the following characterization:

The color got the second lowest assessment for its hue, indicating a Purple-Ruby hue, and the second highest assessment was for *C Intensity* (**Table 4** and **Figure 4**). These results are characteristic of fresh/cool continental regions with extreme thermal amplitudes, and this explains the high-color intensities [54].

For the aroma, there was a strong typicality with the three highest assessments for *Aintensity, Aoverripeness*, and *Aflorcitrusmineral* (**Table 4** and **Figure 4**). The red wine aromatic intensity (*Aintensity*) was the highest for the CENTRAL VALLEYS macroscale area. Additionally, the floral and citrus fruit notes (PC5 *Aflorcitrusmineral*) may be related to the *Touriga Nacional* cultivar (representative of PGI Terras do Dão and PGI Duriense) because they exhibited maximum scores [55]. The highest mineral assessment [56] and the exhibited essence of dried fruits and flowers from PC4 *Aoverripeness* are attributes that may result from the heterogeneous mountain that is known to have significant gaps in altitude and semi-arid locations, especially near the Spanish border [23]. This may explain the observed proximity with the Southern regions, as shown in the clustering dendogram (**Figure 2**).

For the taste, the lowest assessment was for PC3 *Tbittersalty,* and the highest assessment was for PC4 *Tfullpersistent* (**Table 4** and **Figure 4**). The taste characterization exhibited a clear typicality based on the extremely long persistence, which relates with the highest assessment of fullness. This feature may relate to a higher phenolic content of such high density wines which has shown to enhance flavors and mouthfeel persistence [57, 58]. Both the main yeast polysaccharides (mannoproteins) and the principal grape polysaccharides (arabinogalactan-proteins and rhamnogalacturonans) increase the perception of body [52]. The evaluation of wine finish duration by trained panelists indicated the finish of the high ethanol wines lasted longer than the ones with low ethanol [59]. Similar to the Southern reds, wines from the CENTRAL VALLEYS exhibited the lowest salty, bitter, and bubbly sensation levels, suggesting the partial proximity. The bitterness intensities elicited by ethanol-sugar mixtures are lower than those elicited by unmixed ethanol solutions [60], these findings in perfect alignment with our results.

3.3.3. Typical young red wine profile of the CENTRAL COAST and PERIPHERAL VALLEYS macroscale area

For the remaining continental PGIs, which are listed under the PERIPHERAL VALLEYS cluster, they were sensory assessed as similar to the CENTRAL COAST PGIs, and the data were combined (**Figure 3**). Interestingly, the late PGI Beiras, which encompass the administrative merging of coastal and inner wine regions (PGI Terras da Beira (TB), PGI Terras de Cister (TC), and PGI Beira Atlântico (BA)), was officially extinct after the harvest of 2011.

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The hue of the red wines was rated from Purple/Ruby to Ruby/Garnet halfway between typical fresh and warm region hues. Indeed, this peripheral setting includes a vast macroscale area border that may explain the wider values observed in our results. The color intensity received the lowest score (**Table 4** and **Figure 4**).

The aromatic intensity of PERIPHERAL VALLEYS and CENTRAL COAST red wines was the lowest among all of the macroscale areas (**Table 4** and **Figure 4**), which is another difference with the neighboring Central Valleys and is a similarity with the Northern-coastal PGI Minho.

The taste characterization showed long mouthfeel persistence, and it ranked second highest for the assessment of full bodied taste, a feature that is similar to the neighboring Central Valleys. The levels of salty, bitter, and tactile bubbly were slightly increased, suggesting a similarity with the Northern-coastal PGI Minho and some typicality in the acidic-fresh sensory profile (**Table 4** and **Figure 4**).

3.3.4. Typical young red wine profile of the single-clustered PGI MINHO

The northern-coastal PGI MINHO is a wine region, where the world-renowned PDO Vinho Verde is located. This region presented the highest primary typicality assessments according to the stand-alone cluster analysis results (**Figure 2**). This result was strongly supported by 10 of the 12 analyzed attributes that had extreme scores (**Table 4** and **Figure 4**). Similar observations were previously reported by other authors [41], which were based on their geoviticultural multicriteria climatic classification system [61]. The sensory attributes revealed characteristics that allowed clustering dynamics and helped establish a typical sensory profile:

For the color, the highest assessment was for *C Intensity,* and the lowest assessment was for *C Hue*, indicating a Violet-Purple hue. The high intensity is related to the inky local red cultivar, *Vinhão*, which has been shown to have anthocyanin levels that are 24 times higher than other cultivars [62]. A correlation between the anthocyanic content and the bitterness that is elicited was recently published [63]. Moreover, the lowest assessment for PC2 *Tsweetviscous* correlates with the highest acidity levels, and it thus correlates with the lowest pH, explaining the highest content of the colored anthocyanins [43]. The hue assessment that indicated a violet-purple hue is aligned with the first-year consumption of extremely young reds [32], which is typical of PGI Minho and its inner PDO Vinho Verde.

The aroma was considered to be typical as the experts scored one highest assessment for PC3 *Agreenchemical* and three lowest assessments for PC1 *Aredfruitwoody*, PC2 *Aripefruit*, and PC4 A*overripeness*.

The aromatic profile is built on several extreme assessments. The high levels of green and chemical notes and the low levels of ripe fruit may relate to the cool climate and the low ripening conditions [64]. An average intensity was found for the PGI MINHO red wines with an extremely low presence of woody, spicy, and young yeasty red fruit notes.

The taste was considered to be typical as the experts scored the highest assessment for PC1 *Tdryastringent* and PC3 *Tbittersalty* and the lowest assessment for PC2 *Tsweetviscous* and PC4 *Tfullpersistent.*

Located on the extreme northwest corner of mainland Portugal, the PGI MINHO sensory profile exhibited typical gustatory characteristics, such as the highest intensity of dryness, astringency, roughness, and grain tannin mouthfeel, which are related to the greener ripeness [26]. Polyphenols are recognized as substances that provide astringency sensation. However, other substances such as organic acids, sugars, and ethanol can also influence this sensation [65]. The fresh profile was amplified to its peak by the highest presence of salty, bitter, and bubbly sensations. The bubbly sensations were due to typical carbonic gas addition. Inversely, these red wines were assessed as light bodied with a fair persistence, low alcohol-driven tactile sensations, and reduced tannin smoothness. The lowest assessments were for sweet and oily textures. The highest assessment of astringency occurred for the low alcoholic wines [66]. The maximal rate of fresh acidic taste was found for the PC2 *Tsweetviscous*, and this is also typical of the PGI MINHO profile (**Figure 4**). Furthermore, the lack of ethanol and proanthocyanidins greatly increased the perceived acidity [67]. The combination of the effect of excess acidity and astringency was termed *Green* by a panel of experienced wine tasters [35]. Acidity reduces the perception of body [68]. The results of this study contradict the reports of enhanced bitterness by alcohol [69], although some authors suggest that alcohol may suppress the bitter taste when held in the mouth [70].

3.4. Astringency vs. bitterness: A novel macroscale orthogonal approach

The fact that four PCs—**PC1 *Tdryastringent*, PC2 *Tsweetviscous*, PC3 *Tbittersalty* and PC4 *Tfullpersistent***—explained 75% of the total variance of our experiment, justified further

Correlations

	(PC1) Tdryastringent	**(PC2) Tsweetviscous**	**(PC3) Tbittersalty**	**(PC4) Tfullpersistent**
(PC1) Tdryastringent	1	−0.957**	0.434	0.154
(PC2) Tsweetviscous	**−0.957****	1	−0.592*	−0.017
(PC3) Tbittersalty	0.434	**−0.592***	1	−0.502
(PC4) Tfullpersistent	0.154	−0.017	−0.502	1
N	12	12	12	12

*Correlation is significant at the 0.05 level.
**Correlation is significant at the 0.01 level.

Table 5. Pearson correlation matrix of four aggregate tactile attributes.

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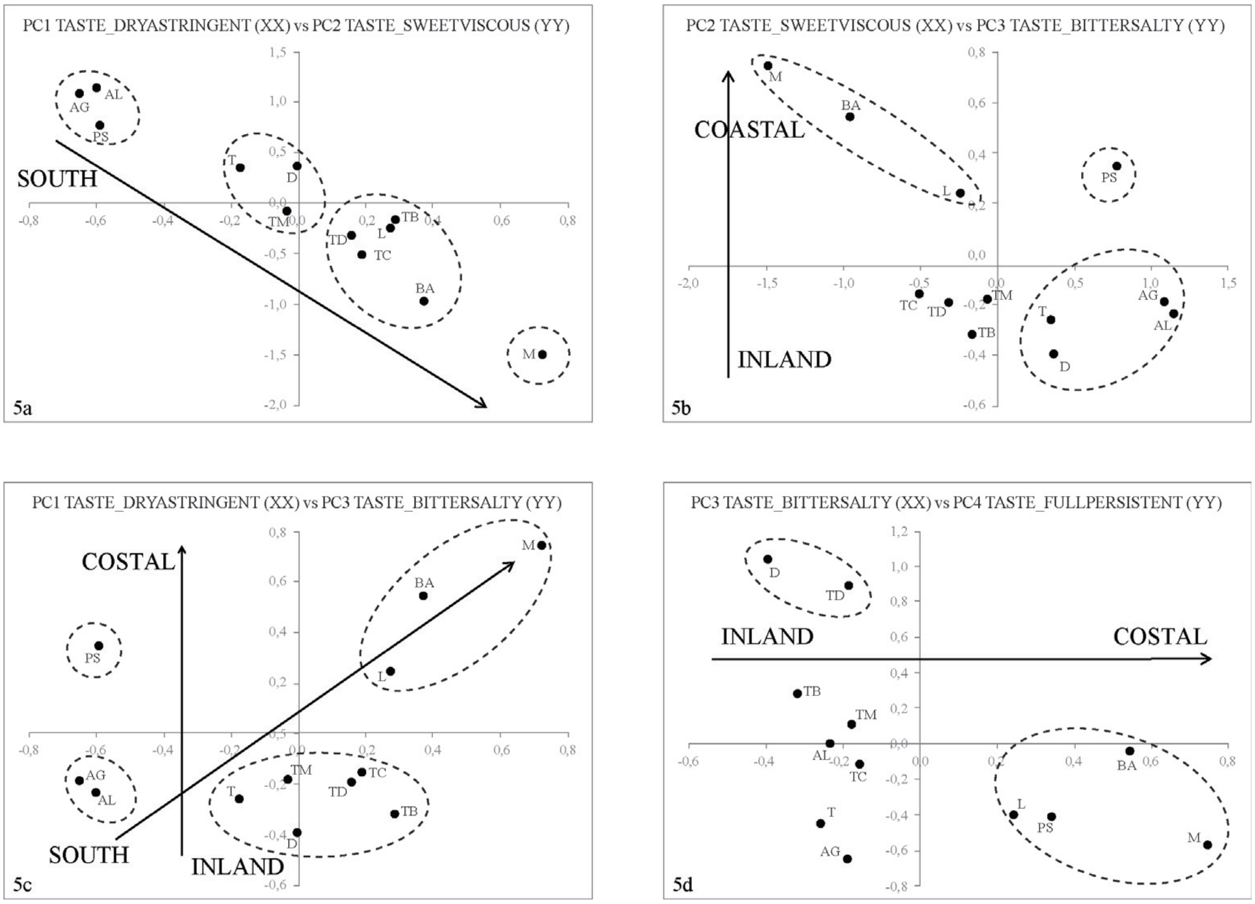

Figure 5. Standardized score bi-plots of the four aggregate tactile descriptors over 12 PGIs (PS, peninsula de Setubal; T, Tejo; AG, Algarve; AL, Alentejano; D, Duriense; TD, Terras do Dão; BA, Beira Atlântico; L, Lisboa; TB, Terras da Beira; TM, Transmontano; TC, Terras de Cister; M, Minho).

research on potential correlation with an orthogonal mapping of the leading sensory attributes of each PC, envisaging red wine PGI typicality. Pearson Correlation was computed between those four PCs (**Table 5**), and results showed expected significant correlation between PC1 and PC2.

The coefficient of −0.957 (close to maximum −1) between PC1 *Tdryastringent* and PC2 *Tsweetviscous* reflected a strong linear mapping of mainland Portugal PGIs, enabling a clear sensory profiling statement, virtually with a North-South reading, as shown in **Figure 5a**.

Astringency was assessed as drier and rougher in the north and smoother in the South. The bi-plot in **Figure 5a** also showed a clear northward decrease in alcohol content. Conversely, acidity was enhanced northward. The sensory measure PC3 *Tbittersalty* included bitterness, saltiness, and fizziness (natural or added CO_2) perceptions as its leading scores. The interpretation must be merely indicative, as the explained variance was weaker than PC1 and PC2 levels; however, those three aggregate perceptions seemed to act as key profilers for sensory differentiation, as showed in **Figure 5b** and **c**. This finding is statistically significant, the negative correlation of PC3 *Tbittersalty* with PC2 *Tsweetviscous* suggesting an inland to coastal increase in bitterness, leading to a well-defined cluster including super humid coastal PGI Minho and temperate coastal PGI Beira Atlântico and PGI Lisboa, as well as a surprising stand-alone southern coastal region (PGI Peninsula de Setubal), which was replaced, in its customary cluster, by a sweet, lowest bitter-salty, north-continental PGI Duriense (**Figure 5c**). The nationwide differentiation of astringency and bitterness introduced an orthogonal reading (N north-S south vs. E inland-W coastal, respectively) rather than a linear one, these findings add novelty to sensory research. The weakest contributing PC4 *Tfullpersistent* presented several inverse scores when compared to PC3 *bittersalty* (**Figure 5d**), and this finding, lacking statistical significance, may justify new and comprehensive studies to confirm the following orthogonal sensory mapping **PC1 (northward) – PC2 (southward) – PC3 (coastal westward) – PC4 (inland eastward)**, the geographical reading showed in **Figure 6**.

3.5. Classic sampling vs. prototypical memory

Among the scientific community, our novel, nationwide, sample-free, noncalibrated, expert memory-based method was accepted [29, 71], as it was challenged on the basis that the data relied on respondents' perceptions rather than direct experience. In this new research, we compare the results mentioned before in this study—signaled as Experiment 1 (LTM)—with the completion of the same questionnaire (Supporting Information) by 19 local experts from the single PGI Beira Atlântico—Experiment 2 (WS)—as a result of a blind tasting of 15 young red wine samples, representing the leading supermarket brands of this wine region.

3.5.1. Experiment 2

Results of the wine tasting assessment by local PGI Beira Atlântico wine experts were organized in order to fully compare with extracted results of experiment 1 regarding the same PGI (**Figure 6**). The panel is widely calibrated, as these professionals belong to the certification panel which must approve typicality and quality of all submitted PGI Beira Atlântico wines. This panel complies with an annual program of inner and inter-laboratorial calibration on aromatic thresholds, triangular tests, and tastant solutions (control standards of sucrose, NaCl, citric acid, quinine, and others).

The assessment of the same sensory questionnaire by the nationwide professional uncalibrated panel and the local professional PGI Atlântico calibrated panel showed a significant Pearson positive correlation of 0.669, this to be considered promising and a green flag for newcoming comparative studies regarding other PGIs.

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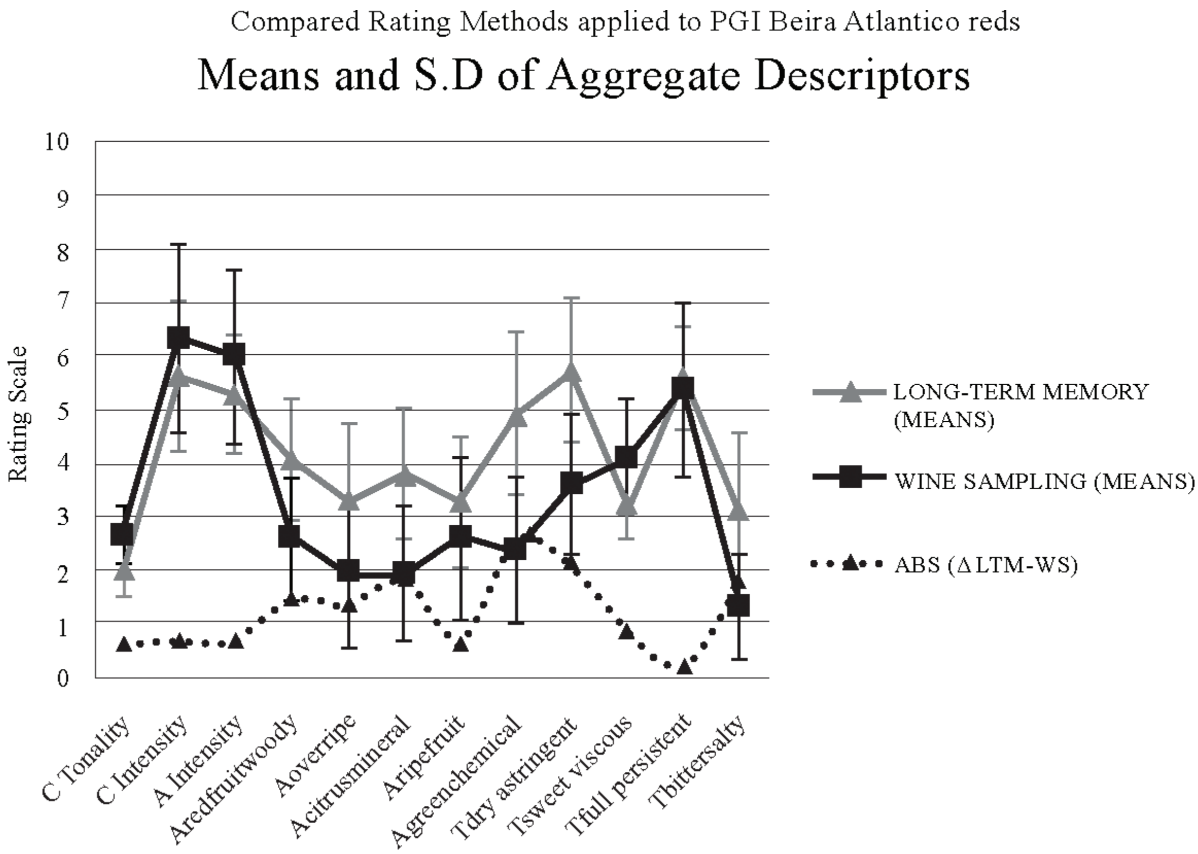

Figure 6. Mean differences between long term memory (LTM) and wine sampling (WS) methods. ABS scores represent absolute differences between both methods.

Primary	Aggregate	(PD Means)	(PD Means)	ABS ()
Descriptor (PD)	Descriptor	Long-term memory	Wine sampling	Δ (LTM-WS)
		Experiment 1	Experiment 2	
Aroma vegetable	Aroma-greenchemical	6.25	2.36	3.89
Taste grain astringency	Taste-dryastringent	5.00	2.19	2.81
Aroma herbal	Aroma-greenchemical	5.95	3.21	2.74
Aroma red fruit	Aroma-redfruitwoody	5.55	2.85	2.70
Taste acid	Taste-sweetviscous (inverted)	7.00	4.46	2.54
Aroma mineral	Aroma-citrusmineral	5.15	2.66	2.49
Taste salty	Taste-bittersalty	3.65	1.27	2.38
Taste rough astringency	Taste-dryastringent	5.60	3.24	2.36
Aroma animal	Aroma-greenchemical	4.25	1.91	2.34
Taste bitter	Taste-bittersalty	4.60	2.30	2.30

Table 6. Top 10 underperfoming primary descriptors.

Focusing on the major mean differences, results show that the local experts tend to evaluate with higher appreciation their local wines, regarding negative sensory descriptors such as *PC3 Agreenchemical* and *PC1 Tdryastringent*.

3.5.2. Uneven calibration needs

There is an ongoing line of research focusing on cost-benefit of calibration stages [72]. Our findings emphasize uneven calibration needs. In **Table 6**, we have highlighted the initial sensory descriptors which could gain accuracy with a calibration stage, such as *mineral aroma* [56], as opposed to other attributes that, according to our results, need no calibration among wine experts, hence, saving time and money [73].

4. Conclusions

In this sensory study on wine typicality, four large-scale areas were identified. PGI MINHO was found to be the most typical of all PGIs, with several extreme rates for the Color, Aroma and Taste. Encompassed by the four Mediterranean PGIs (PGI Peninsula de Setubal, PGI Tejo, PGI Alentejano and PGI Algarve), the SOUTHERN cluster presented several extreme sensory assessments that were essentially opposed to the single-clustered PGI MINHO's profile. Alcohol, acidity, bitterness and astringency were cross-linked; the respective variations were correlated with published literature and expressed as key factors for the regional macroscale differentiation. Bitterness and astringency were found to be sensory different and related on a geographical scale, as bitterness was primarily affected by inland/coastal influence, while astringency confirmed its customary north/south dependence, this finding to be considered new. Moreover, with the proposed methodology, it was possible to achieve a novel nationwide sensory characterization of PGIs, overcoming present day limitations on macroscale sensory research and sample representativeness.

Results by memory of (1 out of 12) extracted PGI Beira Atlântico were compared with the outcome of wine sampling assessment by local experts, using the same sensory questionnaire, and were found significantly correlated. Major differences between results by memory and by sampling were found mostly on unpleasant (negative-prone) sensory descriptors, the local experts showing greater sympathy for local wines. The need for a calibration stage was found uneven regarding the overall group of scrutinized wine descriptors, envisaging potential accuracy on final results only with a selective calibration phase on fewer descriptors.

These findings may lead to condensed information on typicality, which may contribute to a feasible macroscale regulation of small-sized wine regions and allow Portuguese red wines to be readily understood and sorted by a larger group of consumers.

Supporting information

Sensory Questionnaire (**Table 7**).

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STILL RED WINES SENSORY QUESTIONNAIRE

PGI (REGION)

PLEASE ENTER ONE RESPONSE TO EACH QUESTION BY PLACING A TICK IN THE APPROPRIATE BOX.
PLEASE ENSURE ALL QUESTIONS ARE ANSWERED.

DO YOU RESIDE IN THIS REGION? YES ☐ NO ☐

HOW WELL DO YOU KNOW/UNDERSTAND THE SENSORY PROFILE OF THIS PGI WINES?

NOT WELL AT ALL (PLACE A TICK) — PERFECTLY WELL

0	1	2	3	4	5	6	7	8	9	10

YOU WILL BE ANSWERING ABOUT PGI WINES, EXCLUSIVELY.
BUT HOW DIFFERENT WOULD YOUR ASSESSMENT BE IF THIS QUESTIONNAIRE REFERRED TO ITS INNER PDO SENSORY PROFILE?

TOTALLY EQUAL (PLACE A TICK) — TOTALLY DIFFERENT

0	1	2	3	4	5	6	7	8	9	10

CHARACTERIZATION OF TYPICAL **COLOR** (CHOOSE ONLY ONE OF THIS COLOR CATEGORIES, ACCORDING TO PGI TYPICITY)

VIOLET - PURPLE	
PURPLE - RUBY	
RUBY - GARNET	
GARNET - BRICK RED	

REGARDING THE CHOSEN COLOR CATEGORY, PLEASE TICK ONLY ONE CASE ACCORDING TO ITS PGI TYPICAL INTENSITY

EXTREMELY DILUTED (PLACE A TICK) — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

CHARACTERIZATION OF TYPICAL **AROMA**
(PLEASE ENSURE ALL QUESTIONS ARE ANSWERED, EVEN IF YOU DO NOT ENVISAGE ONE OR MORE AROMATIC CATEGORIES WITHIN PGI TYPICITY)

GLOBAL AROMATIC INTENSITY PGI's typicity on overall aromatic intensity

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

FLORAL AROMAS Intensity of rose, orange blossom, violet, carnation, ...

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

DRY FLOWER AROMAS Intensity of hay, dried rose, dried chamomile, ...

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

HERBAL AROMAS Intensity of minths, thyme, grass, infusions, anise, mediterranean bush, ...

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

VEGETABLE AROMAS Intensity of red peppers, green peppers, olives, ...

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

MINERAL AROMAS Intensity of slate, clay, chalk, graphite, hot earth, silex, petroly, mineral-water-like, ...

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

CITRUS FRUIT AROMAS Intensity of orange, lemon, bergamot, grapefruit, ...

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

BLACK FRUIT AROMAS — Intensity of blackcurrant, blueberry, mulberry, ...

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

STONE FRUIT AROMAS — Intensity of black plum, red plum,dark cherry, red cherry, ...

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

DRIED FRUIT AROMAS — Intensity of raisin, dried plum, dried fig, dried banana, ...

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

NUT FRUIT AROMAS — Intensity of almond, walnut, chestnut, pine nut, ...

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

JAM & JELLY FRUIT AROMAS — Intensity of red fruit or black fruit preserve, with or without alcohol, ...

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

BREAD & PASTRY AROMAS — Intensity of bread, butter, egg pastry and bakery, vanilla, ...

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

SPICY AROMAS — Intensity of pepper, clove, nutmeg, cinnamon, cocoa bean, coffee bean, ...

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

CARAMELIZED AROMAS — Intensity of caramel, honey, molasses, pollen, ...

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

WOODY AROMAS — Intensity of fresh (eucalyptus, cedar, resin, ...),
smoked and burnt wood (ink, toasted bread, grilled nuts, toasted coffee, chocolate, ...)

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

CHEMICAL AROMAS — (POSITIVE) Intensity of tooth paste, medicinal, glue, canned fruit, metalic, ...)

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

ANIMAL AROMAS — (POSITIVE) Intensity leather, meat, bacon, musk, wet fur, ...

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

CHARACTERIZATION OF TYPICAL **TASTE**

(PLEASE ENSURE ALL QUESTIONS ARE ANSWERED, EVEN IF YOU DO NOT ENVISAGE ONE OR MORE TASTANT CATEGORIES WITHIN PGI TYPICITY)

BUBBLY — Intensity of bubbly, carbonated mouthfeel

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

SWEET — Intensity of sweet, sugary taste

NO TRACE												EXTREMELY INTENSE
	0	1	2	3	4	5	6	7	8	9	10	

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ACID (SOUR) Intensity of sour, acidic, fresh taste, as in lemon juice

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

SALTY Intensity of salty, sodium or calcium tartrate water

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

BITTER Intensity of bitter taste, as in coffee, resin, quinine

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

DRY (MOUTHFEEL) Intensity of lack of lubrication, desiccation in the mouth

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

SMOOTH (MOUTHFEEL) Intensity of supple, velvet, silk, smooth coating of mouth surfaces

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

ROUGH (MOUTHFEEL) Intensity of grippy, chewy, hard, full, fleshy, harsh mouthfeel

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

GRAIN (MOUTHFEEL) Intensity of clay, talk, chalky, grainy, dusty matter brushing against mouth surfaces

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

ASTRINGENT (GLOBAL) Intensity of global mouthfeel impact, from light, diluted to puckery, chewy interaction

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

FULL BODY Intensity of weight, dry extract, fullness

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

ALCOHOL Intensity of caustic, burning, heat sensations

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

OILY (MOUTHCOAT) Intensity of oily, viscous, round textures

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

LENGTH (PERSISTENCE) Intensity of persistence, length

NO TRACE — EXTREMELY INTENSE

0	1	2	3	4	5	6	7	8	9	10

PLEASE DOUBLE-CHECK THAT ALL QUESTIONS HAVE BEEN ANSWERED.

THANK YOU FOR YOUR KIND COOPERATION.

Table 7. Sensory Questionnaire.

Author details

Anibal Jose-Coutinho[1]*, Patricia Avila[2] and Jorge M. Ricardo-da-Silva[1]

*Address all correspondence to: ajosecoutinho@gmail.com

1 Laboratory Ferreira Lapa, Instituto Superior de Agronomia, Linking Landscape Environment Agriculture and Food (LEAF), University of Lisbon, Lisbon, Portugal

2 Department of Social Methods Research, University Institute of Lisbon (ISCTE-IUL), Lisbon, Portugal

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