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Proficiency testing for sensory profile tests: statistical guidelines - Part 2

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Proficiency testing for sensory profile tests: statistical guidelines - Part 2

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EXECUTIVE SUMMARY

Proficiency testing in sensory analysis is an important step to demonstrate that data obtained from human instruments are as reliable as one would expect from any other measurement tool. The uniqueness of sensory analysis poses some specific problems for measuring the proficiency of the instrument (panel) providing the data. Cultural and individual differences may give rise to different thresholds of perception, and product experience of the panel may lead to differences in the ability to discriminate between samples. Such factors make the job of the statistician more difficult, as defining the expected level of performance in terms of which samples are differentiated, for example, becomes difficult.

This report follows on from a previous document that proposed a procedure to determine the 'expected result' of a ranking test, and subsequently measure panel performance. This document concentrates on testing and validating the proposed procedure through the use of a ring trial on red wine.

Through the use of validation panels, it was possible to demonstrate how to set up the expected result, and to set criteria and limits to measure panel performance. The results of subsequent ring trials are also reported to demonstrate how the overall performance measured for each panel was achieved.

The research demonstrated that it was possible to establish performance criteria using the concept of validation panels. However, there is still work to be done to select a good choice of samples for profiling proficiency tests, as this case study demonstrated.

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1 CCFRA, UK
2 VTT Biotechnology, Finland
3 Swedish Meat Research Institute, Sweden
4 Matforsk – Norwegian Food Research Institute, Norway
5 Polish Academy of Sciences, Poland
6 BioSS, UK
7 University College Cork, Ireland
8 TNO Nutrition and Food Research Institute, Netherlands
9 Unilever Research Colworth Laboratory, UK
10 Biotechnological Institute, Denmark
11 AINIA – Instituto Tecnologico Agroalimentario, Spain
12 Adriant, France
13 SIK – Swedish Institute for Food and Biotechnology, Sweden
14 Nestle R&D Centre Bjuv, Sweden
15 VALIO, Finland
16 INRAN - Instituto Nazionale di Ricerca per gli Alimenti e la Nutrizione, Italy
17 V&S VinSprit – Swedish Wine and Spirits Corporation, Sweden

This report is based on work undertaken by TG2 on Statistical Guidelines for Proficiency Testing. This group included CCFRA (Jean A. McEwan), BioSS (Tony Hunter), Matforsk (Per Lea) and TNO (Leo van Gemert). Particular thanks are given to the contribution of Jean McEwan and Tony Hunter, who undertook the bulk of the data analysis and report writing.

Thanks are also given to the other participants, particularly to those in TG4 undertaking the organisation and sensory evaluation with respect to the profile tests. These data play an important role in developing the statistical guidelines.

CONTENTS

1. INTRODUCTION

1 . Background to Proficiency Testing

Proficiency testing in sensory analysis is an important step to demonstrate that data obtained from human instruments are as reliable as one would expect from any other measurement tool. Sensory analysis is unique in that it uses human assessors to measure the perception of a wide range of stimuli, as detected through the senses of sight, sound, smell, taste and touch. Such measurements are physical translations of perception, and as such differ from physical or chemical measures.

The uniqueness of sensory analysis poses some specific problems for measuring the proficiency of the instrument (panel) providing the data. Cultural and individual differences may give rise to different thresholds of perception, and product experience of the panel may lead to differences in the ability to discriminate between samples. Such factors make the job of the statistician more difficult, as defining the expected level of performance in terms of which samples are differentiated, for example, becomes difficult.

Another issue for the statistical evaluation of the data is the definition of a 'true' value, which is not so clearly defined for sensory analysis. This issue is a big problem for descriptive profile ring trials where panels may use different names to describe the same attribute or may use the same name to describe different attributes. This problem is exacerbated in ring trials where the panels have different languages. In a previous report (McEwan, 2000), the concept of 'expected results' was introduced, where pre-test panels are used to define the criteria for panel performance in ring trials.

This document outlines approaches to the analysis of sensory profile data, with the specific objective of monitoring the performance of the panel as part of a sensory proficiency testing scheme.

1.2 Panel Performance or Assessor Performance

One important aspect to clarify at the outset is the purpose of proficiency testing with respect to performance of panels or performaiice of assessors.

It is very clear that, whether in research or commercial projects, it is the panel result that is used to make decisions about the samples being evaluated. Therefore, proficiency testing is about measuring the performance of a panel, not individuals in the panel.

If individual assessors perform poorly, then their data will bring down the overall performance of the panel, and therefore the panel will not have performed well. Concordance between members of the panel is of interest, as one measure of a panel's performance is measured by determining if each member of the panel provided the same information.

Therefore, this document is concerned with the performance of panels, and not individual assessors within the panel.

1.3 Report Scope

This report develops the work (McEwan, 2000) on establishing performance criteria for measuring the proficiency of sensory descriptive profile panels.

Chapter 2 details the stages required to establish the performance criteria, based on selected validation panels, whilst Chapter 3 puts this into practice using a case study on wine, and Chapter 4 refines the 'expected' results based on the analysis of the validation panels' data.

Chapter 5 reports on the analysis of the main ring trial on wine, whilst Chapter 6 works through the performance of each panel. Chapter 7 offers some thoughts on how to set performance measures based on the experience gained as part of this project.

2. STAGES IN ESTABLISHING PANEL PERFORMANCE

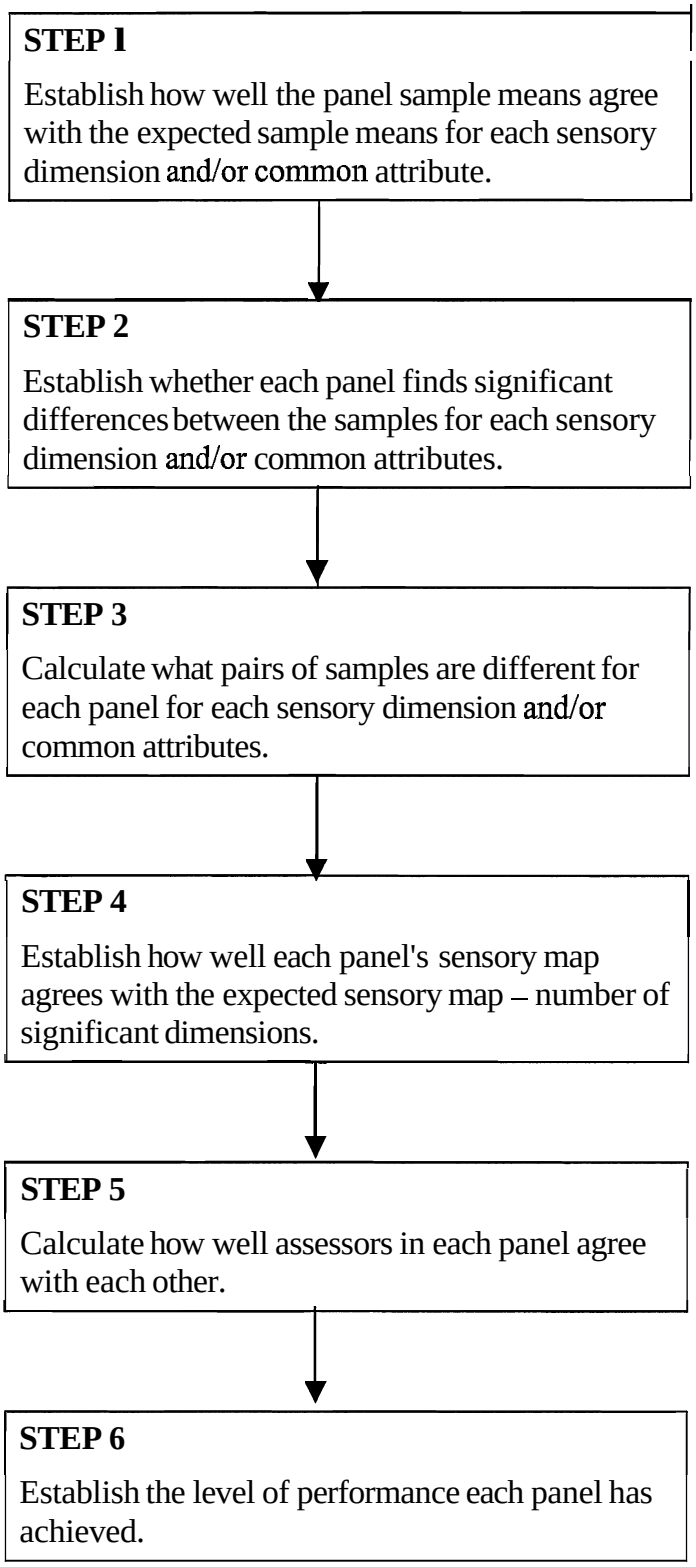
2.1 Introduction

A previous report (McEwan, 2000) suggested a possible scheme for setting criteria for measuring panel performance in descriptive profile proficiency testing. In this report, wine is used to test the workability of the proposed scheme, and to make modifications as appropriate.

This chapter outlines the stages in measuring proficiency of descriptive profile panels, whilst subsequent chapters use the wine data to put the procedure into practice.

2.2 A Possible Performance Scheme

The diagram overleaf outlines a possible scheme for establishing and measuring performance of descriptive profile panels.



This document outlines how the scheme worked in practice using real data. As a result modifications are justified in Chapter 4 (Section 4.4).

2.3 Statistical Procedures for Each Stage

Overview of Data Analysis

Before tackling the specific requirements of each stage in the above flow diagram, it is useful to analyse the data using each of the required statistical methods. This involves the following methods.

- Calculation of sample means, both on 'common' attributes and on sensory dimensions based on multivariate analysis of the whole profile.
- Undertaking GPA and storing the product score results.
- Performing ANOVA on the common attributes and multivariate dimensions.
- Undertaking a multiple comparison test following on from ANOVA.
- Calculating the RV coefficient on the GPA sensory maps.

Step 1 - Calculate the sample means

For each panel in the validation stage, the sample means for each common attribute and for each sensory dimension (from GPA) are calculated. If there is good agreement between the validation panels, then an 'expected sample order (means)' can be specified for each common attribute and sensory dimension. If there is some disagreement, then Steps 2 and 3 will help establish if this is because samples were 'switched' in rating, because there was no perceptible difference between them. The Pearson correlation between the 'expected sample means' and the actual panel sample means at the 10% level of significance can then be calculated. This level of significance is chosen to eliminate the possibility of downgrading a panel because two or more samples were not perceptibly different.

Step 2 – Calculate the significance level associated with sample differences

To establish how well each panel discriminated between the samples, analysis of variance should be undertaken on each common attribute and on each sensory dimension. For the common attributes a two-way analysis of variance with interaction between samples and assessors should be used, where assessors are a random effect. If all panels performed well (i.e. $p \leq 0.01$ (1% significance)) on all attributes, then Step **3** may be required to determine if the test was too easy, in other words the panel was able to discriminate between most of the samples in the profile.

In order to establish discrimination ability for the profile as a whole, generalised Procrustes analysis (GPA) should be undertaken on the data from individual assessors. A one-way analysis of variance specifying the sample as the main effect should then be undertaken, and the number of dimensions significant at $p \leq 0.05$ (5% significance) retained. If all panels performed well (i.e. $p \leq 0.01$ (1% significance)) on all dimensions, then Step **3** may be required to determine if the test was too easy, in other words the panel was able to discriminate between most of the samples in the profile.

Before deciding the 'expected significance level' for each common attribute and sensory dimension, there should be confidence that the decisions based on the validation panels' results will allow some panels in the main test to perform better than the expected result. At the same time the criteria should still allow panels who perform worse than the expected result to be detected.

Step 3 – Calculate what pairs of samples are different

Having established an expected significance level for each common attribute and sensory dimension, the next step is to determine which pairs of samples are different at a specified level of significance (for example, 1%, 5% or 10% significance). This can be achieved

through the use of a suitable multiple comparison test, for example Tukey's HSD method (McEwan, 2000).

From these results, the 'expected sample differences' can be set for each common attribute and sensory dimension.

Step 4 – Determine the expected sensory map

If the panel has performed well, than it would generally be expected that they have a larger number of significant multivariate dimensions than a panel who performed poorly. In addition, a 'good' panel would have a greater percentage of variation explained over the significant dimensions. However, this on its own may not be ideal, so a more suitable test is to define the expected sensory map based on the validation panel data. This means that the sensory maps of the ring trial panels can be measured for similarity with this map.

Step 5 – Calculate agreement between assessors and panels

A GPA should be undertaken on each panel's data, and a sample map obtained for each assessor in the panel. The RV coefficient is then calculated between each pair of assessors and the results averaged (RV1), and between each assessor and the panel consensus (RV2), and the results averaged. An RV of '1' indicates perfect agreement, whilst an RV of '0' illustrates no agreement. **An** expected RV can then be specified.

Step 6 – Establish the performance score linked to different performance levels

Step *6* involves adding the scores from Steps 1-5 together, and allocating a performance level for different score intervals.

3. EXPECTED RESULTS FOR 2000 RING TRIAL – STAGE I

3.1 Introduction

The objective of the pre-testing and validation stage was to ensure that the range of wines selected demonstrated sufficient sensory differences to run a successful ring trial in respect of testing panel performance. In addition, 6 out of the 8 samples would be selected for the main trial, providing this was justified by the data obtained from the validation panels.

3.2 Samples and Sensory Information

Samples

Eight samples of red wine (Table 3.1) were selected by V&S Vin and Sprit to represent a range of sensory characteristics found in wine. Table 3.1 lists the codes and samples, whilst the training attributes (Appendix 2) were potential common attributes, though the future use of these would depend on the validation results.

Table 3.1: Eight samples of wine selected for the pre-test.

	Rep 1	Rep 2	Product Code	Sample Fuller Name	
1	226	334	Cote de Ventoux	La Vieille Ferrne Rouge	France
2	352	171	Corbiere	Ch. Les Ollieux Romanis	France
3	795	899	Cotes du Rhone	Chateau Malijay 1995	France
4	261	521	Parador	Parador	Spain
5	746	992	Solana	Solana Red	Spain
6	103	553	Rioja	Campo Viejo Reserva 1994	Spain
7	227	620	Bardolino	Cadis Bardolino 1998	Italy
8	170	376	Veneto	Cadis Rosso 1998	Italy

Panels

Three panels took part in the first validation stage: Panels N, S and T. Each panel undertook descriptive profiling according to their normal procedure. Appendix 1 lists the number of assessors, attributes and the type of scale used.

Sensory Attributes

Each panel generated a list of odour, flavour and mouthfeel attributes (Appendix 2), together with definitions.

3.3 Initial Data Analysis

Common Attributes

Common attributes were not specifically mentioned, other than the fact that training samples were identified as being associated with certain attributes. However, not all panels used these attributes. The panels were not aware that the training samples were included in the main assessment.

The use of the basic tastes was considered as common attributes, and Table 3.2 illustrates usage by the 3 pre-test panels.

Table 3.2: Use of the 4 basic taste by the pre-test panels to describe the wine samples.

Panel	Sweet	Sour	Bitter	Salt
N6	Yes	Yes	Yes	Yes
S6	Yes	Yes	No	No
T	Yes	Yes	Yes	No

Table 3.3 shows the sample means for the attribute sweet. The correlation between panels was calculated. The correlation between Panels N and T was 0.924, that between N and S was 0.571, and that between S and T was 0.337.

Table 3.3: Sample means for sweet.

	Product Code	**Panel N**	**Panel S**	**Panel T**
1	Cote de Ventoux	21.1	20.3	18.4
2	Corbiere	12.5	17.7	18.0
3	Cotes du Rhone	19.1	19.3	19.5
4	Parador	57.0	24.5	40.0
5	Solana	20.1	22.6	21.3
6	Rioja	15.4	22.1	19.5
7	Bardolino	24.5	16.6	30.3
8	Veneto	20.1	20.9	19.5

Table 3.4 shows the sample means for the attribute sow. The correlation between Panels N and T was 0.473, that between N and S was –0.383, whilst that between S and T was 0.054. Thus there was no agreement between the panels.

Table 3.4: Sample means for acid/sour.

	Product Code	**Panel N**	**Panel S**	**Panel T**
1	Cote de Ventoux	37.9	53.6	45.4
2	Corbiere	31.6	58.4	43.8
3	Cotes du Rhone	36.0	55.9	42.4
4	Parador	25.3	56.2	37.9
5	Solana	41.9	56.7	44.2
6	Rioja	34.1	52.6	47.0
7	Bardolino	38.6	48.3	38.9
8	Veneto	39.7	52.3	46.8

Table 3.5 shows the sample means for the attribute bitter. The correlation between Panels N and T was 0.647.

Table 3.5: Sample means for bitter.

	Product Code	Panel N	Panel S	Panel T
1	Cote de Ventoux	20.6	--	17.2
2	Corbiere	45.2	--	15.5
3	Cotes du Rhone	15.9	--	9.6
4	Parador	9.7	--	5.9
5	Solana	20.4	--	12.5
6	Rioja	38.1	--	14.2
7	Bardolino	13.5	--	10.1
8	Veneto	19.7	--	6.3

From the above analysis there is some indication that sweet and bitter could be common attributes. However, it should be noted that Panel S did not use sweet and acid to discriminate between the samples (Appendix 9).

GPA and Sensory Dimensions

GPA was undertaken on the data from each of the three panels. Tables 3.6 to 3.8 show the sample scores on the first 3 dimensions, together with the sample effect obtained fi-om undertaking ANOVA on each dimension. In addition, a sample multiple comparison value (Tukey's HSD) is given at the 5% level of significance. Appendix 5 provides the sample maps for each panel.

Panels S and T provide three dimensional maps, whilst Panel S only separated samples along one dimension. The Tukey's HSD multiple comparison value (HSD) can be used to determine the number of significantly different pairs, but this is not shown here (see Chapter 4).

Table 3.6: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel N.

	Panel N		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.46	0.27	-0.03
Corbiere	-0.62	0.14	-0.24
Rhone	0.23	-0.88	-0.48
Parador	-0.19	-0.39	0.90
Solana	-0.61	0.15	-0.22
Rioja	0.28	0.26	0.00
Bardolino	0.20	0.16	0.09
Veneto	0.25	0.28	-0.04
HSD	0.08	0.33	0.54
p-value	0.000	0.000	0.000
Variance	48%	19%	7%

Table 3.7: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel S.

	Panel S		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	-0.39	-0.08	-0.22
Corbiere	0.42	0.16	-0.49
Rhone	0.12	0.35	-0.44
Parador	0.81	-0.12	0.47
Solana	-0.32	-0.26	0.30
Rioja	-0.11	0.46	0.09
Bardolino	-0.34	-0.03	0.09
Veneto	-0.19	-0.48	0.21
HSD	0.70	1.67	1.45
p-value	0.001	0.456	0.218
Variance	26%	13%	10%

Table 3.8: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel T.

	Panel T		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.61	0.09	-0.01
Corbiere	-0.74	0.04	0.02
Rhone	0.47	0.75	-0.08
Parador	0.07	-0.18	0.30
Solana	-0.73	0.33	-0.56
Rioja	0.18	-0.04	0.35
Bardolino	0.50	-0.57	-0.43
Veneto	-0.34	-0.42	0.41
HSD	0.42	1.88	2.19
p-value	0.000	0.284	0.601
Variance	39%	13%	9%

GPA and Agreement between Panels

Tables 3.9 and 3.10 show the agreement between the consensus sample maps for the three panels, both for 2 and 3 dimensions. A value of 1 indicates perfect agreement, whilst 0 indicates no agreement. As all values are below 0.5, there is not good agreement, and this is particularly the case between Panels S and T.

Table 3.9: RV coefficient to measure agreement between the consensus sample maps of the three panels

	2 dimensions		**3 dimensions**	
Panel	N	S	N	S
S	0.481	--	0.472	--
T	0.486	0.248	0.443	0.231

GPA and Agreement of Assessors with the Panel Consensus

Table 3.10 shows how well each assessor within a panel agreed with the panel consensus. It is clear that the assessors of Panel N have shown most agreement with the consensus. Panel S with a RV of less than 0.7 has not performed so well. Generally an RV of over 0.9 would be very good, whilst 0.7 would be average. **A** RV of less than 0.5 may be considered poor.

Table 3.10: RV coefficient to measure agreement between each assessor and the consensus map for each panel.

	Panel		
Assessor	**N**	**S**	**T**
1	0.93	0.55	0.76
2	0.84	0.67	0.68
3	0.74	0.59	0.52
4	0.68	0.79	0.69
5	0.78	0.43	0.83
6	0.77	0.74	--
7	0.87	0.74	--
8	0.77	0.60	--
9	0.78	0.61	--
10	0.76	--	--
11	0.65	--	--
Average	0.78	0.64	0.70

Average Agreement between Assessors

Table 3.11 shows the results of calculating the RV coefficient between each pair of assessors within a panel, and then calculating the average agreement between assessors. Panel S performed poorly in this respect, with Panel T providing the best results, but as this panel was reduced to 5 assessors, this may not be a true reflection of the whole panel.

Table 3.11: RV coefficient to measure the average agreement between assessors.

Panel	RV
N	0.58
S	0.35
T	0.78

3.4 Setting Performance Criteria

Based on the data collected, and discussion at a project Plenary meeting, it was felt that these data were not ideal for setting performance criteria for the main trial. This was for several reasons. Firstly, Panel S seemed to be evaluating the samples differently from the other 2 panels. Whilst Panels N and T showed good agreement in many aspects, the reduction of Panel T to 5 assessors, due to incomplete data, meant that these data were not necessarily representative.

In addition, the attributes specified in the training samples were not actually used as common attributes, and so it was felt that testing this concept was not justified with these data.

4. EXPECTED RESULTS FOR 2000 RING TRIAL – STAGE 2

4.1 Introduction

The first validation stage revealed that some methodology issues needed to be clarified. For financial reasons, the number of samples was reduced from eight to six. This meant that validation panels had to be selected from within the main trial, and using information from the first validation stage, which in fact became part of the pre-testing. This chapter works through the validation panels' data to demonstrate how performance criteria may be set to evaluate the performance of panels in the main ring trial.

4.2 Samples and Sensory Information

Samples

Six samples of red wine (Table 4.1) were selected from the eight (Table 3.1) based on the data from the first stage of analysis. Table 4.1 lists the codes and samples, whilst Appendix 2 lists the training attributes for each of the wines.

Table 4.1: Six samples of wine selected for the main ring trial.

	Rep 1	Rep 2	Product Code	Sample Fuller Name	
1	328	126	Cote de Ventoux	La Vieille Ferme Rouge	France
3	170	337	Cotes du Rhone	Chateau Malijay 1995	France
4	577	555	Parador	Parador	Spain
5	958	111	Solana	Solana Red	Spain
6	720	817	Rioja	Campo Viejo Reserva 1994	Spain
7	802	656	Bardolino	Cadis Bardolino 1998	Italy

The samples were selected to cover the range represented by the eight samples. This was achieved through examining GPA and PCA maps, and through discussion at a project Plenary meeting in Helsinki during March, 2000.

Panels

Panels T2, U and Z were allocated as validation panels from within the main ring trial. In addition, the data from Panel N from the first stage for 6 samples were utilised (now called Panel N6). Panel T2 was in fact Panel T in the first stage, but this panel undertook the evaluation for a second time due to some problems with the first profile.

Sensory Attributes

Each panel generated a list of odour, flavour and mouthfeel attributes (Appendix **3),** together with definitions.

4.3 Data Analysis

Common Attribute Potential

The first step was to examine whether the panels had chosen to use the four basic tastes as the recommended common attributes. From Table 4.1 it can be seen that all panels used sour/acid and bitter, with three of the four panels using sweet and bitter.

Expected sample means can only be set for sour and bitter, but for demonstration (research) purposes sweet was examined.

Table 4.1: Use of common attributes across selected validation panels.

Panel	Sweet	Sour	Bitter	Salt
N6	Yes	Yes	Yes	Yes
T2	Yes	Yes	Yes	No
U	No	Yes	Yes	No
Z	Yes	Yes	Yes	No

Tables 4.2 to 4.4 show the sample means for the attributes sweet, sour and bitter, whilst Table 4.5 shows the correlation between panels for these 3 attributes.

Table 4.2: Sample means for sweet.

	Product Code	Panel N6	Panel T2	Panel U	Panel Z
1	Cote de Ventoux	21.1	29.2	--	28.1
2	Cotes du Rhone	19.1	23.6	--	22.1
3	Parador	57.0	56.8	--	38.7
4	Solana	20.1	26.1	--	25.0
5	Rioja	15.4	32.5	--	25.2
6	Bardolino	24.5	28.9	--	19.7

Table 4.3: Sample means for sour/acid.

	Product Code	Panel N6	Panel T2	Panel U	Panel Z
1	Cote de Ventoux	37.9	56.5	48.1	30.7
2	Cotes du Rhone	36.0	58.6	44.9	35.0
3	Parador	25.3	50.2	53.4	27.4
4	Solana	41.9	64.0	46.9	36.8
5	Rioja	34.1	52.0	47.8	43.0
6	Bardolino	38.6	57.8	47.7	40.0

Table 4.4: Sample means for bitter.

	Product Code	Panel N6	Panel T2	Panel U	Panel Z
1	Cote de Ventoux	20.6	27.5	46.5	31.5
2	Cotes du Rhone	15.9	29.7	50.0	31.0
3	Parador	9.6	19.2	36.7	27.8
4	Solana	20.4	28.3	43.7	27.6
5	Rioja	38.1	27.3	47.8	24.5
6	Bardolino	13.5	20.3	46.4	24.3

Table 4.5: Correlation between panels for sweet, sour and bitter.

		Panel N6	Panel T2	Panel U
Sweet	Panel T2	0.938		
	Panel Z	0.848	0.905	
Sour	Panel T2	0.877		
	Panel U	-0.796	-0.690	
	Panel Z	0.502	0.223	-0.574
Bitter	Panel T2	0.527		
	Panel U	0.469	0.683	
	Panel Z	-0.314	0.475	0.108

From Table 4.5 it can be seen that there is good agreement between the three panels using the attribute sweet, and therefore the 'expected means' can be calculated as the across panel average (Table 4.6).

For sour, Panel U is clearly using this term in the opposite way from the others, but Appendix 9 illustrates that they did not use sour to discriminate between the samples. Only panels N6 and T2 show good agreement. As Panel T2 was a wine panel, it was

decided to calculated the 'expected means' as the average of Panels N6 and T2.

There was poor agreement between the panels with respect to bitter. However, with the exception of Panel N6 and Z, all other correlation coefficients were positive. The 'expected means' were taken as the average for Panels N6, T2 and U.

Table 4.6: Calculated 'expected means' for sweet, sour and bitter.

	Product Code	Sweet	Sour	Bitter
1	Cote de Ventoux	26.1	47.2	47.5
2	Cotes du Rhone	21.6	47.3	46.5
3	Parador	50.8	37.8	43.0
4	Solana	23.7	53.0	50.9
5	Rioja	24.4	43.1	44.6
6	Bardolino	24.4	48.2	48.0

Finally, for interpretation of the correlations, it is important to check that the attributes are actually discriminating between the samples. The ANOVA results are provided in Appendix 9.

GPA and Sensory Dimensions

GPA was undertaken on all the data from each of the four panels. Tables 4.7 to 4.10 show the sample scores on the first 3 dimensions, together with the sample effect obtained from undertaking ANOVA on each dimension. In addition, a sample multiple comparison value (HSD) is given at the 5% level of significance.

Examining the p-value indicates that only Panels N6 and T2 provided three dimensional maps, whilst Panels U and Z only discriminated between the samples along one dimension. Interestingly Panel Z used Dimension 2 to discriminate between the samples, whilst Dimension 1 was not used at all.

Table 4.7: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel N6.

	Panel N6		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	-0.275	-0.295	-0.030
Rhone	0.390	0.275	0.870
Parador	-0.115	0.895	-0.455
Solana	-0.290	-0.275	0.000
Rioja	0.810	-0.360	-0.445
Bardolino	-0.515	-0.240	0.065
p-value	0.000	0.000	0.001
HSD	0.123	0.303	0.633
Variance	42%	24%	9%

Table 4.8: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel T2.

	Panel T2		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.065	0.180	0.310
Rhone	0.035	0.540	-0.630
Parador	0.250	-0.770	-0.380
Solana	0.240	0.270	0.305
Rioja	-0.885	-0.140	0.085
Bardolino	0.300	-0.075	0.310
p-value	0.000	0.000	0.036
HSD	0.413	0.306	1.021
Variance	33%	19%	11%

Table 4.9: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel U.

	Panel U		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	-0.380	0.160	0.050
Rhone	0.225	-0.625	0.085
Parador	0.790	0.345	-0.090
Solana	-0.245	0.210	0.440
Rioja	-0.185	-0.220	-0.620
Bardolino	-0.205	0.125	0.135
p-value	0.000	0.188	0.225
HSD	0.441	--	--
Variance	20%	15%	14%

Table 4.10: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel Z.

	Panel Z		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.100	-0.250	-0.350
Rhone	0.010	0.300	0.310
Parador	-0.205	0.695	0.535
Solana	0.105	-0.460	0.165
Rioja	-0.215	0.330	-0.565
Bardolino	0.205	-0.615	-0.095
p-value	0.983	0.037	0.381
HSD	--	1.297	--
Variance	21%	15%	11%

GPA and Agreement between Panels

Table 4.11 shows the agreement between the 4 validation panels. There is good agreement between Panels N6 and T2, and to a lesser extent good agreement between N6 and U, and between T2 and U. However, Panel Z showed poor agreement with the other panels.

Table 4.11: RV coefficient to measure agreement between the consensus sample maps of the four panels: **3** dimensions.

Panel	**N6**	**T2**	**U**	**Z**
N6	1.000	--	--	--
T2	0.876	1.000	--	--
U	0.746	0.702	1.000	--
Z	0.437	0.358	0.533	1.000

Panels N6 and T2 provided **3** dimensional solutions; Panel T2 was experienced with wine. Therefore, the consensus of these two panels was taken as the expected sample map.

Table 4.12: Sample scores for the three dimensions of the expected sample map.

	Expected Sample Map		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.150	0.350	-0.270
Ventoux	0.190	0.370	0.050
Rhone	-0.230	-0.130	1.000
Rhone	-0.180	-0.140	0.900
Parador	0.330	-0.950	-0.300
Parador	0.200	-0.910	-0.220
Solana	0.260	0.430	-0.080
Solana	0.250	0.310	0.100
Rioja	-0.990	0.050	-0.430
Rioja	-0.830	0.070	-0.360
Bardolino	0.450	0.300	-0.330
Bardolino	0.410	0.240	-0.050

This map (Table 4.12) was derived from undertaking GPA on the data of both panels, where all the individual assessors were input to the analysis.

GPA and Agreement of Assessors with the Panel Consensus

Table 4.13: RV coefficient to measure agreement between each assessor and the consensus map for each panel.

	Panel				
Assessor	N6	**T2**	**U**	Z	**Expect**
1	0.94	0.77	0.78	0.71	0.88
2	0.86	0.85	0.56	0.65	0.85
3	0.79	0.66	0.70	0.71	0.74
4	0.64	0.8	0.58	0.79	0.66
5	0.73	0.63	0.68	0.61	0.79
6	0.74	0.85	0.54	0.84	0.76
7	0.82	0.77	0.69	0.76	0.75
8	0.79	0.78	0.65	0.71	0.73
9	0.87	0.62	0.75	0.72	0.79
10	0.76	0.82	0.72	0.68	0.80
11	0.65	--	0.69	0.76	0.67
12	--	--	--	0.71	0.76
13	--	--	--	0.72	0.81
14	--	--	--	--	0.61
15	--	--	--	--	0.72
16	--	--	--	--	0.49
17	--	--	--	--	0.85
18	--	--	--	--	0.79
19	--	--	--	--	0.74
20	--	--	--	--	0.58
21	--	--	--	--	0.79
Average	0.781	0.755	0.667	0.721	0.741

Table 4.13 shows, for each panel, the agreement between each assessor and the panel consensus as measured by the RV coefficient. The final column shows this result for the 21 assessors of the data used to obtain the expected sample map. The average results indicate that the assessors of Panel N6 were most in agreement with the panel consensus, whilst Panel U did not perform so well.

Average Agreement between Assessors

Table 4.14 shows the results of calculating the RV coefficient between each assessor within a panel, and then calculating the average agreement between assessors. It is clear that the assessors of Panel U did not agree with each other, whilst better agreement was indicated for Panel N6.

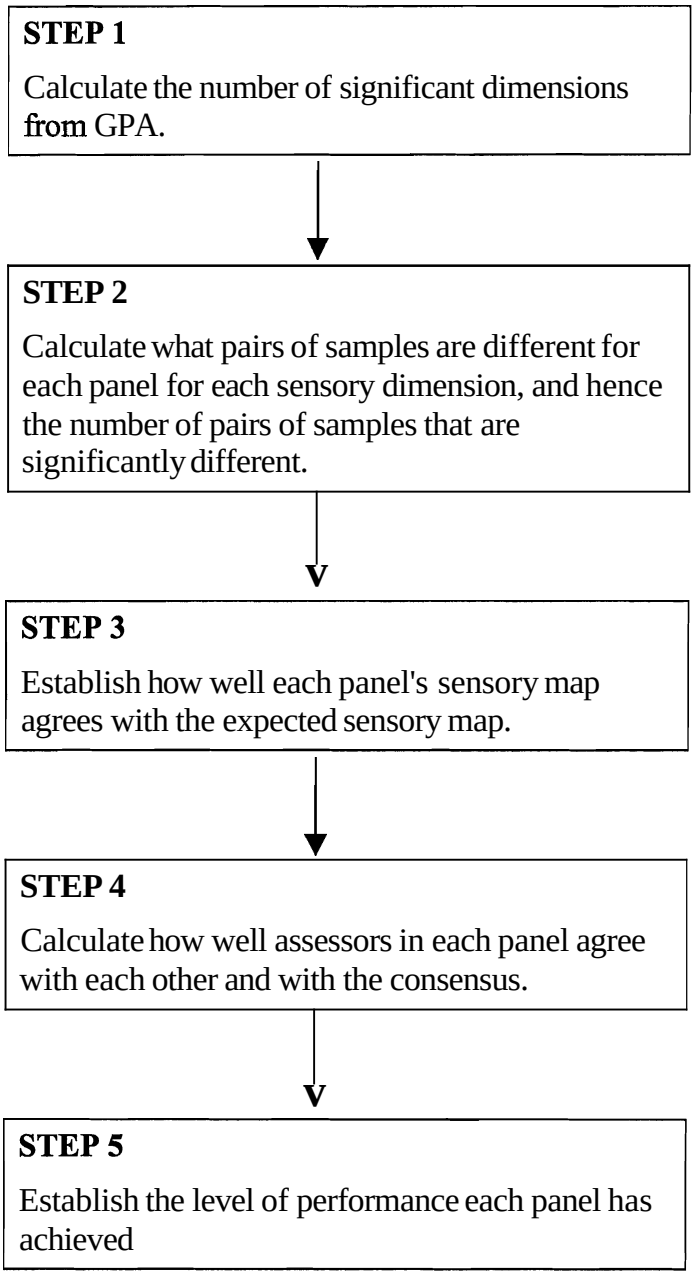
Table 4.14: RV coefficient to measure the average agreement between assessors.

Panel	RV
N6	0.575
T2	0.535
U	0.393
Z	0.488
Expect	0.541

It is not unexpected that the agreement between assessors is lower than that between each assessor and the consensus.

4.4 Expected Results and Performance Criteria

Steps 1 and 2 from the suggested procedure (Section 2.2) were not considered feasible having worked through the wine data. Instead the procedure will start with determining the number of significant differences between samples across the significant GPA dimensions.



Step 1 – Number of Significant Dimensions

Table 4.15 shows the p-value associated with sample differences along the first three sensory dimensions. In this case, all three dimensions were significant, whilst further dimensions were not. As this result is based on 2 very good panels, the expected result could be set as 2 significant dimensions. The 5% level of significance will be used.

Score 0	No significant dimensions	
Score 1	1 significant dimension	
Score 2	2 significant dimensions	'expected result'
Score **3**	3 significant dimensions	

Step 2 –Number of Significant Differences between Pairs of Samples

Table 4.15 shows the average expected sample scores together with the sample p-value and 5% multiple comparison value. The number of significant pairs across the three dimensions was calculated (Table 4.16).

Table 4.15: Expected average sample scores across **3** significant dimensions, with HSD multiple comparison value.

	Expected Sample Differences		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.170	0.360	-0.110
Rhone	-0.205	-0.135	0.950
Parador	0.265	-0.930	-0.260
Solana	0.255	0.370	0.010
Rioja	-0.910	0.060	-0.395
Bardolino	0.430	0.270	-0.190
p-value	0.000	0.000	0.001
HSD	0.252	0.164	1.113
Variance	37%	20%	12%

The 'Overall' column of Table 4.16 shows the summary of the number of significant pairs. In other words, if a pair is found significantly different on at least one dimension, then it appears as a 'yes' in the final column.

Table 4.16: Number of significant pairs (5% level) across the 3 significant dimensions for the expected sample map.

		Expected Sample Differences			
		Dim 1	**Dim 2**	**Dim 3**	**Overall**
Ventoux	Rhone	Yes	Yes	No	Yes
Ventoux	Parador	No	Yes	No	Yes
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	Yes	Yes	No	Yes
Ventoux	Bardolino	Yes	No	No	Yes
Rhone	Parador	Yes	Yes	Yes	Yes
Rhone	Solana	Yes	Yes	No	Yes
Rhone	Rioja	Yes	Yes	Yes	Yes
Rhone	Bardolino	Yes	Yes	Yes	Yes
Parador	Solana	No	Yes	No	Yes
Parador	Rioja	Yes	Yes	No	Yes
Parador	Bardolino	No	Yes	No	Yes
Solana	Rioja	Yes	Yes	No	Yes
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	Yes	Yes	No	Yes
		10	12	3	13

Based on Table 4.16 which shows the number of significantly different pairs over the three dimensional map, the following scoring system was set. This was also based on consulting the number of significant pairs from the individual validation panels (Appendix 8).

Score 0	≤ 4 significant pairs	
Score 1	5 significant pairs	
Score **2**	6 significant pairs	
Score 3	7 significant pairs	
Score 4	8 significant pairs	
Score 5	9-10 significant pairs	'expected result'
Score 6	11-12 significant pairs	
Score 7	13-15 significant pairs	

Step 3 – Expected Sample Map

Table 4.17 shows the RV coefficient between the expected sample map (Table 4.12) and consensus sample map from the four validation panels. As expected Panels N6 and T2 perform well as their data were used to create the expected result.

Table 4.17: RV coefficient to measure the agreement between the expected sample map and the consensus maps from the 4 validation panels.

Panel	**Assessors**
N6	0.970
T2	0.955
U	0.739
Z	0.418

Panel Z performed poorly with an RV of less than 0.5, whilst Panel U was in between. Based on these results the following scores were set.

Score 0	RV ≤ 0.50	
Score 1	RV > 0.50	
Score 2	RV > 0.60	
Score 3	RV > 0.70	
Score 4	RV > 0.80	'expected result'
Score 5	RV > 0.90	

Step 4 – Agreement between Assessors in the Panel and with the Consensus

Table 4.18 shows the average agreement between each assessor in a panel (2nd column), and between each assessor and the consensus map for the validation panels (3rd column). The final row of the table represents these figures for the 'expected' panel results.

Table 4.18: RV coefficient to measure the average agreement between each assessor and between each assessor and the consensus map for each panel.

Panel	Assessors	Consensus
N6	0.575	0.781
T2	0.535	0.755
U	0.393	0.667
Z	0.488	0.721
Expected	0.541	0.741

From these results agreement between assessors is expected to be at least 0.5. Therefore, the following criteria were set

Score 0	RV ≤ 0.45	
Score 1	RV > 0.45	
Score 2	RV > 0.50	'expected result'
Score 3	RV > 0.55	

In terms of agreement of each assessor with the consensus, the expected average should be at least 0.70. Therefore, the following criteria were set

Score 0	RV I0.65	
Score 1	RV > 0.65	
Score 2	RV > 0.70	'expected result'
Score 3	RV > 0.75	
Score 4	RV > 0.80	

Step 5 - Performance Scores

Based on the 3 steps above a potential total score of 22 (3 + 7 + 5 + 3 + 4) is possible. In terms of the expected overall score this can be calculated as the sum of all the expected results from Steps 1 to 4, giving a score of 15 (2 + 5 + 4 + 2 + 2).

Given that a panel can score 1 less than the expected result on any step (1, 2, 3, 4a or 4b), then the expected overall score could be set as the interval 14-15.

Score = 15.1-22.0	Better than expected
Score = 14 – 15	'Expected result'
Score < 14.0	Less than expected

5. MAIN WINE RING TRIAL

5.1 Introduction

This chapter works through the analysis of the additional wine profile data with a view to collecting information to test the performance criteria proposed in Chapter 4. Whilst the common attributes were discarded from the final scheme, correlations of the scores with the expected scores are reported to provide further evidence for inclusion or exclusion of these in future ring trials.

5.2 Common Attributes

Table 5.1 shows the panels using each of the 4 basic tastes, which were proposed as potential common attributes.

Table 5.2 shows the correlation coefficient between the mean attribute score and the expected score for the 3 proposed common attributes, as appropriate. It is clear that there was good agreement for sweet, poor agreement for bitter, with sour/acid showing variable results. It seemed strange that Panel U used sour/acid in the opposite way from the consensus result.

Table 5.3 shows the correlation coefficients between panels for each of the common attributes investigated: sweet, sour/acid and bitter. These results generally reflect those shown in Table 5.2.

Table 5.1: Panels using the 4 potential common attributes.

Panel	**Sweet**	**Sour**	**Bitter**	**Salt**
N6	Yes	Yes	Yes	Yes
O	Yes	Yes	Yes	No
P	Yes	Yes	Yes	No
Q	Yes	Yes	Yes	No
R	Yes	Yes	Yes	Yes
S6	Yes	Yes	No	No
T2	Yes	Yes	Yes	No
U	No	Yes	Yes	No
W	Yes	Yes	Yes	No
X	No	Yes	Yes	No
Y	No	Yes	Yes	No
Z	Yes	Yes	Yes	No

Table 5.2: Correlation coefficient between the expected sample means and actual sample means for each panel.

Panel	**Sweet**	**Sour**	**Bitter**
N6	0.978	0.973	-0.037
O	0.901	0.755	-0.630
P	0.708	0.737	-0.034
Q	0.608	0.586	0.107
R	0.941	0.499	0.298
S6	0.635	-0.068	--
T2	0.984	0.965	0.412
U	--	-0.772	0.330
W	0.787	0.346	0.147
X	--	0.772	0.679
Y	--	-0.290	-0.063
Z	0.925	0.384	0.095

Table 5.3: Correlation between the sample means for each panel, for the three common attributes.

		N6	O	P	Q	R	S6	T2	U	W	X	Y
Sweet	O	0.853										
	P	0.723	0.556									
	Q	0.648	0.795	0.577								
	R	0.963	0.914	0.759	0.823							
	S6	0.511	0.808	0.049	0.404	0.521						
	T2	0.938	0.909	0.767	0.624	0.924	0.643					
	W	0.823	0.879	0.674	0.953	0.943	0.462	0.780	--			
	Z	0.848	0.857	0.449	0.391	0.773	0.811	0.905	--	0.591	--	--
Sour	O	0.689										
	P	0.644	0.873									
	Q	0.583	0.880	0.858								
	R	0.621	0.585	0.290	0.652							
	S6	-0.234	0.279	0.549	0.364	-0.361						
	T2	0.878	0.780	0.793	0.547	0.325	0.119					
	U	-0.799	-0.868	-0.713	-0.799	-0.689	0.123	-0.690				
	W	0.449	0.533	0.549	0.789	0.574	0.009	-0.207	-0.749			
	X	0.772	0.726	0.415	0.484	0.757	-0.280	0.722	-0.681	0.145		
	Y	-0.341	0.287	0.408	0.529	-0.064	0.723	-0.216	-0.121	0.493	-0.371	
	Z	0.502	0.458	0.049	0.413	0.940	-0.544	0.224	-0.575	0.341	0.797	-0.248
Bitter	O	0.125										
	P	0.291	-0.284									
	Q	0.436	-0.050	0.802								
	R	0.603	-0.111	0.686	0.951							
	T2	0.523	-0.122	0.606	0.922	0.986						
	U	0.472	0.427	-0.006	0.468	0.614	--	0.681				
	W	0.665	0.301	0.287	0.766	0.859	--	0.867	0.848			
	X	0.577	-0.066	-0.057	0.351	0.609	--	0.678	0.826	0.725		
	Y	0.763	0.367	0.118	0.592	0.698	--	0.674	0.693	0.926	0.621	
	Z	-0.318	-0.093	0.286	0.581	0.433	--	0.479	0.111	0.357	-0.026	0.237

5.3 ANOVA on GPA Dimensions and Sample Differences

Tables 5.4 to 5.11 show the results of ANOVA on the first 3 GPA dimensions for each panel. The results for the allocated validation panels are provided in Table 4.7 to 4.10. Where the dimension shows a difference between the samples at the 5% level of significance, the Tukey multiple comparison value (HSD) is used to establish what pairs of samples are different (see Appendix 8 for details).

Examining the p-values indicates that most panels only used one dimension to discriminate between the samples, suggesting that the level of sample differences are not as good as may be expected from a well trained panel.

Table 5.4: Sample means for the first three GPA diniensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel O.

	Panel O		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.370	0.010	-0.035
Rhone	-0.465	-0.090	0.345
Parador	-0.885	0.475	-0.200
Solana	0.535	0.490	0.370
Rioja	0.040	-0.885	-0.605
Bardolino	0.415	0.005	0.120
p-value	0.000	0.070	0.572
HSD	0.554	--	--
Variance	32%	14%	13%

Table 5.5: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel P.

	Panel P		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	-0.395	-0.400	-0.285
Rhone	-0.285	0.520	-0.115
Parador	0.710	0.625	0.100
Solana	-0.465	-0.250	-0.045
Rioja	-0.200	0.010	-0.120
Bardolino	0.630	-0.495	0.465
p-value	0.048	0.191	0.907
HSD	1.403	--	--
Variance	30%	16%	13%

Table 5.6: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel Q.

	Panel Q		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.210	0.065	-0.095
Rhone	0.205	-0.400	0.310
Parador	-0.645	-0.175	0.230
Solana	0.075	0.185	0.020
Rioja	0.465	0.025	-0.175
Bardolino	-0.305	0.295	-0.285
p-value	0.001	0.649	0.741
HSD	0.520	--	--
Variance	17%	14%	12%

Table 5.7: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel R.

	Panel R		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.030	-0.015	0.460
Rhone	-0.035	0.175	-0.030
Parador	-0.705	-0.020	-0.280
Solana	0.370	-0.030	-0.340
Rioja	0.175	0.430	-0.085
Bardolino	0.170	-0.545	0.270
p-value	0.019	0.215	0.267
HSD	0.811	--	--
Variance	27%	16%	10%

Table 5.8: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel S6.

	Panel S6		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.410	0.040	-0.030
Rhone	-0.105	-0.290	-0.685
Parador	-0.935	0.150	0.090
Solana	0.260	0.485	0.440
Rioja	0.045	-0.525	0.275
Bardolino	0.325	0.135	-0.095
p-value	0.000	0.403	0.256
HSD	0.494	--	--
Variance	30%	15%	10%

Table 5.9: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel W.

	Panel W		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	-0.240	-0.605	-0.745
Rhone	-0.445	-0.265	0.220
Parador	0.665	0.635	-0.405
Solana	0.255	-0.320	0.540
Rioja	-0.750	0.765	0.160
Bardolino	0.520	-0.215	0.230
p-value	0.004	0.008	0.185
HSD	0.919	1.012	--
Variance	**23%**	17%	10%

Table 5.10: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel X.

	Panel X		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	-0.180	0.180	0.235
Rhone	0.105	-0.370	-0.225
Parador	0.750	-0.045	-0.325
Solana	-0.270	0.615	-0.205
Rioja	-0.435	-0.320	0.265
Bardolino	0.030	-0.060	0.260
p-value	0.056	0.263	0.675
HSD	--	--	--
Variance	22%	18%	13%

Table 5.11: Sample means for the first three GPA dimensions, with the ANOVA p-value and 5% HSD multiple comparison: Panel Y.

	Panel Y		
	Dim 1	**Dim 2**	**Dim 3**
Ventoux	0.250	0.510	0.075
Rhone	-0.165	0.205	0.280
Parador	-0.705	-0.725	0.010
Solana	0.685	0.010	-0.020
Rioja	-0.515	0.500	-0.045
Bardolino	0.455	-0.500	-0.305
p-value	0.002	0.038	0.973
HSD	0.787	1.296	--
Variance	28%	14%	11%

Table 5.12 summarises the number of significantly different pairs of samples, at the 5% significance level. From these results it can be seen that not many panels perform well, compared to what can potentially be achieved by a well trained panel. This suggests that either wine experience is a critical factor, or that the panels did not have sufficient training on the product.

Table 5.12: Number of significantly different sample pairs over 3 dimensions as calculated using Tukey's multiple comparison at the 5% level of significance.

Panel	Number
N6	14
O	6
P	0
Q	6
R	4
S6	8
T2	11
U	7
W	8
X	0
Y	6
Z	0

5.4 Agreement with the Expected Sample Map

Table 5.13 shows the RV coefficient to measure the agreement between each panel's consensus map and the expected sample map. As 6 out of 12 panels had RV coefficients of less than 0.5, this suggests that there was poor agreement.

Table 5.13: RV coefficient to measure the agreement between the expected sample map and the consensus maps from each panels.

Panel	Assessors
N6	0.970
O	0.678
P	0.420
Q	0.464
R	0.476
S6	0.562
T2	0.955
U	0.739
W	0.572
X	0.454
Y	0.497
Z	0.418

5.5 Agreement within a Panel

Agreement within a panel is measured by calculating two RV coefficients. Firstly, the RV coefficient between each pair of assessors is calculated, and the average taken to represent an average agreement between assessors (2nd column of Table 5.14). Secondly, the RV coefficient is measured between each assessor and the consensus, and then the average agreement with the consensus is calculated (3rd column of Table 5.14).

As expected, the average agreement between assessors is less than the average agreement between each assessor and the panel consensus.

Table 5.14: RV coefficient to measure the average agreement between each pair of assessors and between each assessor and the consensus map for each panel.

Panel	Assessors	Consensus
N6	0.575	0.781
O	0.528	0.753
P	0.395	0.686
Q	0.531	0.764
R	0.421	0.688
S6	0.409	0.682
T2	0.535	0.755
U	0.393	0.667
W	0.464	0.716
X	0.421	0.698
Y	0.441	0.695
Z	0.488	0.721
Expected	0.541	0.741

6. PANEL PERFORMANCE

This chapter outlines the steps for calculating the performance score for each panel, including those designated as validation panels. Normally, the validation panels would not be included in the results of the main ring trial, as they were used to set the performance criteria. However, for this report they are included for interest and comparison.

6.1 Step 1 – Number of Significant Dimensions

Table 6.1 shows the number of significant dimensions related to the GPA sample maps. The final column indicates the achieved score from the scheme proposed in Chapter 4. It is clear that only Panels N6 and T2 have performed better than expected.

Table 6.1: Number of significant dimensions, at the 5% significance level, together with the performance score.

Panel	Significant Dimensions	Score
N6	*3*	*3*
O	1	1
P	1	1
Q	1	1
R	1	1
S6	1	1
T2	3	3
U	1	1
W	2	2
X	0	0
Y	1	1
Z	1	1

Performance Scores for Step 1

Score 0	0 dimensions
Score 1	1 dimension
Score 2	2 dimensions
Score 3	3 dimensions

6.2 Step 2 – Number of Significantly Different Pairs

Table 6.2 shows the number of significantly different pairs as obtained across the 3 dimensional sample map derived from GPA. The final column indicates the achieved score from the scheme proposed in Chapter 4. It is clear that Panels N6 and T2 performed well.

Table 6.2: Number of significantly different pairs, at the 5% significance level, together with the performance score.

Panel	Number of Significant Pairs	Score
N6	14	7
O	6	2
P	0	0
Q	6	2
R	4	0
S6	8	4
T2	11	6
U	7	3
W	8	4
X	0	0
Y	6	2
Z	0	0

Performance Scores for Step 2

Score 0	≤ 4 pairs
Score 1	5 pairs
Score 2	6 pairs
Score 3	7 pairs
Score 4	8 pairs
Score 5	9 – 10 pairs
Score 6	11 – 12 pairs
Score 7	13 – 15 pairs

6.3 Step 3 – Agreement with Expected Sample Map

Table 6.3 shows the agreement between the panel consensus and the expected sample map, for each panel, together with the allocated performance score. It can be seen that only Panels N6 and T2 performed well, but this is as expected as these panels were used to define the performance criteria.

Table 6.3: RV coefficient to measure the agreement between the panel consensus and expected sensory maps, together with the performance score.

Panel	RV	Score
N6	0.970	5
O	0.678	2
P	0.420	0
Q	0.464	0
R	0.476	0
S6	0.562	1
T2	0.955	5
U	0.739	3
W	0.572	1
X	0.454	0
Y	0.497	0
Z	0.418	0

Performance Scores for Step 3

Score0	RV ≤ 0.50
Score 1	RV > 0.50
Score2	RV > 0.60
Score 3	RV > 0.70
Score 4	RV > 0.80
Score 5	RV > 0.90

6.4 Step 4 - Agreement within a Panel

Table 6.4 shows the RV coefficient to measure the average agreement between assessors within a panel, and also the average agreement between each assessor and the panel consensus.

Table 6.4: RV to measure agreement between assessors, and between each assessor and the panel consensus, together with the performance score.

Panel	Assessors	Score - a	Consensus	Score - b
N6	0.575	3	0.781	3
O	0.528	2	0.753	3
P	0.395	0	0.686	1
Q	0.531	2	0.764	3
R	0.421	0	0.688	1
S6	0.409	0	0.682	1
T2	0.535	2	0.755	3
U	0.393	0	0.667	1
W	0.464	1	0.716	2
X	0.421	0	0.698	1
Y	0.441	0	0.695	1
Z	0.488	1	0.721	2

Performance Scores for Step 4a		***Performance Scores for Step 4b***	
Score 0	RV ≤ 0.45	Score 0	RV ≤ 0.65
Score 1	RV > 0.45	Score 1	RV > 0.65
Score 2	RV > 0.50	Score 2	RV > 0.70
Score 3	RV > 0.55	Score 3	RV > 0.75
		Score 4	RV > 0.80

As with previous steps, most panels have performed poorly, though in this step at least all received a score for Step 3b.

6.5 Step 5 – Final Performance Score

Table 6.4 provides a summary of the performance of each panel over each of the 3 stages, together with the total performance score (Step 5).

Table 6.4: Summary of performance scores for Steps 1 to 4, together with the total score (Step 5) and the performance grade.

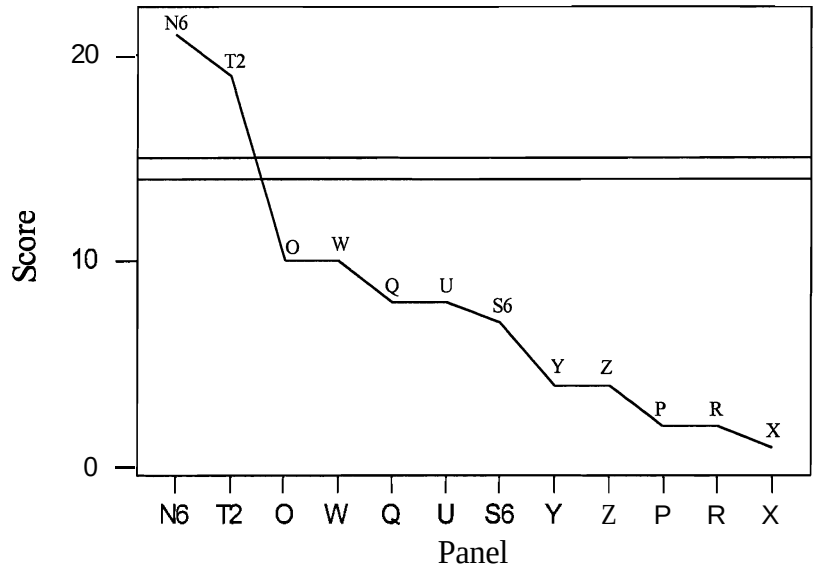
Panel	Step 1	Step 2	Step 3	Step 4a	Step 4b	Step 5	Performance
N6	**3**	**7**	5	**3**	**3**	21	***> expected***
O	1	2	2	**2**	**3**	10	< expected
P	1	0	0	**0**	**1**	2	< expected
Q	1	2	0	2	3	8	< expected
R	1	0	0	0	1	2	< expected
S6	1	4	1	0	1	7	< expected
T2	3	6	5	2	3	19	***> expected***
U	1	3	3	0	1	8	< expected
W	2	4	1	1	2	10	< expected
X	0	0	0	0	1	1	< expected
Y	1	2	0	0	1	4	< expected
Z	1	0	0	1	2	4	< expected
Expected	***2***	***5***	***4***	***2***	***2***	***14-15***	

Using the specified performance criteria few of the panels has performed particularly well. In fact, only 2 of the validation panels (N6 and T2) performed well, and they were used to set the criteria.

Graphical Representation

Figure 6.1 represents the final overall performance score as a histogram, illustrating the expected result band.

Figure 6.1: Wine Profile performance summary.



This graph illustrates that most panels performed below the expected result scoring range, with the exception of Panels N6 and T2. Panels O and W were closest to the expected overall score followed by Panels Q and U.

6.6 Remarks on the Performance Grade

From the case study on wine, it is apparent that few of the panels performed as well as expected. Even if the expected grade was set below what these good panels could achieve, then 10 of the 12 panels performed at a level below expected, both in the individual steps and overall. This raises some questions regarding the choice of samples and more importantly the choice of validation panels used to set the expected results. Nonetheless, even with lower criteria, for example an expected overall score of 10, 8 out of the 12 panels would still not have achieved this.

As previously stated the two panels (N6 and T2) with good discrimination ability were those used to set the level of performance expected of a well trained panel. One of these panels was a dedicated wine tasting panel, whilst the other was not. However, this panel trained in a specific way using the reference samples and descriptors.

7. GUIDANCE FOR FUTURE RING TRIALS

Based on the worked examples on wine, the performance scheme proposed in Chapter 4 was shown to discriminate between the laboratories. However, as most panels did not perform well, relative to the set expected results, some discussion is still required to refine the procedure for future ring trials.

7.1 Screening, Pre-testing and Validation

The importance of screening and pre-testing prior to undertaking validation cannot be over-emphasised. As demonstrated, the results of the first pre-test (original validation stage) were inconclusive due to differences in interpreting the instructions, particularly in relation to each assessor completing the duplicate assessments for all samples (Panel T). In addition, the diversity of results made it difficult to know the expected result.

The results of the second validation stage proved to be satisfactory for setting performance criteria, particularly as 2 of the 4 selected panels performed well in terms of discriminating between samples, and in the agreement within and between panels. However, there was an issue regarding whether the criteria were too harsh.

This particularly scenario raises the question of 'correct' selection of the validation panels for setting expected results. There is a good argument to use panels with past and demonstrated expertise with the product. This would allow the expected results to be set at a realistic level, but still allow criteria for expert panels to be built in, if required for a particular proficiency test. In addition, the wine results again raise the question of spiked samples rather than market place samples (Section 7.3).

7.2 Setting Performance Criteria

The setting of performance criteria was more difficult than the exercise undertaken on ranking (McEwan, 2001). However, it is still worth noting the importance of working through several scenarios prior to finalising the performance criteria. The final scheme was based on the results of working through several alternatives (not reported) and revising radically the proposed scheme from earlier work (McEwan, 2000).

In this exercise, one scenario was chosen based on the 'good' validation panel results, and subsequently demonstrated a poor (and unacceptable) performance for many of the main trial panels. However, even if the criteria on expected results were relaxed, the performance of most panels would still be below expected. Therefore, in this example proficiency test, panel performance was poor, probably due to the complexity of wine as a product, and the requirement for further training. Nonetheless, it should be remembered that performance criteria should be chosen on the basis of the data, and therefore should be reviewed for each new product or perhaps as a result of experience with previous proficiency tests.

Another critical point is the relative implied weighting of each step in the performance scheme, as this could have significant implications on the final overall performance score. In an earlier version of the performance criteria (not reported), Step 2 on the number of significantly different pairs of samples only scored between 0 and 3, thus minimising the importance of this step in relation to Step 3, for example. In fact, sample differences are an important outcome from profiling. For this reason, the revision adjusted Step 2 to score from 0 to 7, thus attaching more importance to this step.

It is acknowledged there are still issues that need to be considered in terms of improving the Performance Scheme further. It could be useful to develop a more statistically based weighting procedure for each of the steps. Moreover, the concept of confidence intervals could be an attractive option.

One final issue is the ability to compare results across proficiency tests. Clearly a laboratory will want to demonstrate improvement over time. However, the Performance Scheme will differ for different products and depending how challenging the task is in terms of perceptible differences between samples. More thought and work is required, as at present results can only really be compared within a proficiency test.

7.3 Selection of Samples for Profile Proficiency Testing

This project has undertaken two proficiency tests, one on spiked tomato soup (flavour and thickener) and one on commercial red wine. With the benefit of experience, it would appear that neither product was ideal, though the wine trial yielded better and more useful data than the tomato soup trial (McEwan, 2000).

It could be worth examining the BAPS scheme (Brewing Analytes Proficiency Testing Scheme) on beer, where encapsulated flavours are used (Boughton *et al.*, 1999; Simpson, 1999). However, the addition of one flavour at a time is too simplistic for a profiling exercise, so the addition of up to 4-5 flavours or ingredients would be more useful. In addition, alcohol does pose problems for panels due to drink driving considerations. Nonetheless, a task for further discussion could be the use of encapsulated flavours in another type of product, according to an experimental design.

Further work could usefully consider developing several realistic product systems for profiling proficiency tests. This could be important for the financial viability of running such a scheme, as undertaking validation for profiling is an expensive exercise.

7.4 The Common Attribute Debate

Much discussion has taken place regarding the value of common attributes as part of the proficiency test. This case study demonstrated that their use is still under question, though this is surprising for the use of the basic tastes, which should be common to all panels.

Clearly, in an international proficiency test, common attributes need to be understood across languages, and this is a major barrier for all cross-cultural studies. The use of references is a logical solution, but this too has problems. Many sensory scientists believe that the panel should be free to develop and define their own terminology. Thus, forcing the use of an attribute goes against this principle. It is the task of further research to resolve whether there is a place for common attributes in descriptive profiling proficiency tests.

REFERENCES

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McEwan, J.A. (2000). Proficiency Testing for Sensory Profile Tests: Statistical Guidelines. Part 1. R&D Report No. 119. CCFRA.

McEwan, J.A. (2001). Proficiency Testing for Sensory Ranking Tests: Statistical Guidelines. Part 2. R&D Report No. 126. CCFRA.

Simpson, B. (1999). Validation of Beer Taster Performance. The Brewer, September, 444-451.

APPENDIX 1: PANELS PARTICIPATING IN WINE TRIALS

First Validation Stage (Pre-test)

Panel	Assessors	Attributes	Scale Range	Scale Type
N	11	18	0 – 9	Continuous
S	9	21	0 – 100	Continuous
T	5	21	0 - 100	Continuous

Second Validation Stage

Panel	Assessors	Attributes	Scale Range	Scale Type
N6	11	18	0 – 9	Continuous
T2	10	24	0 - 100	Continuous
U	11	25	1 - 9	Continuous
Z	13	20	0 - 100	Continuous

Main Trial

Panel	Assessors	Attributes	Scale Range	Scale Type
O	10	25	0 - 100	Continuous
P	7	22	0 - 100	Continuous
Q	8	30	0 - 100	Continuous
R	9	24	0 - 10	Continuous
S2	9	21	0 - 100	Continuous
W	10	26	0 – 10	Continuous
X	8	20	0 - 15	Continuous
Y	11	23	1 - 9	Category

Scales (convert to 0 – 100)

To convert the scales to all range from 0 to 100, the following procedure should be used. Let the current scale range from a to b, and the target scale range from A to B and let X denote the original value and Y denote the target value.

$$Y = \frac{[(B - A)*X + A*b - B*a]}{b - a}$$

In the case A = 0, the formula can be simplified.

APPENDIX 2: 1" STAGE SENSORY ATTRIBUTES

Training Attributes

High in full-body	Cote de Ventoux	La Vieille Ferme Rouge	France
High in harsh/dry and bitter	Corbiere	Ch. Les Ollieux Romanis	France
High in spicy	Cotes du Rhone	Chateau Malijay 1995	France
High in sweetness	Parador	Parador	Spain
High in berry	Solana	Solana Red	Spain
High in oak/barrel	Rioja	Campo Viejo Reserva 1994	Spain
High in sugar	Bardolino	Cadis Bardolino 1998	Italy
Low body, harsh and oak	Veneto	Cadis Rosso 1998	Italy

Panel N

	Category	Attribute	Abbreviation	Definition
1	Odour	Intensity	Intense-0	A stratification of different fragrances which creates a bulk of sensations more or less intense
2	Odour	Persistence	Persist-0	A range of sensations which affect the olfactory organ for a longer or shorter time
3	Odour	Fruity (berry)	FruitBerry-O	Scent combining different smells of berry
4	Odour	Dried h i t s	FruitDry-O	Scent combining different smells of dried fruits
5	Odour	Spicy	Spicy-0	A smell which remind the aromas of spices
6	Odour	Oaky/barrel	Oaky-O	A smell which remind the odour of oak/barrel
7	Odour	Vegetal/green	Vegetal-O	A smell which remind the odour of green vegetables /grass-like
8	Odour	Herbal	Herbal-0	A smell which remind the odour of herbs
9	Odour	Floral	Floral-0	A scent of different withered red flowers
10	Taste	Sweet	Sweet	Basic taste associated to sucrose
11	Taste	Sour	Sour	Basic taste associated to organic acids
12	Taste	Salty	Salt	Basic taste associated to mineral salts
13	Taste	Bitter	Bitter	Basic taste associated to polyphenols (tannins)
14	Flavour	Intensity	Intensity-F	A stratification of gustatory, tactile and olfactory sensation
15	Flavour	Persistence	Persist-F	Longer or shorter duration of taste and tactile sensations
16	Flavour1 Mouthfeel	Alcoholic	Alcohol-FM	Warming/burning sensation in the mouth due to alcohol
17	Mouthfeel	Tannic	Tannic	Binding and drying sensation in the mouth due to tannins
18	Mouthfeel	Consistency	Consistency	Overall sensation of fluidity (mouthfeel)

Panel - S

	Category	Attribute	Abbreviation	Definition
1	Odour	Strength	Strength-0	Overall intensity of all odours present
2	Odour	Alcoholic	Alcohol-0	Ethanolic, fumy, solvent, alcohol
3	Odour	Fruity – Red Fruits	FruitRed-O	Reminiscent of raspberries, blackcurrants, strawberries, Summer Pudding etc.
4	Odour	Fruity – Dried Fruits	FruitDry-O	Dried h i t s (dates, raisins etc.)
5	Odour	Spicy	Spicy-0	Reminiscent of black pepper, cloves, cinnamon
6	Odour	Herbal	Herbal-0	Fresh or dried herbs e.g. peppermint, bay leaves
7	Odour	Woody/Oaky	Woody-0	Oak, cedarwood, pencil shavings
8	Odour	Vegetal	Vegetal-O	Sulphury, cabbage, drains
9	Mouthfeel	Astringent	Astringent	Mouth drying, mouth stripping, teeth coating, tannic
10	Mouthfeel	Body	Body	Thickness in the palate, from thin/watery (low) to thick/heavy (high)
11	Flavour	Strength	Strength-F	Overall intensity of all flavours present
12	Flavour	Fruity – Red Fruits	FruitRed-F	Reminiscent of raspberries, blackcurrants, strawberries, Summer Pud etc.
13	Flavour	Fruity – Dried Fruits	FruitDry-F	Dried fruits (dates, raisins etc.)
14	Flavour	Spicy	Spicy-F	Reminiscent of black pepper, cloves, cinnamon
15	Taste	Sweet	Sweet	Reminiscent of sucrose, a basic taste
16	Taste	Acid	Acid	Sharp, sour, citric
17	Flavour	Herbal	Herbal-F	Fresh or dried herbs e.g. peppermint, bay leaves
18	Flavour	Woody/Oaky	Woody-F	Oak, cedarwood, pencil shavings
19	Flavour	Vegetal	Vegetal-F	Sulphury, cabbage, drains
20	Aftertaste	Alcoholic	Alcohol-AT	Leaving a warming sensation
21	Aftertaste	Bitter	Bitter-AT	Reminiscent of quinine sulphate, a basic taste

Panel T

	Category	Attribute	Abbreviation	Definition
1	Flavour	Total impact	Total-F	
2	Flavour	Alcohol/burning	Alcohol-F	
3	Taste	Sweet	Sweet	
4	Taste	Sour	Sour	
5	Flavour/Mouth	Smooth	Smooth	
6	Mouthfeel	Full-bodied	FullBody	
7	Mouthfeel	Astringent	Astringent	
8	Mouthfeel	Dry	Dry	
9	Flavour	Berry	Berry-F	
10	Flavour	Blackcurrant	Backcurrant-F	
11	Flavour	Fruity	Fruity-F	
12	Flavour	Spicy/Herbs	SpicyHerby-F	
13	Flavour	Vanilla	Vanilla-F	
14	Flavour	Oak	Oak-F	
15	Flavour	Cedar	Cedar-F	
16	Flavour	Earthy	Earthy-F	
17	Flavour	Burnt	Burnt-F	
18	Flavour	Dried fruit/Raisin	FruitDry-F	
19	Flavour	Metallic	Metal-F	
20	Taste	Bitter	Bitter	
21	Aftertaste	Aftertaste	Aftertaste	

Note: no definitions provided.

APPENDIX 3: VALIDATION STAGE SENSORY ATTRIBUTES

Panel N6

These data were a subset from the first pre-test, so the attributes remain the same (Panel N).

Panel T2

	Category	Attribute	Abbreviation	Definition
1	Odour	Total impact	Impact-O	Overall intensity of all odours present
2	Odour	Berry / Fruity	Berry-O	Smells of berry and/or fruit
3	Odour	Dried Fruit	DryFruit-O	Smells of dried fruits (raisins, figs etc.)
4	Odour	Blackcurrant	Blackcurrant-O	Blackcurrant
5	Odour	Vegetal / Sulphur	Vegetal-O	Boiled vegetables (cauliflower etc.), sulphur
6	Odour	Spicy	Spicy-O	Spices and herbs
7	Odour	Barrel	Barrel-O	Oak, cedar, vanilla
8	Odour	Earthy	Earthy-O	Humus, earth, earth cellar, decaying leaves
9	Flavour	Total impact	Impact-F	Overall intensity of all flavours present
10	Flavour	Alcohol / Burning	Alcohol-F	Warming/burning sensation in the mouth due to alcohol
11	Taste	Sweet	Sweet	Basic taste associated to sucrose
12	Flavour	Berry / Fruity	Berry-F	Different tastes of berry and/or fruit
13	Mouthfeel	Smooth	Smooth-MF	Sensation of softness in the palate
14	Mouthfeel	Full-bodied	FullBody-MF	Thickness in the palate, from thin/watery (low) to thick/heavy (high)
15	Taste	Sour	Sour	Basic taste associated to organic acids
16	Mouthfeel	Astringent / Dry	Astringent-MF	Mouth drying ,teeth coating, tannic
17	Flavour	Spicy	Spicy-F	Spices and herbs
18	Flavour	Oaky / Woody	Woody-F	Wood, oak, cedar
19	Taste	Bitter	Bitter	Basic taste
20	Aftertaste	Total impact	Impact-AT	Overall intensity of the aftertaste
21	Aftertaste	Berry	Berry-AT	Leaving a taste of berry
22	Aftertaste	Sour	Sour-AT	Leaving a taste of acidity
23	Aftertaste	Astringent	Astringent-AT	Leaving a mouth drying sensation
24	Aftertaste	Bitter	Bitter-AT	Leaving a bitter taste

Panel U

	Category	Attribute	Abbreviation	Definition
1	Odour	Aroma of alcohol	Alcohol-0	Smell of alcohol/spirits
2	Odour	Fruit/berry aroma	Berry-0	Smell of fresh berries like blackbeny, cherry, pear
3	Odour	Acidic aroma	Acid-0	Smell of citric acid, tartaric acid
4	Odour	Spicy aroma	Spicy-0	Smell of spices like rosmarin, cinnamon, pepper
5	Odour	Woody, burned aroma	Woody-0	Smell of cut wood
6	Odour	Vanilla aroma	Vanilla-0	Smell of vanilla
7	Odour	Complexity of aroma	Complex-0	The complexity of smell - number of different smells
8	Odour	Chemical aroma	Chemical-0	Pungent chemical smell, sulfury, rubber, petroleum
9	Odour	Earthy/organical aroma	Earthy-0	Smell of animalsweat, urine, earth, rotten leaves
10	Odour	Vegetative aroma	Vegetal-O	Smell of bell pepper, blackberry leaves, aspargus
11	Odour	Harmonious aroma	Harmonious-0	The balanse of smells
12	Taste	Flavour of alcohol	Alcohol-F	Taste of alcohol/spirits
13	Taste	Fruit/berry taste	Berry-F	Taste of fruit and berries
14	Taste	Acidic taste	Acid	Taste of citric acid, tartaric acid
15	Taste	Spicy taste	Spicy-F	Taste of spices like rosmarin, cinnamon and pepper
16	Taste	Woody, burned taste	Woody-F	Taste of cut wood
17	Taste	Vanilla taste	Vanilla-F	Taste of vanilla
18	Taste	Body	Body-F	body: the richness of tastes- complexity of tastes
19	Taste	Chemical taste	Chemical-F	Pungent taste, sulfur, rubber, petroleum, metal
20	Taste	Earthy/organical taste	Earthy-F	Taste of animalsweat, urine, earth, rotten leaves
21	Taste	Vegetative taste	Vegetal-F	Taste of bell pepper, blackberry leaves, aspargus
22	Taste	Bitter taste	Bitter	Taste of black olive
23	Texture	Astringency	Astringent-MF	Astringency
24	Taste	Harmonius taste	Harmonious-F	The balanse of taste
25	Aftertaste	Aftertaste	Aftertaste	The intensity of taste after one minute in the mouth

Panel Z

	Category	Attribute	Abbreviation	Definition
1	Odour	Overall intensity	Intense-0	Overall intensity of odour by sniffing
2	Odour	Berry-like	Berry-0	Odorous characteristic associated with berries (strawberry, black currant etc.)
3	Odour	Woody (oak)	Woody-0	Odorous characteristic associated with wood barrels (oak etc.)
4	Odour	Sulphurous	Sulphur-0	Odorous characteristic associated with hydrogen sulphide (rotten egg etc.)
5	Odour	Floral	Floral-0	Odorous characteristic associated with flowers ('sweet odour')
6	Odour	Musty	Musty-0	Odorous characteristic associated with wet basements or turned soil
7	Odour	Alcoholic	Alcohol-0	Odorous characteristic associated with ethyl alcohol ('warming odour')
8	Mouthfeel	Richness	Rich-0	Mouthfeel sensation blooming throughout the mouth (rich), opposite to 'light' mouthfeel
9	Mouthfeel	Astringency	Astringent-MF	Mouthfeel sensation associated with tannins
10	Flavour	Overall intensity	Intense-F	Overall intensity of flavour in mouth while tasting
11	Flavour	Berry-like	Berry-F	Flavour characteristic associated with berries (strawberry, black currant etc.)
12	Flavour	Sourness	Sour	Basic taste associated with acids (citric acid etc.)
13	Flavour	Woody (oak)	Woody-F	Flavour characteristic associated with wood barrels (oak etc.)
14	Flavour	Bitterness	Bitter	Basic taste associated with bitter tasting compounds (caffeine etc.)
15	Flavour	Sweetness	Sweet	Basic taste associated with sugras (sucrose etc.)
16	Flavour	Spicyness	Spicy-F	Flavour associated with spices (peppers etc.)
17	Flavour	Alcoholic	Alcohol-F	Flavour characteristic associated with ethyl alcohol ('warming flavour')
18	Flavour	Musty	Musty-F	Flavour characteristic associated with wet basements or turned soil
19	After-taste	Overall intensity	Intense-AT	Overall intensity of after-taste after spitting the wine out
20	After-taste	Length	Length-AT	Length of the after-taste

APPENDIX 4: MAIN TRIAL SENSORY ATTRIBUTES

Panel O

	Category	Attribute	Abbreviation	Definition
1	Odour	Pungent	Pungent-0	Physically penetrating sensation in the nasal cavity. Sharp smelling irritant
2	Odour	Sulphur	Sulphur-0	Sulphur odours ranging slight sulphur to cooked cabbage
3	Odour	Farmyard/vegetal	Vegetal-O	Smell associated with farmyard (silage, musty, damp, barny)
4	Odour	Burnt, smoky, acrid	Burnt-0	Penetrating aromatics of charred substances including wood. Tainted by exposure to smoke.
5	Odour	Fresh	Fresh-0	Outside in the garden and airy.
6	Odour	Berries	Berry-0	Blackberries, mixed berries, blackcurrants
7	Odour	Sweet fruit	SweetFruit-O	Raspberry (syrup), strawberry (syrup)
8	Odour	Tart fruit	TartFruit-O	Sourlcrab apple, citrus, gooseberry
9	Odour	Any spice	Spicy-0	Smell associated with any spice including pepper
10	Odour	Perfume	Perfume-0	Floral, incense
11	Mouthfeel	Body	Body-MF	Weight of the wine in you mouth
12	Flavour	Sweetness	Sweet	Fundamental taste sensation of which sucrose is typical.
13	Flavour	Acidity	Acid	Sour, tangy, citrus-like. The fundamental taste sensations of which lactic acids and citric acids are typical. May also be associated with a vinegar/sharp flavour
14	Flavour	Bitter	Bitter	Chemical-like, disprin, asprin. Taste sensations of which caffeine and quinine are typical.
15	Flavour	Berries	Berry-F	Mixed fruit, blackcurrant, blackberries
16	Flavour	Tart fruit	TartFruit-F	Sour/crab apple, citrus, gooseberries
17	Flavour	Sweet fruit	SweetFruit-F	Strawberries, raspberries
18	Flavour	Complexity	Complex-F	The number of attributes found. Assessed by measuring the number of odour, flavour and after flavour attributes scored
19	After Flavour	Mixed spices	Mixspice-AT	Flavour of any spice lingering in the mouth
20	After Flavour	Acidic	Acid-AT	Sour, tangy, citrus-like lingering in the mouth
21	After Flavour	Bitter	Bitter-AT	Chemical-like, disprin, asprin. Taste sensations of which caffeine and quinine are typical lingering in the mouth
22	After Flavour	Sweet jammy fruit	SweetFruit-AT	Flavour lingering in the mouth reminiscent of jam
23	After Flavour	Artificial sweet	Artsweet-AT	Artificial sweet flavour reminiscent of candy or confectionery
24	After Flavour	Astringent	Astringent-AT	Mouth-drying, harsh. The complex of drying, puckering and shrinking sensations in the lower cavity causing contractions of the body tissue.
25	After Flavour	Alcohol	Alcohol-AT	Sensation of 'heat' in the mouth remaining after the wine has been spit out.

Panel P

	Category	Attribute	Abbreviation	Definition
1	Odour	Disinfectant	Disinfectant-O	Odour disinfectant, alcohol and ether
2	Odour	Pungent	Pungent-O	A pungent and sharp odour
3	Odour	Caramelised	Caramel-O	A caramelised and sweet odour
4	Odour	Berry	Berry-O	Odour of strawberry, raspberry and black currant
5	Odour	Dried fruit	DryFruit-O	Odour of dried fruit:raisin, plum and fig
6	Odour	Spicy	Spicy-O	Odour of pepper and clove
7	Odour	Woody	Woody-O	Odour of cedar and oak
8	Odour	Burnt	Burnt-O	Odour of burnt/toast
9	Odour	Earthy	Earthy-O	Odour of earth and earth cellar
10	Taste	Alcohol	Alchohol-F	Taste of alcohol
11	Taste	Sweet	Sweet	Sweet taste
12	Taste	Berry	Berry-F	Taste of strawberry, raspberry and black currant
13	Taste	Dried fruit	DryFruit-F	Taste of dried fruit: raisin ,plum and fig
14	Taste	Spicy	Spicy-F	Taste of pepper ,clove
15	Taste	Woody	Woody-F	Taste of cedar and oak
16	Taste	Burnt	Burnt-F	Taste of burnt /roasted
17	Taste	Acid	Acid	Taste of citric acid
18	Taste	Bitter	Bitter	Taste of quinine
19	Mouthfeel	Astringent	Astringent-MF	A harsh and astringent feeling
20	Mouthfeel	Pricking	Prickling-MF	A pricking and overpowering feeling
21	Mouthfeel	Full-bodied	FullBody-MF	A full-bodied mouthfeeling
22	Aftertaste	Aftertaste	Aftertaste	Olfactory sensation which occurs after elimination of the product

Panel Q

	Category	Attribute	Abbreviation	Definition
1	Odour	Odour intensity	Intense-0	Total impression of the intensity of the odour
2	Odour	Alcohol	Alcohol-0	Intensity of the alcohol odour
3	Odour	Flowery	Flowery-0	Intensity of the odour of flowers, including odours fresh flowers and of flowers of shrubs and trees
4	Odour	Forest/vegetal mould	Vegetal-O	Odour of potting compost, peat, moss, mould, hay, green leaves, withered leaves
5	Odour	Fruity	Fruity-0	Odour of different fruits like apples, pears, apricots, mandarins, cherries, grapefruit etc.
6	Odour	Herby	Herby-0	The odour of thyme, mace, chervil, dill, fennel, nutmeg, pepper, clove etc, but the odour of leather and tobacco too
7	Odour	Wood	Wood-0	The odour of raw wood, like: cedar, oak, but liquorice (different forms and types) too
8	Odour	Chemical	Chemical-0	Chemical odours like sulphur, nail polish, iodine and disinfectant odours
9	Odour	Sour	Sour-0	Intensity of the sour odour
10	Flavour	Flavour intensity	Intense-F	The total impression of the total flavour intensity
11	Flavour	Alcohol	Alcohol-F	The intensity of the alcohol flavour
12	Flavour	Bitter	Bitter	The intensity of the bitter taste
13	Flavour	Black currant	Blackcurrant-F	The intensity of black currant, cherry and other red fruits
14	Flavour	Fruity	Fruity-F	The intensity of the fruity flavour, like: apple, pear, apricot, orange, grapefruit
15	Flavour	Wood	Wood-F	The intensity of the wood flavour
16	Flavour	Iron	Iron-F	The intensity of the iron-like, metallic flavour (like blood?)
17	Flavour	Herby	Herby-F	The intensity of the herby flavour
18	Flavour	Sweet	Sweet	The intensity of the sweet taste
19	Flavour	Sour	Sour	The intensity of the sour taste
20	Mouthfeel	Warm	Warm-MF	The temperature of the wine when you take the first sip
21	Mouthfeel	Dry	Dry-MF	The rough feeling caused by having wine in your mouth
22	Mouthfeel	Burning	Burning-MF	The burning feeling in your mouth caused by the acid in the wine and the alcohol
23	Mouthfeel	Astringent	Astringent-MF	The sour/bitter feeling which is responsible for feeling the mouth screwing up ('not possible to translate')
24	After-taste	After-taste intensity	Intense-AT	The total impression of the total after-taste intensity
25	After-taste	Alcohol	Alcohol-AT	The intensity of the alcohol after-taste
26	After-taste	Fruity	Fruity-AT	The intensity of the fruity after-taste
27	After-taste	Wood	Wood-AT	The intensity of the woody after-taste
28	After-taste	Iron	Iron-AT	The intensity of the iron-like/metallic after-taste
29	After-taste	Sour	Sour-AT	The intensity of the sour after-taste
30	After-taste	Ashingent	Ashingent-AT	The intensity of the bitter/sour taste in the mouth

Panel R

	Category	Attribute	Abbreviation	Definition
1	Odour	Sharp	Sharp-0	Irritating sensation perceived when sniffing
2	Odour	Sour	Sour-0	Odour characteristic for unripe fruits volatiles (e.g. apples and plums)
3	Odour	Astringent-like	Astringent-0	Olfactory sensation of tartness perceived when sniffing
4	Odour	Alcoholic	Alcohol-0	Characteristic for ethanol
5	Odour	Caramel-like	Caramel-0	Characteristic odour of slightly caramelised sugar, can be also found in "heavy", sweet wine
6	Odour	Sweet	Sweet-0	Mild, honey-like or nectar-like odour
7	Odour	Floral	Floral-0	Characteristic for flowers like jasmine or honeysuckle
8	Odour	Fruity-natural	FruitNatural-O	Characteristic for fresh fruits juice from grapes, blackcurrants, cherry etc.
9	Odour	Fruity-artificial	FruitArtif-O	Characteristic for artificial flavourings (aromas) of fruit type
10	Odour	Almond-like	Almond-0	Characteristic for bitter almonds or cherry stones
11	Odour	Young wine-like	YoungWine-O	Characteristic for young, still fermenting red wine with yeasty note
12	Odour	Cucumber brine-like	Cucumber-0	Characteristic for lactic fermented cucumbers brine, with dominant note of dill seeds
13	Odour	Musty	Musty-0	Characteristic for wet old cellar
14	Odour	Odour "body"	Body-0	Overall perception of odour intensity, fullness and harmonisation
15	Taste	Sour	Sour	Basic taste
16	Mouthfeel	Astringent	Astringent-MF	Dry feeling in the mouth resulted by tannins
17	After-taste	Pungent	Pungent-AT	Feeling of pungency on the edges of tongue, developing as after-taste
18	Flavour	Alcoholic	Alcohol-AT	Characteristic for ethanol, with warming effect in the niouth
19	Flavour	Young wine-like	YoungWine-F	Characteristic for young, still fermenting red wine
20	Flavour	Fruity-natural	FruitNatural-F	Characteristic for fresh fruits juice from grapes, blackcurrants, cherry etc.
21	Taste	Sweet	Sweet	Basic taste
22	Taste	Bitter	Bitter	Basic taste
23	Taste	Salty	Salty	Basic taste
24	Flavour	Flavour "body"	Body-F	Overall perception of flavour intensity, fullness and harmonisation

Panel W

	Category	Attribute	Abbreviation	Definition
1	Aroma	Overall strength	Strength-0	The overall strength of aroma perceived when the lid is removed from the glass.
2	Aroma	Blackcurrant aroma	Blackcurrant-O	the strength of blackcurrant aroma perceived.
3	Aroma	Dried fruit aroma	DryFruit-O	the strength of dried fruit aroma (e.g. raisins, mincemeat)
4	Aroma	Other fruit aroma	'Not used'	the strength of other fruit aroma (e.g. red fruits, citrus fruits). describe.
5	Aroma	Spicy aroma	Spicy-0	the strength of spicy aroma (e.g. cinnamon, Christmas cake, mulled wine)
6	Aroma	Peppery aroma	Peppery-O	the strength of peppery aroma (e.g. black pepper, white pepper)
7	Aroma	Woody aroma	Woody-0	the strength of woody aroma (e.g. oak)
8	Aroma	Medicinal aroma	Medicinal-0	the strength of medicinal aroma (e.g. tunes, antiseptic, herbs, eucalyptus)
9	Aroma	Acetone aroma	Acetone-0	the strength of acetone aroma (e.g. pear drops, paint stripper)
10	Aroma	Other aroma	'Not used'	the strength of an other aroma not previously scored. describe.
11	Flavour	Overall strength	Strength-F	the overall strength of flavour perceived in the mouth.
12	Flavour	Blackcurrant flavour	Blackcurrant-F	the strength of blackcurrant flavour
13	Flavour	Dried fruit flavour	DryFruit-F	the strength of dried fruit flavour (e.g. raisins, mincemeat)
14	Flavour	Orange flavour	Orange-F	the strength of orange flavour (e.g. citrus, candied peel).
15	Flavour	Other fruit flavour	'Not used'	the strength of other fruit flavour (e.g. red fruits). please describe.
16	Flavour	Spicy flavour	Spicy-F	the strength of spicy flavour (e.g. cinnamon, Christmas cake, mulled wine)
17	Flavour	Peppery flavour	Peppery-F	the strength of peppery flavour (e.g black pepper, white pepper).
18	Flavour	Woody flavour	Woody-F	the strength of woody flavour (e.g. oak)
19	Flavour	Medicinal flavour	Medicinal-F	the strength of medicinal flavour (e.g. tunes, antiseptic, herbs, eucalyptus)
20	Flavour	Nutty flavour	Nutty-F	the strength of nutty flavour (e.g. almonds, walnuts).
21	Flavour	Sweet taste	Sweet	the level of sweet taste associated with sucrose.
22	Flavour	Acidic taste	Acid	the level of acidic taste (e.g. vinegar, lemon juice).
23	Flavour	Bitter taste	Bitter	the level of bitter taste associated with tannin or caffeine.
24	Flavour	Other flavour	'Not used'	the strength of an other flavour not previously scored. please describe.
25	Mouthfeel	Thickness	Thick-MF	the viscosity of the sample in the mouth.
26	Mouthfeel	Hot sensation	Hot-MF	the level of hot sensation felt on the inside of the mouth before the sample is spat out
27	Mouthfeel	Astringent	Astringent-MF	the level of astringent/dry feel perceived before the sample is spat out.
28	Mouthfeel	Tingling	Tingling-MF	the level of tingling felt around the inside of the mouth before the sample is spat out
29	Aftertaste	Astringent afterfeel	Astringent-AT	the level of astringent/dry feel perceived after the sample has been spat out.
30	Aftertaste	Strength	Strength-AT	the strength of flavours/tastes perceived after the sample has been spat out.

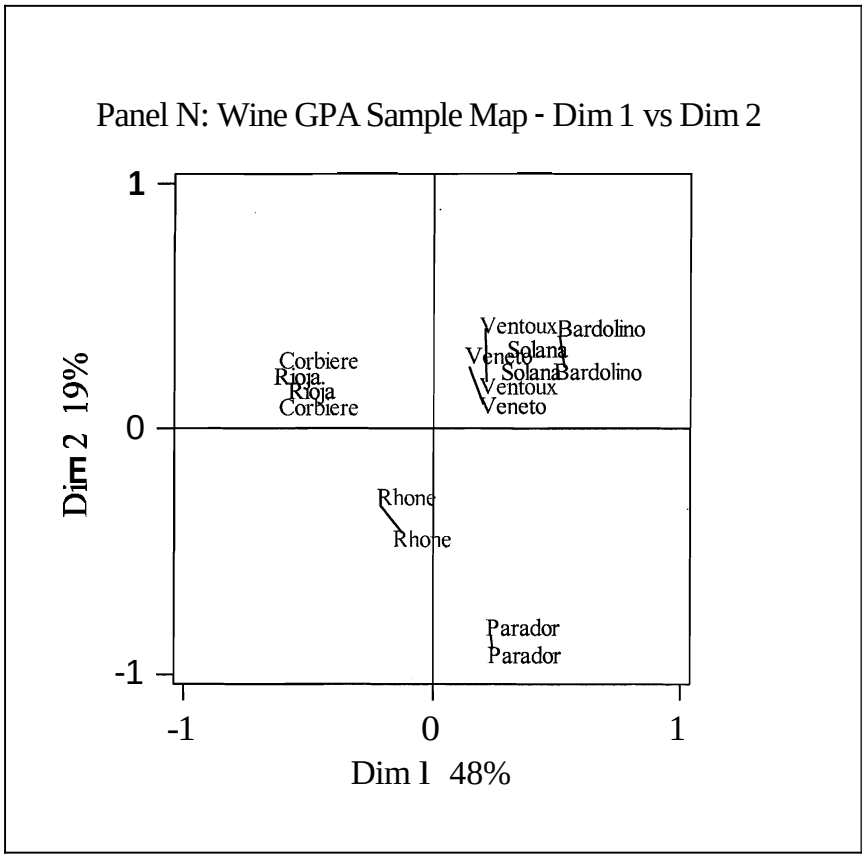
Panel X

	Category	Attribute	Abbreviation	Definition
1	Smell	Spirit (alcohol)	Alcohol-0	How much the sample smells of pure alcohol.
2	Smell	Berry /grape	Berry-0	How much the sample smells of berry and/ or grapes.
3	Smell	Acidic	Acid-0	How acidic the sample smells.
4	Smell	Earthy /mould	Earthy-0	How much the sample smells of soil /mould. A slightly heavy and dark smell.
5	Smell	Spicy	Spicy-0	How much the sample smells spicy .
6	Smell	Elderberry	Elderberry-0	How much the sample smells of Elderberry.
7	Smell	Chemical	Chemical-0	How much the sample smells chemical/ sulphurous.
8	Mouthfeel	Drying	Dry-MF	How much the sample feels, that it dry out the mouth.
9	Mouthfeel	Astringent	Astringent-MF	How much the sample feels, astringent in the mouth.
10	Mouthfeel	Sticky	Sticky-MF	How much the sample gets sticky in the mouth.
11	Taste	Acidic	Acid1	How acidic the taste is.
12	Taste	Spirit (alcohol)	Alcohol-F	How much the sample has a taste of alcohol.
13	Taste	Berry /grape	Beny-F	How much the sample has a taste of Berry or grape.
14	Taste	Elderberry	Elderberry-F	How much the sample has a taste of Elderberry.
15	Taste	Spicy	Spicy-F	How much the sample has a spicy taste
16	Taste	Earthy /mould	Earthy-F	How much the sample has a taste of soil and mould.
17	Taste	Acidic	Acid2	How much real sour taste the sample has.
18	Taste	Bitter	Bitter	How much bitter taste the sample has.
19	Aftertaste	Spicy-aftertaste	Spicy-AT	How much of the aftertaste is spicy.
20	Aftertaste	Bitter-aftertaste	Bitter-AT	How bitter the aftertaste is.

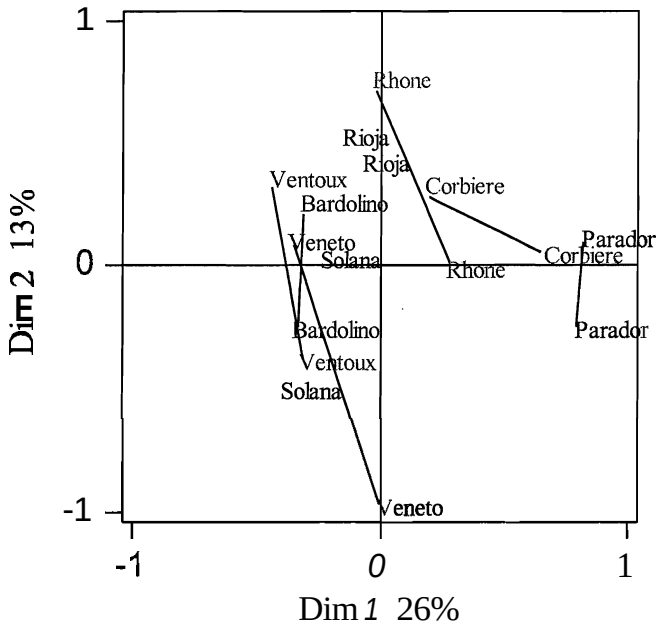
Panel Y

	Category	Attribute	Abbreviation	Definition
1	Odour	Global odour	Global-0	Global intensity of smell, no matter what type of smell
2	Odour	Fruity odour	Fruity-0	Refreshing feeling the nose, near of the natural freshness of grape
3	Odour	Smoke odour	Smoke-0	Fire of wood, chimney, smell of the embers at the end of a fire
4	Odour	Red fruits' odour	RedFruit-O	Raspberry, mulberry, strawberry, bilberry, blackcurrant
5	Odour	Prune's odour	Prune-0	Candied prunes, prunes steeped in alcool and sugar
6	Odour	Liquorice's odour	Liquorice-0	
7	Odour	Oakharrel odour	Oak-0	
8	Odour	Undergrowth's odour	Undergrowth-0	Undergrowth in autumn : moulds, mushrooms , wet leaves
9	Mouthfeel	Thickness in mouth	Thick-MF	
10	Mouthfeel	Covering	Cover-MF	Sensation of covering the tongue, leaving a film on the tongue
11	Flavour	Strength of global taste	Global-F	Global intensity of taste, no matter what type of taste
12	Flavour	Well-built	Complex-F	Complexity, richness of the wine in mouth
13	Flavour	Red fruits' flavour	RedFruit-F	Raspberry, mulberry, strawberry, bilberry, blackcurrant
14	Flavour	Mushroom flavour	Mushroom-F	
15	Flavour	Cherry stone flavour	Cherrystone-F	
16	Flavour	Oakharrel flavour	Oak-F	
17	Flavour	Spicy flavour	Spicy-F	Pepper, cinnamon, cloves, nutmeg, …
18	Mouthfeel	Prickly	Prickly-MF	Feeling of prickling at the end of the tongue (mechanic feeling)
19	Taste	Acid taste	Acid	
20	Taste	Bitter taste	Bitter	
21	Mouthfeel	Astringent taste	Astringent	Sensation of the tannins, sensation of drying out of the mouth, contraction of the mucous membranes (mechanic feeling)
22	Flavour	Alcohol	Alcohol-F	Warms up, bums in mouth
23	Flavour	Length in mouth	Length-F	Long lasting, persistence of aroma in mouth

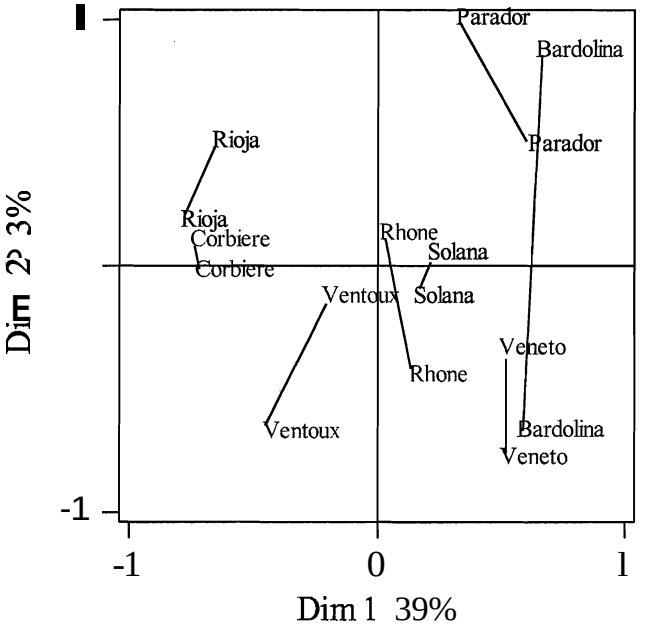
APPENDIX 5: GPA SAMPLE MAPS – 1" STAGE



Panel S: Wine GPA Sample Map - Dim 1 vs Dim 2



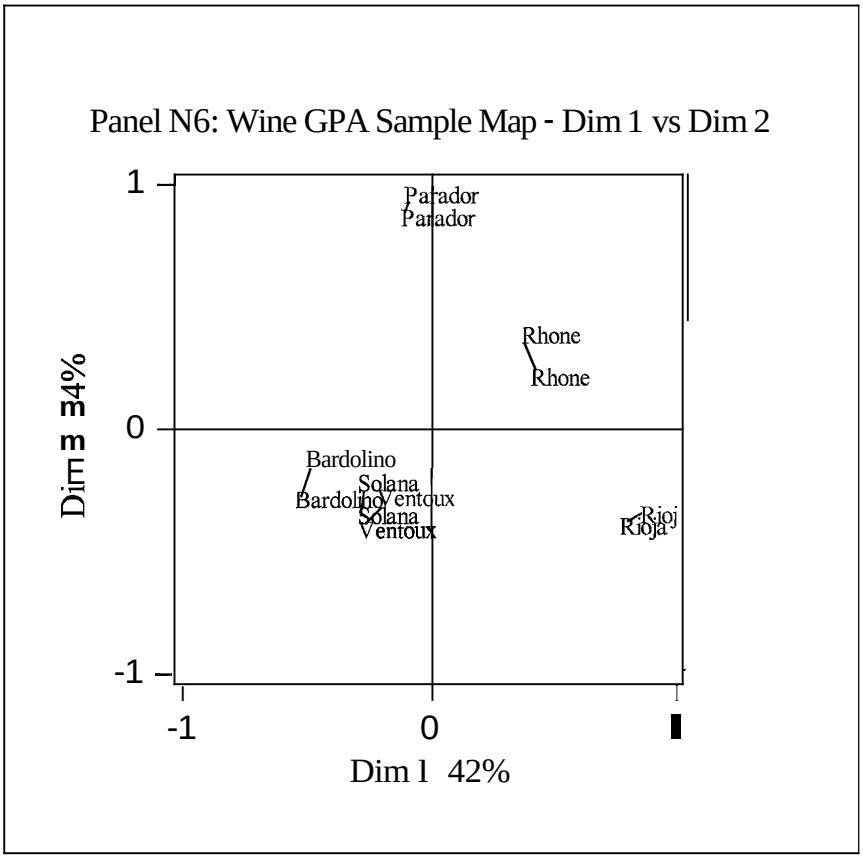
Panel T: Wine GPA Sample Map - Dim 1 vs Dim 2

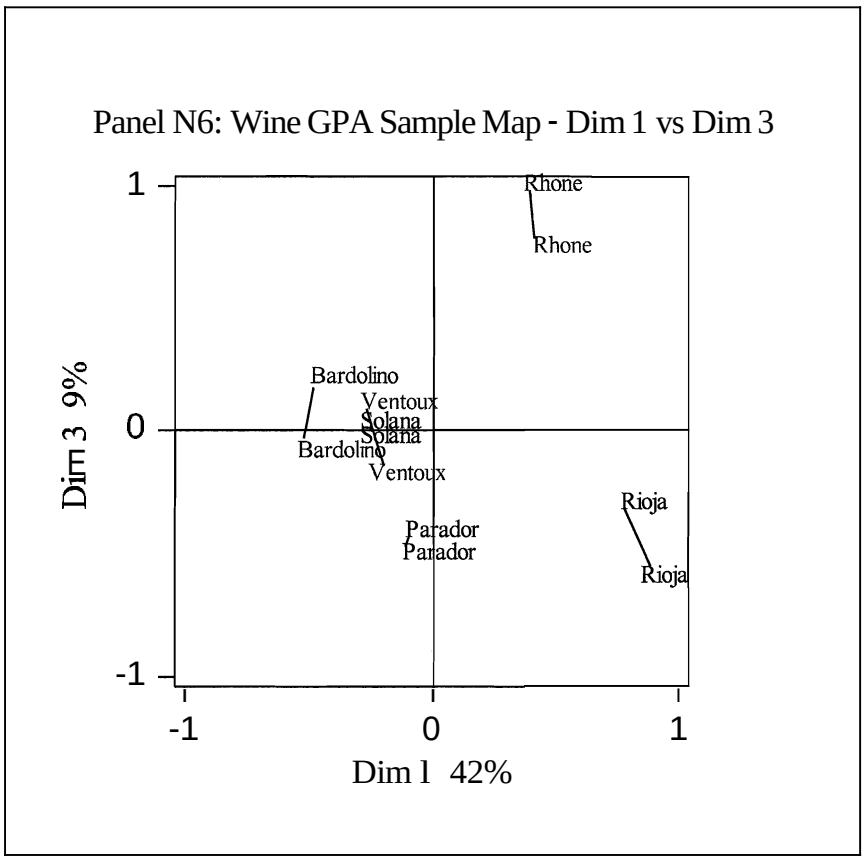


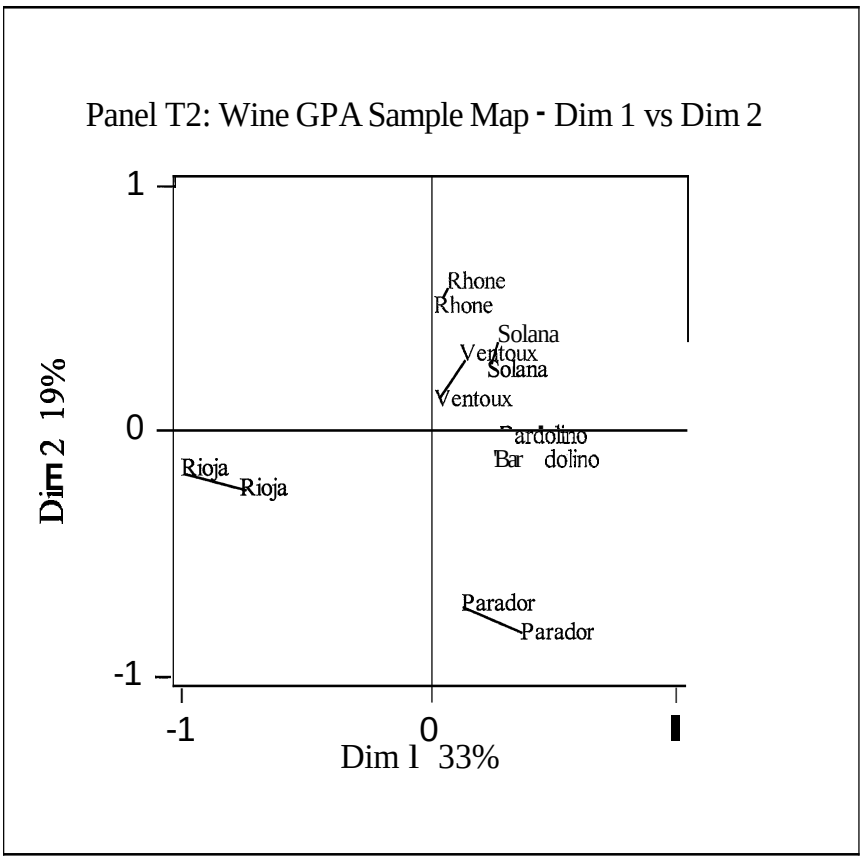
APPENDIX 6: GPA SAMPLE MAPS – VALIDATION STAGE

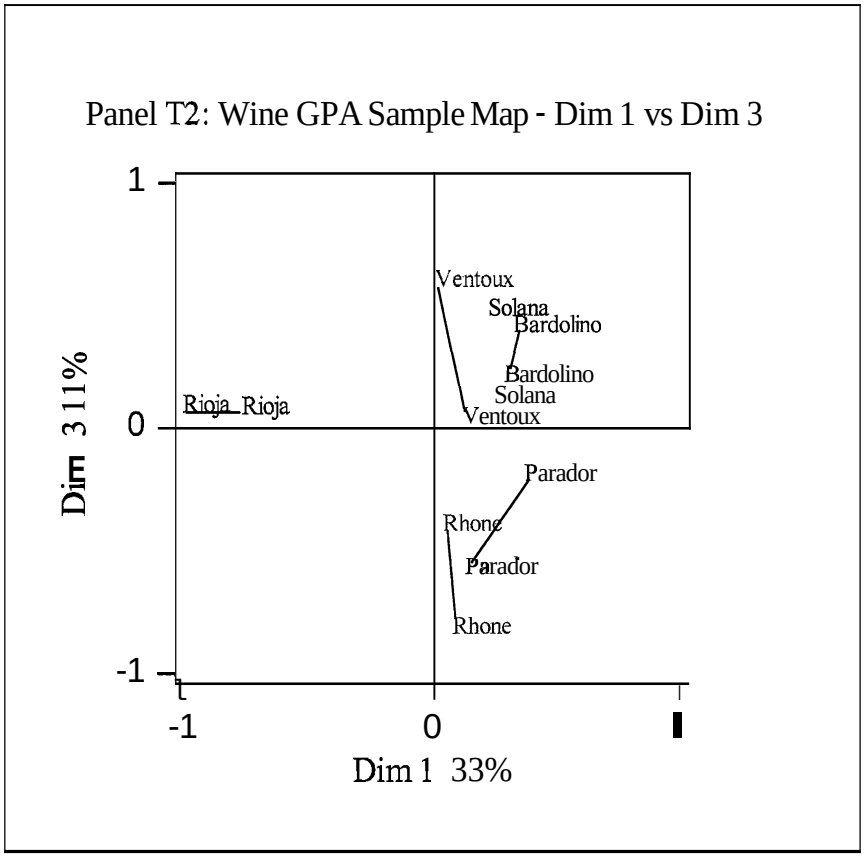
This appendix shows the sample maps obtained from GPA for the panels participating in the main ring trial. Dimension **3** is only plotted where it discriminated between the saniples at the 5% level of significance.

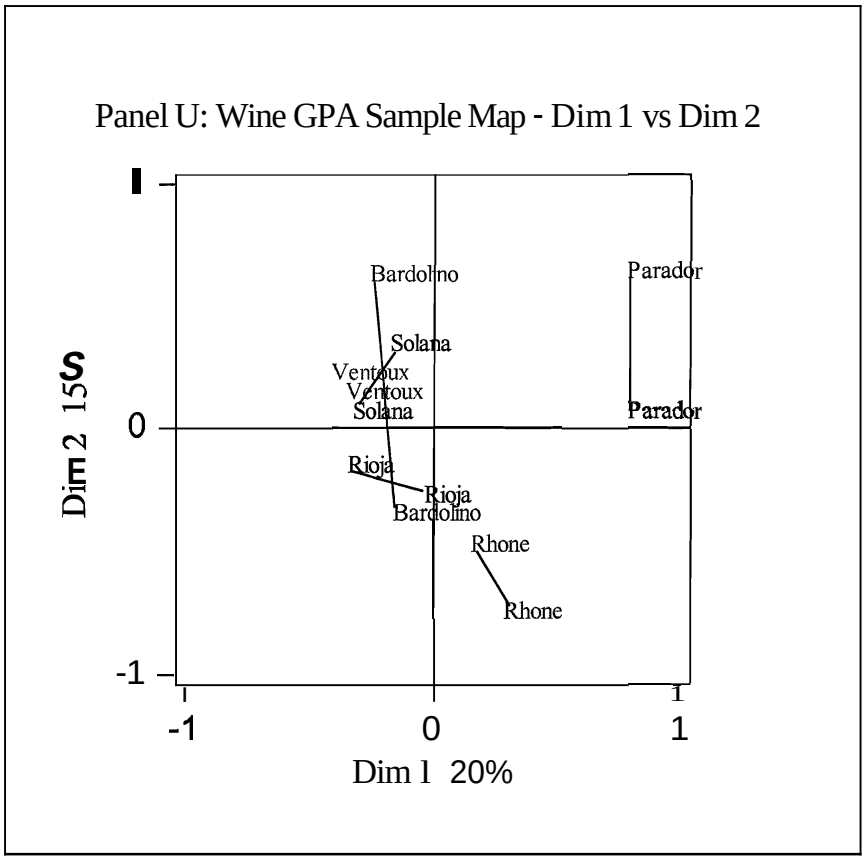
Panel N6 results are from the subset of the profile on the original 8 samples.

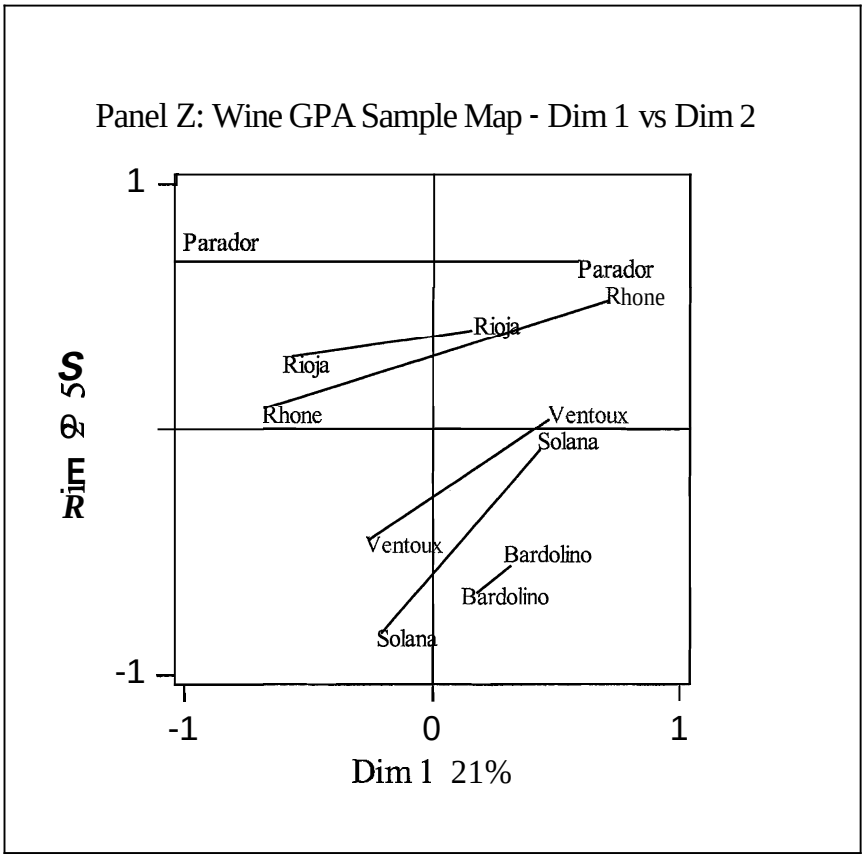

Panel N6: Wine GPA Sample Map - Dim 1 vs Dim 2
1
0
-1
-1
0
Parador
Parador
Rhone
Rhone
Bardolino
Solana
Ventoux
Rioj
Rioja
Dim 1 42%


Panel N6: Wine GPA Sample Map - Dim 1 vs Dim 3
1
0
-1
-1
0
1
Rhone
Rhone
Bardolino
Ventoux
Solana
Rioja
Parador
Parador
Rioja
Dim 1 42%


Panel T2: Wine GPA Sample Map - Dim 1 vs Dim 2
1
0
-1
Dim 2 19%
Rhone
Rhone
Solana
Ventoux
Solana
Ventoux
Bardolino
Bardolino
Rioja
Rioja
Parador
Parador
-1
0
Dim 1 33%


Panel T2: Wine GPA Sample Map - Dim 1 vs Dim 3
1
0
-1
Dim 3 11%
Ventoux
Solana
Bardolino
Bardolino
Solana
Rioja Rioja
Ventoux
Parador
Rhone
Parador
Rhone
-1
0
Dim 1 33%

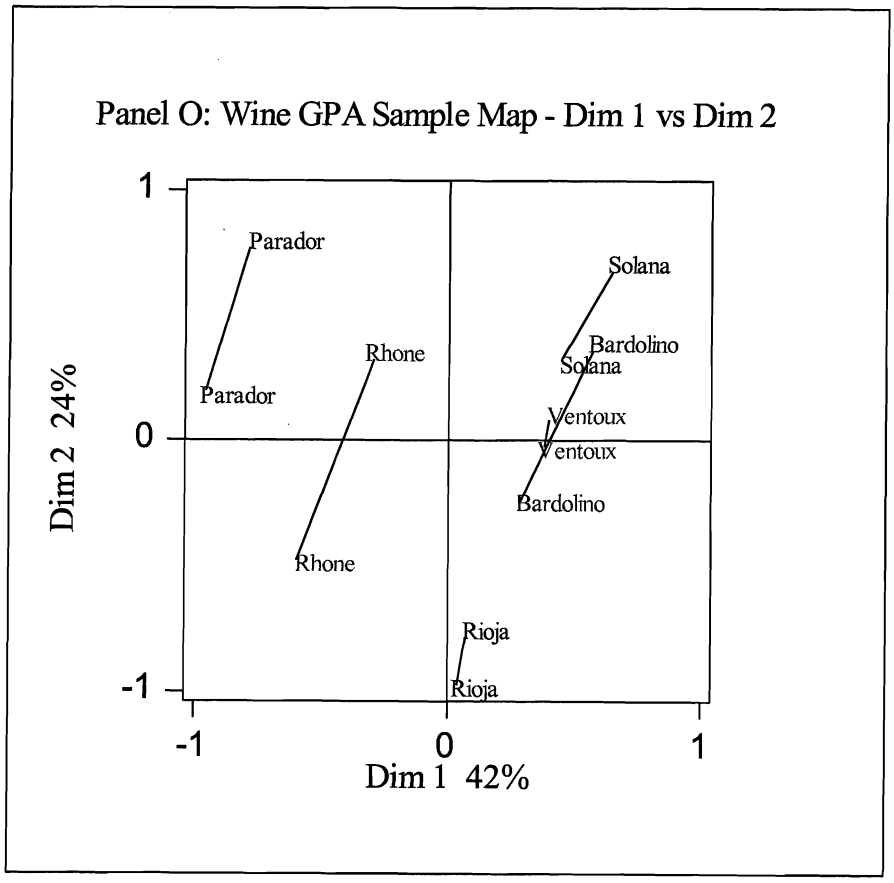

Panel U: Wine GPA Sample Map - Dim 1 vs Dim 2
Bardolino
Parador
Solana
Ventoux
Ventoux
Solana
Parador
Rioja
Rioja
Bardolino
Rhone
Rhone
1
0
-1
-1
0
1
Dim 2 15%
Dim 1 20%


Panel Z: Wine GPA Sample Map - Dim 1 vs Dim 2
Parador
Parador
Rhone
Rioja
Rioja
Rhone
Ventoux
Solana
Ventoux
Bardolino
Bardolino
Solana
1
0
-1
-1
0
1
Dim 2 15%
Dim 1 21%

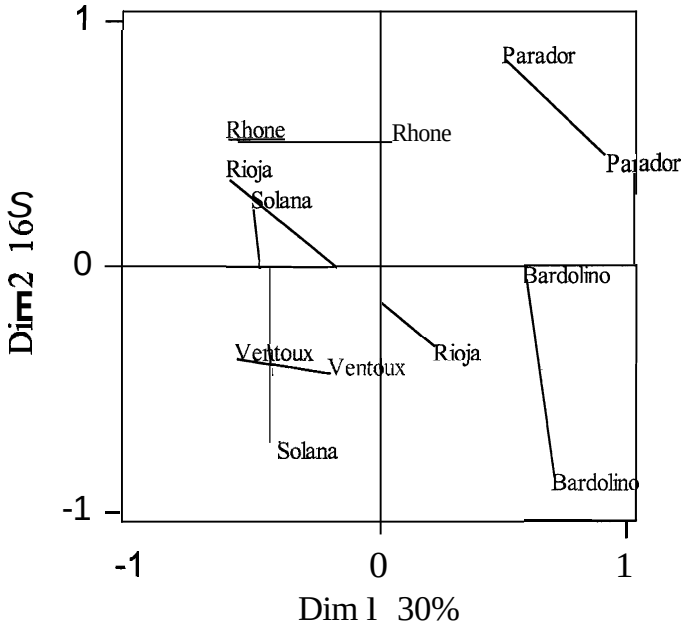
APPENDIX 7: GPA SAMPLE MAPS – MAIN TRIAL

This appendix shows the sample maps obtained from GPA for the panels participating in the main ring trial. As previously, Dimension 3 is only plotted where it discriminated between the samples at the 5% level of significance.

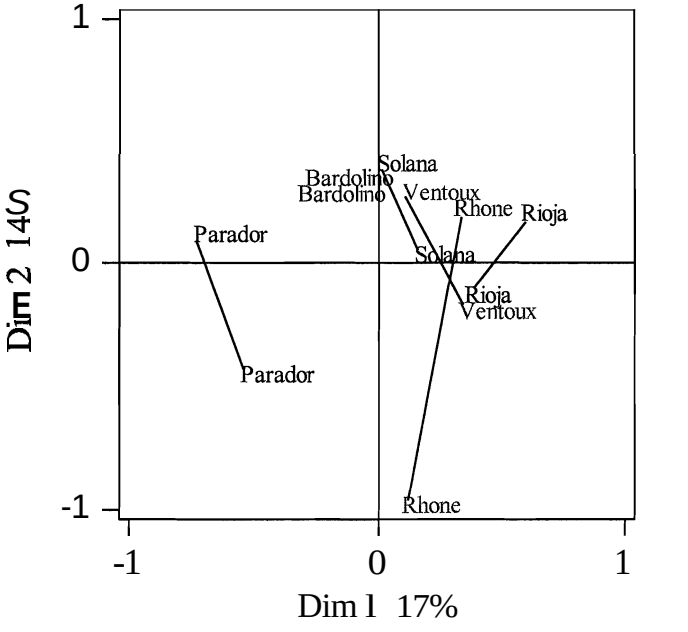
Panel S6 results are from the subset of the profile on the original 8 samples.

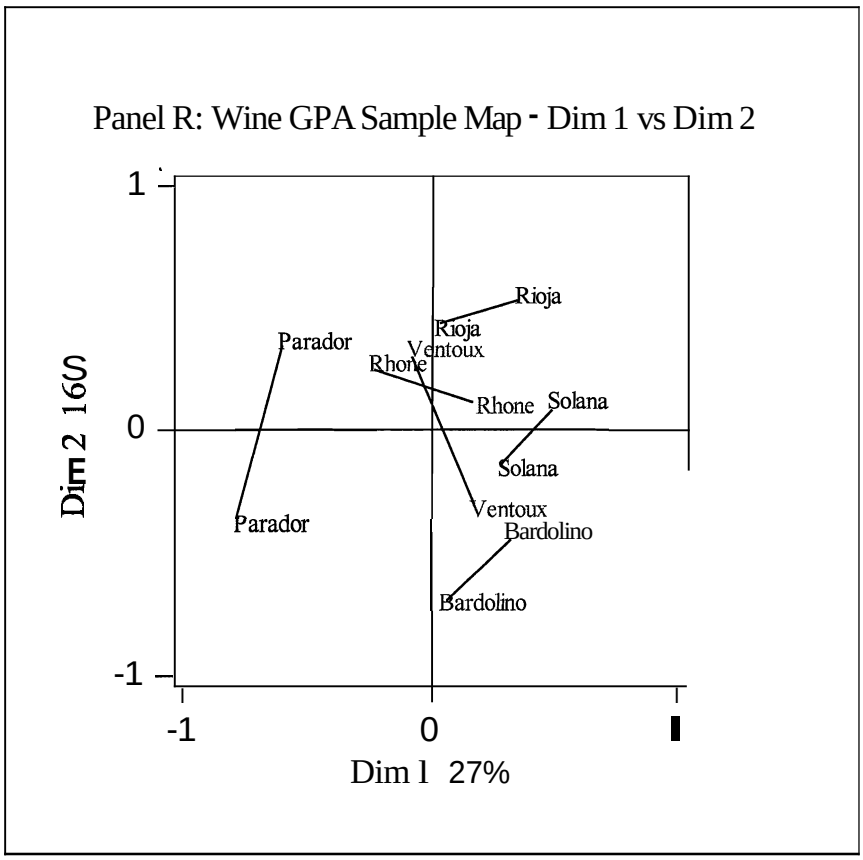


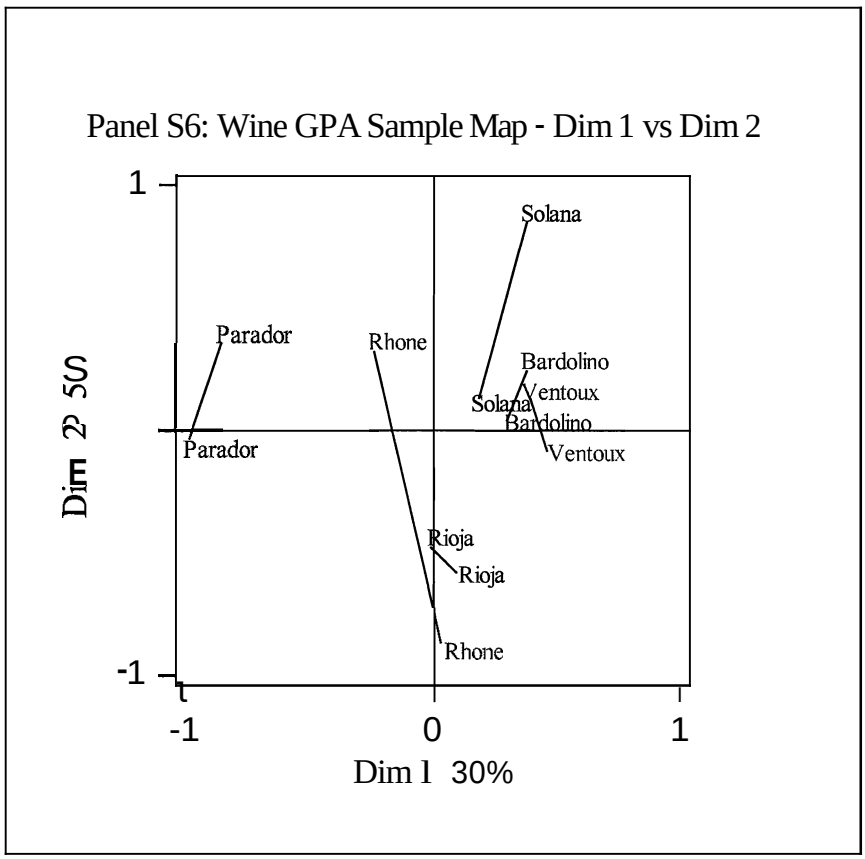
Panel P: Wine **GPA** Sample Map - Dim 1 vs Dim 2



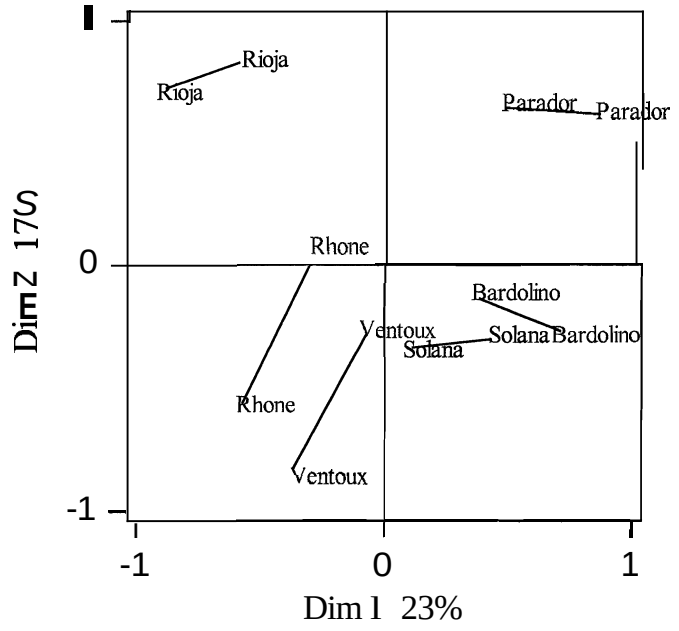
Panel Q: Wine **GPA** Sample Map - Dim 1 vs Dim 2



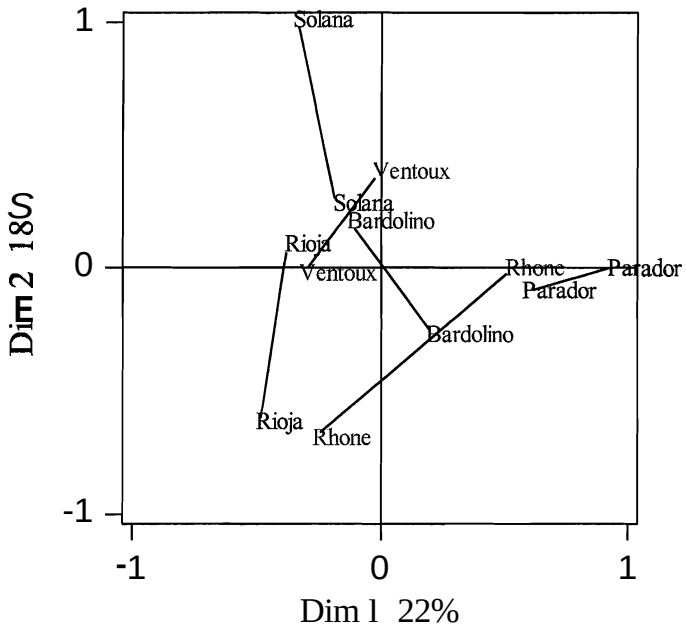

Panel R: Wine GPA Sample Map - Dim 1 vs Dim 2
1
0
-1
-1
0
Dim 1 27%
Rioja
Rioja
Parador
Ventoux
Rhone
Rhone
Solana
Solana
Ventoux
Parador
Bardolino
Bardolino

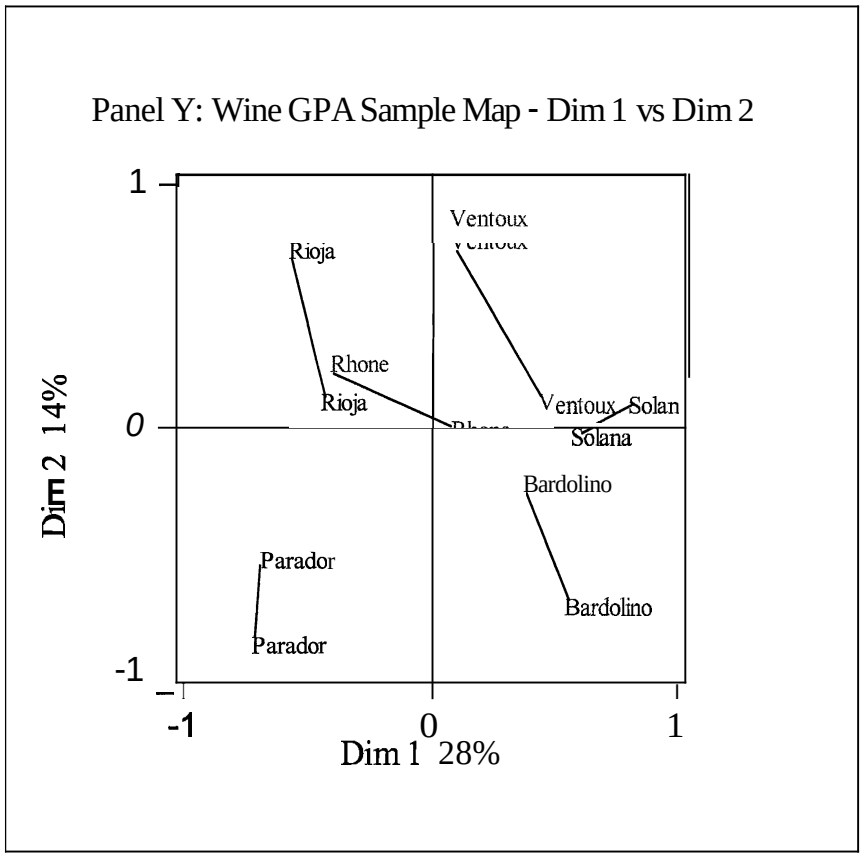

Panel S6: Wine GPA Sample Map - Dim 1 vs Dim 2
1
-1
-1
0
1
Dim 1 30%
Solana
Parador
Rhone
Bardolino
Ventoux
Solana
Bardolino
Parador
Ventoux
Rioja
Rioja
Rhone

Panel W: Wine GPA Sample Map - Dim 1 vs Dim 2



Panel X: Wine GPA Sample Map - Dim 1 vs Dim 2




Panel Y: Wine GPA Sample Map - Dim 1 vs Dim 2
1
0
-1
Dim 2 14%
-1
0
1
Dim 1 28%
Ventoux
Rioja
Rhone
Rioja
Ventoux
Solan
Solana
Bardolino
Bardolino
Parador
Parador

APPENDIX 8: NUMBER OF SIGNIFICANT PAIRS

Panel N6

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	Yes	Yes	Yes	Yes
Ventoux	Parador	Yes	Yes	No	Yes
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	Yes	No	No	Yes
Ventoux	Bardolino	Yes	Yes	No	Yes
Rhone	Parador	Yes	Yes	Yes	Yes
Rhone	Solana	Yes	Yes	Yes	Yes
Rhone	Rioja	Yes	Yes	Yes	Yes
Rhone	Bardolino	Yes	Yes	Yes	Yes
Parador	Solana	Yes	Yes	No	Yes
Parador	Rioja	Yes	Yes	No	Yes
Parador	Bardolino	Yes	Yes	No	Yes
Solana	Rioja	Yes	No	No	Yes
Solana	Bardolino	Yes	No	No	Yes
Rioja	Bardolino	Yes	No	No	Yes
		14	9	***5***	14

Panel O

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	Yes	No	No	Yes
Ventoux	Parador	Yes	No	No	Yes
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	No	No	No	No
Ventoux	Bardolino	No	No	No	No
Rhone	Parador	No	No	No	No
Rhone	Solana	Yes	No	No	Yes
Rhone	Rioja	No	No	No	No
Rhone	Bardolino	Yes	No	No	Yes
Parador	Solana	Yes	No	No	Yes
Parador	Rioja	No	No	No	No
Parador	Bardolino	Yes	No	No	Yes
Solana	Rioja	No	No	No	No
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	No	No	No	No
		6	0	0	***6***

Panel P

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	No	No	No	No
Ventoux	Parador	No	No	No	No
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	No	No	No	No
Ventoux	Bardolino	No	No	No	No
Rhone	Parador	No	No	No	No
Rhone	Solana	No	No	No	No
Rhone	Rioja	No	No	No	No
Rhone	Bardolino	No	No	No	No
Parador	Solana	No	No	No	No
Parador	Rioja	No	No	No	No
Parador	Bardolino	No	No	No	No
Solana	Rioja	No	No	No	No
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	No	No	No	No
		0	0	0	0

Panel Q

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	No	No	No	No
Ventoux	Parador	Yes	No	No	Yes
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	No	No	No	No
Ventoux	Bardolino	Yes	No	No	Yes
Rhone	Parador	Yes	No	No	Yes
Rhone	Solana	No	No	No	No
Rhone	Rioja	No	No	No	No
Rhone	Bardolino	No	No	No	No
Parador	Solana	Yes	No	No	Yes
Parador	Rioja	Yes	No	No	Yes
Parador	Bardolino	No	No	No	No
Solana	Rioja	No	No	No	No
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	Yes	No	No	Yes
		6	0	0	*6*

Panel R

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	No	No	No	No
Ventoux	Parador	No	No	No	No
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	No	No	No	No
Ventoux	Bardolino	No	No	No	No
Rhone	Parador	No	No	No	No
Rhone	Solana	Yes	No	No	Yes
Rhone	Rioja	No	No	No	No
Rhone	Bardolino	No	No	No	No
Parador	Solana	Yes	No	No	Yes
Parador	Rioja	Yes	No	No	Yes
Parador	Bardolino	Yes	No	No	Yes
Solana	Rioja	No	No	No	No
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	No	No	No	No
		4	0	0	4

Panel S6

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	No	No	No	No
Ventoux	Parador	Yes	No	No	Yes
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	No	No	No	No
Ventoux	Bardolino	No	No	No	No
Rhone	Parador	Yes	No	No	Yes
Rhone	Solana	Yes	No	No	Yes
Rhone	Rioja	Yes	No	No	Yes
Rhone	Bardolino	Yes	No	No	Yes
Parador	Solana	Yes	No	No	Yes
Parador	Rioja	Yes	No	No	Yes
Parador	Bardolino	Yes	No	No	Yes
Solana	Rioja	No	No	No	No
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	No	No	No	No
		8	0	0	8

Panel T2

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	No	Yes	No	Yes
Ventoux	Parador	No	Yes	No	Yes
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	Yes	Yes	No	Yes
Ventoux	Bardolino	No	No	No	No
Rhone	Parador	No	Yes	No	Yes
Rhone	Solana	No	No	No	No
Rhone	Rioja	Yes	Yes	No	Yes
Rhone	Bardolino	No	Yes	No	Yes
Parador	Solana	No	Yes	No	Yes
Parador	Rioja	Yes	Yes	No	Yes
Parador	Bardolino	No	Yes	No	Yes
Solana	Rioja	Yes	Yes	No	Yes
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	Yes	No	No	Yes
		5	10	0	11

Panel U

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	Yes	No	No	Yes
Ventoux	Parador	Yes	No	No	Yes
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	No	No	No	No
Ventoux	Bardolino	No	No	No	No
Rhone	Parador	Yes	No	No	Yes
Rhone	Solana	Yes	No	No	Yes
Rhone	Rioja	No	No	No	No
Rhone	Bardolino	No	No	No	No
Parador	Solana	Yes	No	No	Yes
Parador	Rioja	Yes	No	No	Yes
Parador	Bardolino	Yes	No	No	Yes
Solana	Rioja	No	No	No	No
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	No	No	No	No
		7	0	0	7

Panel W

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	No	No	No	No
Ventoux	Parador	No	Yes	No	Yes
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	No	Yes	No	Yes
Ventoux	Bardolino	No	No	No	No
Rhone	Parador	Yes	No	No	Yes
Rhone	Solana	No	No	No	No
Rhone	Rioja	No	No	No	No
Rhone	Bardolino	Yes	No	No	Yes
Parador	Solana	No	Yes	No	Yes
Parador	Rioja	Yes	No	No	Yes
Parador	Bardolino	No	No	No	No
Solana	Rioja	Yes	Yes	No	Yes
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	Yes	No	No	Yes
		5	**4**	0	**8**

Panel X

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	No	No	No	No
Ventoux	Parador	No	No	No	No
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	No	No	No	No
Ventoux	Bardolino	No	No	No	No
Rhone	Parador	No	No	No	No
Rhone	Solana	No	No	No	No
Rhone	Rioja	No	No	No	No
Rhone	Bardolino	No	No	No	No
Parador	Solana	No	No	No	No
Parador	Rioja	No	No	No	No
Parador	Bardolino	No	No	No	No
Solana	Rioja	No	No	No	No
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	No	No	No	No
		0	0	0	**0**

Panel Y

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	No	No	No	No
Ventoux	Parador	Yes	No	No	Yes
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	No	No	No	No
Ventoux	Bardolino	No	No	No	No
Rhone	Parador	No	No	No	No
Rhone	Solana	Yes	No	No	Yes
Rhone	Rioja	No	No	No	No
Rhone	Bardolino	No	No	No	No
Parador	Solana	Yes	No	No	Yes
Parador	Rioja	No	No	No	No
Parador	Bardolino	Yes	No	No	Yes
Solana	Rioja	Yes	No	No	Yes
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	Yes	No	No	Yes
		6	0	0	*6*

Panel Z

		Dim 1	Dim 2	Dim 3	Overall
Ventoux	Rhone	No	No	No	No
Ventoux	Parador	No	No	No	No
Ventoux	Solana	No	No	No	No
Ventoux	Rioja	No	No	No	No
Ventoux	Bardolino	No	No	No	No
Rhone	Parador	No	No	No	No
Rhone	Solana	No	No	No	No
Rhone	Rioja	No	No	No	No
Rhone	Bardolino	No	No	No	No
Parador	Solana	No	No	No	No
Parador	Rioja	No	No	No	No
Parador	Bardolino	No	Yes	No	Yes
Solana	Rioja	No	No	No	No
Solana	Bardolino	No	No	No	No
Rioja	Bardolino	No	No	No	No
		0	0	0	0

APPENDIX 9: ANOVA ON COMMON ATTRIBUTES

1" Trial

Panel N

Attribute	Sample	Mean	p-value	Sign	NK	
Sweet	Parador	57.0	0.000	0.10%	7.2	A
	Bardolino	24.5				B
	Ventoux	21.1				B C
	Solana	20.1				B C
	Veneto	20.1				B C
	Rhone	19.1				B C D
	Rioja	15.4				C D
	Corbiere	12.5				D
Sour	Solana	41.9	0.000	0.10%	9.2	A
	Veneto	39.7				A B
	Bardolino	38.6				A B
	Ventoux	37.9				A B
	Rhone	36.0				A B
	Rioja	34.1				A B C
	Corbiere	31.6				B C
	Parador	25.3				C
Salty	Rioja	19.8	0.020	5%	6.1	!
	Corbiere	19.7				!
	Rhone	19.1				!
	Solana	16.4				!
	Ventoux	16.4				!
	Veneto	15.7				!
	Bardolino	15.4				!
	Parador	14.1				!
Bitter	Corbiere	45.2	0.000	0.10%	8.2	A
	Rioja	38.1				A
	Ventoux	20.6				B
	Solana	20.4				B
	Veneto	19.7				B
	Rhone	15.9				B C
	Bardolino	13.5				B C
	Parador	9.7				C

Panel S

Attr	Sample	Mean	p-value	Sign	NK	
Sweet	Parador	24.5	0.298	NS	0	
	Solana	22.6				
	Rioja	22.1				
	Veneto	20.9				
	Ventoux	20.3				
	Rhone	19.3				
	Corbiere	17.7				
	Bardolino	16.6				
Acid	Corbiere	58.4	0.242	NS	0	
	Solana	56.7				
	Parador	56.2				
	Rhone	55.9				
	Ventoux	53.6				
	Rioja	52.6				
	Veneto	52.3				
	Bardolino	48.3				

Panel T

Flavour	Sample	Mean	p-value	Sign	NK	
Sweet	Parador	40.0	0.000	0.10%	12.3	**A**
	Bardolino	30.3				A B
	Solana	21.3				B
	Veneto	19.5				B
	Rioja	19.5				B
	Rhone	19.5				B
	Ventoux	18.4				B
	Corbiere	18.0				B
Sour	Rioja	47.0	0.673	NS	0	
	Veneto	46.8				
	Ventoux	45.4				
	Solana	44.2				
	Corbiere	43.8				
	Rhone	42.4				
	Bardolino	38.9				
	Parador	37.9				
Bitter	Ventoux	17.2	0.0261	5%	11.64	!
	Corbiere	15.5				!
	Rioja	14.2				!
	Solana	12.5				!
	Bardolino	10.1				!
	Rhone	9.6				!
	Veneto	6.3				!
	Parador	5.9				!

2nd Trial

Panel N6

Attribute	Sample	Mean	p-value	Sign	NK			
Sweet	Parador	57.0	0.000	0.10%	7.02	**A**		
	Bardolino	24.5					B	
	Ventoux	21.1					B	C
	Solana	20.1					B	C
	Rhone	19.1					B	C
	Rioja	15.4						C
Sour	Solana	41.9	0.000	0.10%	9.08	**A**		
	Bardolino	38.6				**A**		
	Ventoux	37.9				**A**		
	Rhone	36.0				**A**		
	Rioja	34.1				**A**	B	
	Parador	25.3					B	
Salt	Rioja	19.8	0.023	5%	5.45	**A**		
	Rhone	19.1				**A**	B	
	Solana	16.4				**A**	B	
	Ventoux	16.4				**A**	B	
	Bardolino	15.4				**A**	B	
	Parador	14.1					B	
Bitter	Rioja	38.1	0.000	0.10%	6.51	**A**		
	Ventoux	20.6					B	
	Solana	20.4					B	
	Rhone	15.9					B	C
	Bardolino	13.5						C
	Parador	9.7						C

Panel O

Attribute	Sample	Mean	p-value	Sign	NK	
Sweet	Parador	38.5	0.000	0.10%	10.81	A
	Solana	28.0				A B
	Rioja	26.3				B
	Bardolino	22.7				B
	Ventoux	21.7				B
	Rhone	20.2				B
Acid	Rhone	19.6	0.609	NS	0	
	Solana	19.6				
	Rioja	17.4				
	Bardolino	16.7				
	Ventoux	16.3				
	Parador	14.7				
Bitter	Rhone	13.9	0.361	NS	0	
	Rioja	13.6				
	Bardolino	13.2				
	Parador	12.1				
	Ventoux	12.0				
	Solana	8.8				

Panel P

Attribute	Sample	Mean	p-value	Sign	NK	
Sweet	Parador	40.4	0.000	0.10%	10.33	A
	Bardolino	37.4				A B
	Rioja	31.9				A B C
	Ventoux	28.2				B C
	Rhone	26.4				C
	Solana	23.8				C
Acid	Solana	45.0	0.638	NS	0	
	Rhone	44.5				
	Ventoux	43.0				
	Rioja	41.7				
	Bardolino	40.9				
	Parador	40.5				
Bitter	Solana	37.9	0.001	1%	9.37	A
	Rhone	37.5				A
	Rioja	35.6				A
	Parador	34.1				A B
	Ventoux	30.2				A B
	Bardolino	25.1				B

Panel Q

Attribute	Sample	Mean	p-value	Sign	NK	
Bitter	Rhone	44.6	0.140	NS	0	
	Rioja	40.8				
	Solana	40.7				
	Ventoux	39.9				
	Parador	34.6				
	Bardolino	29.9				
Sweet	Parador	30.1	0.092	NS	0	
	Solana	26.0				
	Bardolino	25.4				
	Rioja	21.9				
	Rhone	17.9				
	Ventoux	14.2				
Sour	Rhone	42.9	0.571	NS	0	
	Solana	42.6				
	Rioja	41.4				
	Ventoux	39.1				
	Bardolino	34.9				
	Parador	33.2				

Panel R

Attribute	Sample	Mean	p-value	Sign	NK	
Sour	Rioja	48.9	0.212	**NS**	0	
	Solana	46.5				
	Bardolino	46.0				
	Rhone	45.3				
	Ventoux	44.3				
	Parador	41.0				
Sweet	Parador	25.6	0.000	0.10%	6.31	**A**
	Bardolino	18.8				B
	Solana	17.9				B
	Rioja	16.5				B
	Ventoux	15.8				B
	Rhone	15.6				B
Bitter	Rhone	15.2	0.045	5%	4.6	!
	Rioja	14.8				**!**
	Solana	14.7				**!**
	Ventoux	14.3				**!**
	Parador	11.6				!
	Bardolino	11.3				**!**
Salty	Rioja	7.7	0.596	NS	0	
	Bardolino	7.6				
	Parador	6.9				
	Solana	6.4				
	Rhone	6.3				
	Ventoux	5.7				

Panel S6 (1"pre-test)

Attribute	Sample	Mean	p-value	Sign	NK	
Sweet	Parador	24.5	0.233	NS	0	
	Solana	22.6				
	Rioja	22.1				
	Ventoux	20.3				
	Rhone	19.3				
	Bardolino	16.6				
Acid	Solana	56.7	0.187	NS	0	
	Parador	56.2				
	Rhone	55.9				
	Ventoux	53.6				
	Rioja	52.6				
	Bardolino	48.3				

Panel T2

Attribute	Sample	Mean	p-value	Sign	NK	
Sweet	Parador	56.8	0.000	0.10%	9.84	**A**
	Rioja	32.5				B
	Ventoux	29.3				B
	Bardolino	28.9				B
	Solana	26.1				B
	Rhone	23.6				B
Sour	Solana	64.0	0.027	5%	12.4	A
	Rhone	58.6				A B
	Bardolino	57.8				A B
	Ventoux	56.5				A B
	Rioja	52.0				A B
	Parador	50.2				B
Bitter	Rhone	29.7	0.004	1%	9.42	A
	Solana	28.3				A B
	Ventoux	27.5				**A** B
	Rioja	27.3				**A** B
	Bardolino	20.3				B
	Parador	19.2				B

Panel U

Attribute	Sample	Mean	p-value	Sign	NK	
Acid	Parador	53.4	0.125	NS	0	
	Ventoux	48.1				
	Rioja	47.8				
	Bardolino	47.7				
	Solana	46.9				
	Rhone	44.9				
Bitter	Rhone	50.0	0.000	0.10%	7.54	**A**
	Rioja	47.8				A
	Ventoux	46.5				A
	Bardolino	46.4				A
	Solana	43.7				A B
	Parador	36.7				B

Panel W

Attribute	Sample	Mean	p-value	Sign	NK	
Sweet	Parador	60.6	0.000	0.10%	13.51	A
	Bardolino	46.6				B
	Solano	46.4				B
	Rioja	37.4				B C
	Rhone	31.3				C
	Ventoux	30.7				C
Acid	Rhone	48.1	0.000	0.10%	11.55	A
	Ventoux	47.3				A
	Rioja	46.7				A
	Solano	39.6				A B
	Bardolino	36.8				A B
	Parador	31.2				B
Bitter	Rioja	47.7	0.000	0.10%	13.55	A
	Rhone	47.6				**A**
	Ventoux	46.8				A
	Solano	36.9				**A** B
	Bardolino	32.3				B
	Parador	25.4				B

Panel X

Attribute	Sample	Mean	p-value	Sign	NK	
Acid1	Solana	51.7	0.430	NS	0	
	Bardolino	50.6				
	Rioja	48.8				
	Rhone	48.2				
	Ventoux	44.9				
	Parador	43.4				
Acid2	Solana	38.3	0.002	1%	11.22	A
	Bardolino	30.2				A B
	Rioja	29.7				A B
	Ventoux	29.2				A B
	Rhone	25.8				B
	Parador	21.3				B
Bitter	Ventoux	51.2	0.006	1%	12.13	A
	Solana	51.1				A
	Rioja	51.0				A
	Bardolino	49.6				A
	Rhone	48.6				A B
	Parador	37.0				B

Panel Y

Attribute	Sample	Mean	p-value	Sign	NK	
Acid	Rhone	40.9	0.535	NS	0	
	Rioja	39.4				
	Parador	38.9				
	Ventoux	38.4				
	Solana	37.9				
	Bardolino	34.9				
Bitter	Rioja	43.4	0.009	1%	10.11	A
	Ventoux	42.9				A B
	Rhone	39.4				A B
	Solana	35.4				A B
	Bardolino	34.9				A B
	Parador	32.8				B

Panel Z

Attribute	Sample	Mean	p-value	Sign	NK	
Sour	Rioja	43.0	0.143	NS	0	
	Bardolino	40.0				
	Solana	36.8				
	Rhone	35.0				
	Ventoux	30.7				
	Parador	27.4				
Bitter	Ventoux	31.5	0.821	NS	0	
	Rhone	31.0				
	Parador	27.8				
	Solana	27.6				
	Rioja	24.5				
	Bardolino	24.3				
Sweet	Parador	38.7	0.092	NS	0	
	Ventoux	28.1				
	Rioja	25.2				
	Solana	25.0				
	Rhone	22.1				
	Bardolino	19.7				