Industry allocated project number

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FINAL REPORT
2018

1. PROGRAMME AND PROJECT LEADER INFORMATION

	Research Organisation Programme leader	Project leader
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2. PROJECT INFORMATION

Research Organisation Project number	P04000008 (previously 000301; ww10/26)
Project title	Effect of yeast contact time on the flavour profile and quality of Méthode Cap Classique wines.
Short title	MCC

Fruit kind(s)	Wine grapes		
Start date (mm/yyyy)	04/2013	**End date** (mm/yyyy)	03/2018

Key words	Méthode Cap Classique, yeast autolysis, sparkling wine

3. TOTAL PROJECT COST

	CFPA	DFTS	SAAPPA SASPA	SATI	Winetech	THRIP	OTHER
TOTALS					1 337 941	86 239	1 392 549
Total cost of project from start to date in real terms							R 2 816 729

Approved by Research Organisation Programme leader (tick box) √

4. EXECUTIVESUMMARY

Objectives & Rationale

Current legislation for South African bottle fermented sparkling wine or Méthode Cap Classique (MCC) prescribes a minimum of nine months on the yeast lees before disgorgement. Industry wishes to increase the lees contact time to a minimum of 12 months for a standard category, and 24 months for a higher category. However, limited scientific data is available to support the proposed classifications. The objective of this project was therefore to collaborate with the Cap Classique Producers Association (CCPA) and specific MCC producers in microbial, chemical and sensory monitoring and analyses of Chardonnay and Pinot noir MCC wines to confirm anecdotal evidence and give scientific support to the proposed changes in legislation. The project was planned to run over three financial years to cover two separate 24-month production processes. An extension of the project was granted to facilitate a longer than 24-month maturation time, in line with industry practices, and for a final year of data analyses.

Methods

Eight MCC producers donated fourteen 2012 and ten 2013 MCC wines with lees intact. The wines were stored at Le Lude Cellar, Franschhoek for the duration of the project. The wines were production wines and not specifically produced for the project. The wines were regularly withdrawn for microbial, chemical and sensory analyses and the results were reported according to months on lees. Chemical analyses included standard chemical parameters (WineScan™), spectral fingerprinting, total extract; nitrogen (yeast assimilable nitrogen; Lecco combustible nitrogen, amino acids), total polysaccharides, volatile aroma compounds, and polyphenols. Sensory analyses by an industry and research team tasting panel was done on disgorged wines.

Key Results

Total amino acid profiles could be used as a tool to distinguish young from mature wines while yeast assimilable nitrogen (YAN) analyses may have value as a tool for monitoring individual wines for autolyses development. Infra-red fingerprinting and pattern recognition methods could also be a useful tool to categorise wines based on the time on yeast lees. Sensory analyses showed that MCC wines develop further after nine months on the lees. This development is not linear and a favourable time for disgorgement would be vintage dependant but could be after 12-13 months, 25-30 months and after 50 months on the lees.

Conclusion and Discussion / Recommendation

The data generated during this investigation supports the concept of a multi-tier classification of MCC wines. This will bring about an overall improvement in the quality of the wines, and promote a better understanding by the consumer. Favourable times to disgorge would be after 12-13 months, 25-30 months and after 50 months on the lees. However, due to vintages differences, a controlled sensory evaluation would have to be carried out to determine if the MCC wines are stylistically correct. This could entail something similar as is done for Noble Late Harvest vs. Natural Sweet wines by the Wine and Spirit Board sensory panels.

5. PROBLEM IDENTIFICATION AND MOTIVATION

Current legislation for South African bottle fermented sparkling wine or Méthode Cap Classique (MCC) prescribes a minimum of nine months on the yeast lees before disgorgement. However, many producers leave the wine in contact with the yeast lees for a much longer period to ensure a more developed flavour profile. A maximum time on lees is not prescribed by legislation, and the actual time on lees is determined by the stylistic character the producer is after vs. the costs

involved in “dead capital” while the wines undergo maturation. Consequently the consumer is confronted with various flavour profiles and wine styles when opening a bottle of MCC. These range from young (nine month matured) wines that are fruity with minimal autolysis and aged character, through various styles to mature wines with more complex and developed flavour profiles. Current labelling does not give much of a guide to the age or style of the wine and only some producers give the age on lees or disgorgement date on the back label. All these wines are marketed as Method Cap Classique.

In an effort to promote consumer understanding of the various styles of MCC, the Cap Classique Producers Association (CCPA), whose members represent about 90% of the volume produced in industry, wishes to increase the lees contact time from nine months to a minimum of 12 months for a standard category. There is also a desire to bring in a second category, of 24 months’ or longer lees contact. Proposals have already been made to the Wine and Spirit Board in this regard by industry. However, no MCC scientific data is available to support the proposed classifications. This research topic was given a high priority (level 1) by the Winetech Vinification Technology Committee in 2013.

6. OBJECTIVES

- To collaborate with the Cap Classique Producers Association (CCPA) and specific MCC producers.
- Microbial, chemical and sensory monitoring and analyses of Chardonnay and Pinot noir MCC wines to confirm anecdotal evidence and give scientific support to proposed changes in legislation.
- Investigation of two separate production processes (vintages).
- A further sub-aim was also to investigate analytical methods that are easily assessable to sparkling wine producers.

7. PERFORMANCE CHART (for the duration of the project).

	Milestone	Target Date	Extension Date	Date completed
1.	Identification of participating cellars	April 2013		May 2013
2.	Literature survey for optimal methodology			
3.	Finalisation of participating cellars in collaboration with CCPA and submission of first samples.	June 2013		June 2013
4.	Review of preliminary findings - report back to CCPA	December 2013		July 2014
5.	Initiation of trial for the second vintage	May 2014		May 2014
8.	Review and annual progress report after 12 months	July 2014		July 2014
7.	Review preliminary findings 1st vintage (18 months) and 2nd vintage (6 months) - report back to CCPA	December 2014		July 2014
8.	Review and annual progress report	July 2015		July 2015
9.	Review findings of 1st vintage (25 months) and 2nd vintage (18 months) – report back to CCPA	December 2015		Nov. 2015
10.	Review and annual progress report	July 2016		Aug. 2016

11.	Review findings of 2nd vintage (25 months) and comparisons over vintages – report back to CCPA	September 2016		July 2016
12.	Further analyses beyond 24 months	March 2017		May 2018
13.	Final report and recommendations	July 2018 as per approved project extension.		July 2018
14.	Journal publication(s) – final milestone SAJEV submission of manuscript Popular publication in Wineland – after acceptance of manuscript by journal	December 2018		

8. WORK PLAN (MATERIALS AND METHODS)

8.1 Research material and numbering system

Commercial MCC wines with yeast lees intact and closed by crown caps were donated by individual cellars belonging to the Cap Classique Producers Association CCPA (Table 1). The range of wines covered 100% Chardonnays (Blanc de Blanc), Chardonnay/Pinot noir blends, and Rosé. The yeast used for all the wines was IOC 18-2007 (Lallemand). The exception was wine 5 that was produced with EC1118 (Lallemand, South Africa). The wines were stored at Le Lude cellar so that maturation temperature and location was not a variable. The average storage temperature was 15°C. Each wine was given a unique number from 1 to 27 and samples were numbered with the following format: 'wine number/months on lees'. Subsequent to the final analyses, the remaining wine stocks were transferred to the Nietvoorbij Research Cellar wine store.

Table 1. Participating producers and MCC wine details used in this investigation.

Vintage and wine number		**Producer**	**Cellar location**	**Winemaker's name**	**Cultivar[1]**	**2012 wines**		**2013 wines**	
'12	**'13**					**Blend ratio (%)**	**Months on lees in April 2012**	**Blend ratio (%)**	**Months on lees in April 2013**
Chardonnay (Blanc de Blanc)									
1	15	Graham Beck	Robertson	Pieter Ferreira	Cy	100	8	100	5
2	16	Môreson	Franschhoek	Clayton Reabow	Cy	100	6	100	4
3	Np[2]	Boschendal	Franschhoek	Lizelle Gerber	Cy	100	8	-	-
4	Na[3]	Chabivin	Stellenbosch	Hendrik Snyman	Cy	100	10	-	-
5	Np	Simonsig[5]	Stellenbosch	J Malan/H Meyer	Cy	100	5	-	-
Blends of Chardonnay and Pinot noir									
6	Np	KWV	Paarl	Kobus vd Merwe	Cy/Pn	80/20	8	-	-
8	20	Le Lude	Franschhoek	Paul Gerber	Cy/Pn	60/40	6	68/32	5
9	21	Graham Beck	Robertson	Pieter Ferreira	Cy/Pn	50/50	8	51/49	5
10	22	Boschendal	Franschhoek	Lizelle Gerber	Cy/Pn	49/51	8	49/51	4

Table 1 (cont.)

Vintage and wine number		Producer	Cellar location	Winemaker's name	Cultivar[1]	2012 wines		2013 wines	
'12	**'12**					**Blend ratio (%)**	**Months on lees in April 2012**	**Blend ratio (%)**	**Months on lees in April 2012**
11	19	Simonsig	Stellenbosch	J Malan/H Meyer	Cy/Pn/Pm	46/50/4	8	37/63	9
12	24	JC le Roux	Stellenbosch	Elunda Basson	Cy/Pn	40/60	5	40/60	9
13	Na	Chabivin	Stellenbosch	Hendrik Snyman	Cy/Pn	40/60	8	-	-
14	27	Graham Beck	Robertson	Pieter Ferreira	Cy/Pn	20/80	8	25/75	9
Rosé									
7	26	Le Lude	Franschhoek	Paul Gerber	Cy/Pn	30/70	6	20/80	5
Na	23	Simonsig	Stellenbosch	J Malan/H Meyer	Pin/Pn	-	-	43/57	9

[1]Cy = Chardonnay; Pn = Pinot noir, Pm = Pinot meunier, Pin = Pinotage. [2]Np = not produced. [3]Na = not available due to limited stock. [5]Produced with a different yeast to all the others.

8.2 Sampling and sample preparation

Wines were withdrawn for chemical and sensory analyses and the results were reported according to months on lees. Wines were analysed at regular intervals from 8-9 months up until 50 months and 48-50 months on the lees for the 2012 and 2013 wines, respectively. A statistical valid design led to five bottles of wine being withdrawn in a randomised manner from the storage bins at each time interval, three for microbial and chemical analyses, and two for sensory analyses.

The bottles destined for chemical analyses were stored at 4°C overnight, before opening. The entire contents of the bottles were transferred to two litre Erlenmeyer flasks and agitated to suspend the yeasts. After yeast samples were taken, the wines were clarified by centrifugation. The centrifugation also served to de-gas the wines. The wines were then transferred to sample bottles and, where appropriate, frozen for later analyses. The bottles of wine for sensory analyses were riddled and disgorged by Simonsig Wine Estate to remove the yeast sediment. No dosage was added and the bottles were closed again with crown caps and kept at 15°C until analysed.

8.3 Chemical and microbial analyses

Cell counts were done microscopically (Newbauer counting chamber under 400x magnification). Standard wine chemical analyses (alcohol, pH, volatile acidity, reducing sugar, glycerol) was done on a FOSS WineScan™ (IWBT, Stellenbosch University, Stellenbosch). Other chemical analyses were: total extract (Koelenhof Wynlaboratorium, Stellenbosch); yeast assimilable nitrogen (FORMOL titration, South African Wine Laboratories Association, 2002), total polysaccharides (Usseglio-Tomasset method, P. Loubser, personal communication 2002), volatile aroma compounds (GC-FID method, Central Analytical Facility, Stellenbosch University, Stellenbosch) and 19 amino acids (Central Analytical Facility). The volatile aroma compounds were only done on wines that had been on the lees for nine months. Polyphenol analyses (gallic acid, catechin, caffeic acid, epicatechin, epigallocatechin 3-*O*-gallate, p-coumaric acid, malvidin) was also done on a selection of young (9-13 months) and matured wines (26 months on lees) (HPLC Analytical Laboratory, ARC Infruitec-Nietvoorbij). Lecco combustible nitrogen (Bemlab, Somerset West) and protein analyses (von der Haar method - chemical lysis and simultaneous solubilisation in SDS and urea), was also done on a selection of samples. In addition, infra-red spectral imaging was investigated with a Bruker ALPHA FTIR Spectrometer (Nietvoorbij Analytical Facility, ARC Infruitec-Nietvoorbij, Stellenbosch).

8.4 Sensory analyses

Two bottles of wine per time interval were analysed by a panel. The panel was composed of winemakers belonging to the CCPA and trained ARC team members averaging 14 ± 4 judges per session (male and female, ranging from 22 to 60 years old). Wines (approximately 60 mL) were served blind in clear ISO tasting glasses at a temperature of 15°C, with the time on lees and style of wine i.e. Blanc de Blanc, blend or rosé, revealed to the judges. Due to the wines being of different ages (time on lees) and vintages (Table 1) at the start of the investigation, an individual sensory session mostly included wines from different ages and from both vintages. A tasting sheet was drawn up with the assistance of the members of the CCPA. Wines were rated on an unstructured 10 cm line scale and judges were asked to rate colour (unacceptable to acceptable), overall aroma intensity, fruit character and autolytic character (none to prominent), acidity (less to high), fullness/body (thin to full), and stage of development (young to mature).

8.5 Statistical analyses

Data was analysed by principal component analysis (PCA) and discriminant analyses (DA) to examine the relationships among and between the variables and months of maturity. Principal component analysis and DA were constructed using XLSTAT software (Addinsoft, Version 2015, Paris, France).

9. RESULTS AND DISCUSSION

Bottled fermented sparkling wines following the traditional production methods of Champagne, France have been produced in South Africa since 1971. Although this sector has shown strong growth since 1971, very little research has been undertaken for the South African wine industry producers. As outlined under the Problem statement and Objectives this investigation aims to help position and strengthen the image of Méthode Cap Classique wines, and help with proposed legislative changes.

In collaboration with the CCPA, eight producers were selected to participate in the project. The producers were Graham Beck Wines, Môreson Family Wines, Boschendal, Chabivin Champagne & MCC House, Simonsig Wine Estate, KWV, Le Lude and The House of JC le Roux. Fourteen 2012 wines and ten 2013 wines with yeast lees intact were donated. This was substantially more than the initially six wines indicated in the project proposal. The wines included 100% Chardonnays (Blanc de Blanc), various Chardonnay/Pinot noir blends and rosé wines (Table 1). The total donation was in excess of 1700 individual bottles of MCC wine with a current market value of R289 200 at an estimated average price of R170 a bottle.

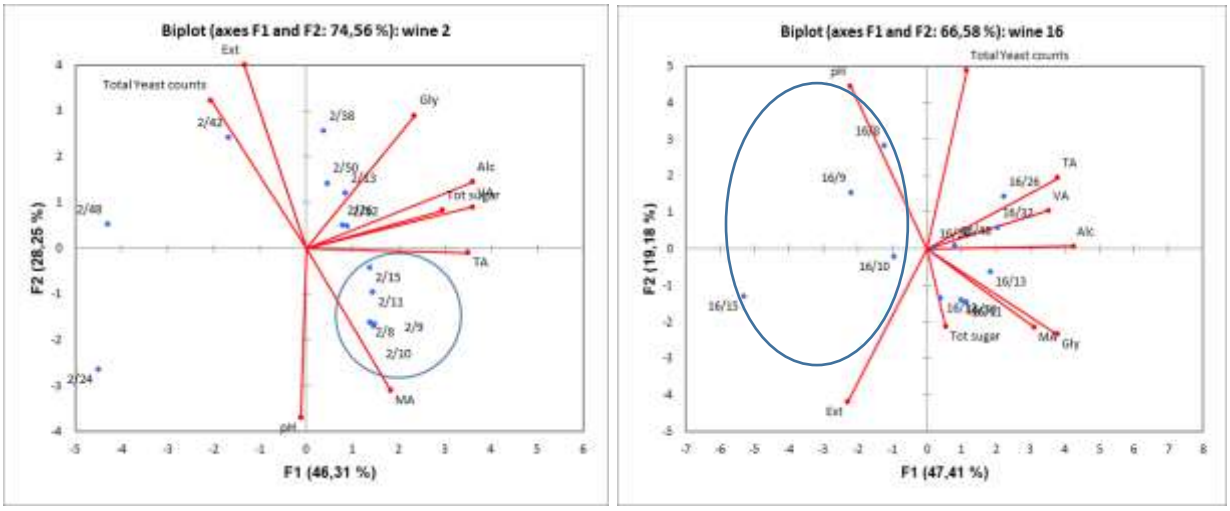
The yeast used in all the wines, barring one, are the same industry standard, IOC 18-2017. The exception was EC1118, also a well-known sparkling wine yeast (Table 1). Storage in one location (Le Lude cellar, Franschhoek) ensured that maturation temperature was not a variable during the investigation.

Analyses began at eight to nine months on the lees. As the wines were not of the same age at the start of the investigation, the final analyses were done on a range of wines from 38 to 50 months on the lees. Data is aligned to the actual time on lees and represents a base line of how a selection of South African MCC wines developed on the lees over time.

The types of analyses included a range from the cheaper, easily accessible Winescan™ and total extract analyses, to analyses that are more expensive e.g. volatile aromatic compounds and individual amino–acids analyses. Only figures illustrating the main trends for a few selected individual wines are shown in this report. More detailed data is presented in the Addendums.

9.1 Chemical and microbial data: 2012 and 2013 wines

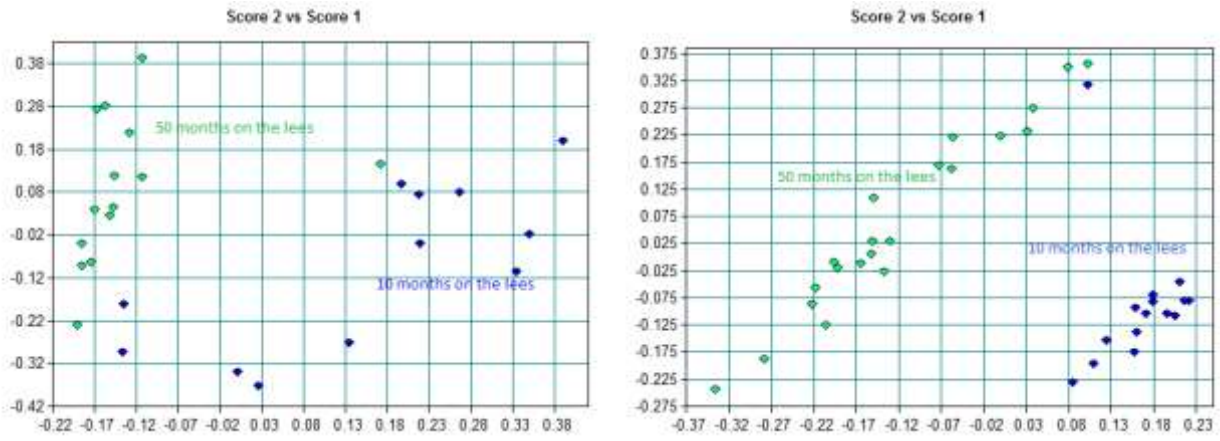
Total yeast counts, Winescan™ and total extract data Principle component analyses of all the 2012 wine data for total yeast counts, Winescan™ (total sugar, total acidity, pH, alcohol, malic acid, volatile acidity, glycerol) and total extract values showed no association between the different wine samples. This was an indication that there were no common trends between the different wines during ageing (Addendum 1). Analyses of the same data set per wine, however, showed that younger wines (8 to 15 months on lees) grouped together, and mostly associated with higher concentrations of malic acid and total acidity (illustrated in Fig. 1a, and Addendum 2). Older wines showed no specific association or grouping. It appears that wines between 8 and 15 months on the lees appear chemically similar to each other, but then show marked changes as they age. This, therefore, supports the industry's perception that longer ageing than the current legislated 9 months on lees leads to a different product with a perceived reduced acidity. Analyses of the data from the 2013 wines show a similar grouping of the younger wines (9-15 months), albeit a general association with a higher pH (Fig. 1b and Addendum 3). Older wines again show no specific association with measured parameters.



(a) (b)

Fig 1. PCA bi-plots of total yeast counts, Winescan™ and total extract data of young to mature MCC wines for (a) wine 2 (2012); and (b) wine 16 (2013). Both wines are a 100% Chardonnay (Blanc de Blanc) MCC from the same producer.

Infra-red spectroscopy (FTRI) Mid-infrared (MIR) spectroscopy is a valuable analytical tool that measures changes in the absorption of energy by different functional groups in chemical compounds due to characteristic vibrational frequencies associated with stretching and/or bending of bonds. These include carbon-oxygen (C–O), oxygen-hydrogen (O–H) and carbon-carbon (C–C) bonds. Unique spectral fingerprints can therefore be obtained for different samples, with more absorption bands typically being observed for more complex molecular structures. Wine has a complex matrix and infrared (IR) spectroscopy combined with pattern recognition methods has been used to differentiate between wines using different yeast and lactic acid bacteria inoculation strategies. The use of this type of analyses is relatively new within the South African wine research environment. This strategy was used to investigate wines that had been on the lees for 10 and 50 months, respectively. Spectral fingerprints were generated using an Alpha FTIR spectrophotometer and subjected to principal component analyses with the instrument's OPUS software. For both the 2012 and 2013 wines, barring some outliers, a clear separation was observed between the young and old wines (Fig. 2a and b). This technology therefore holds promise as a tool to routinely classify young and old wines, if a relevant calibration could be set up. This technology should be reasonably accessible to wine producers as both WineScan™ and Alpha instruments are found at many cellar and commercial wine laboratories.

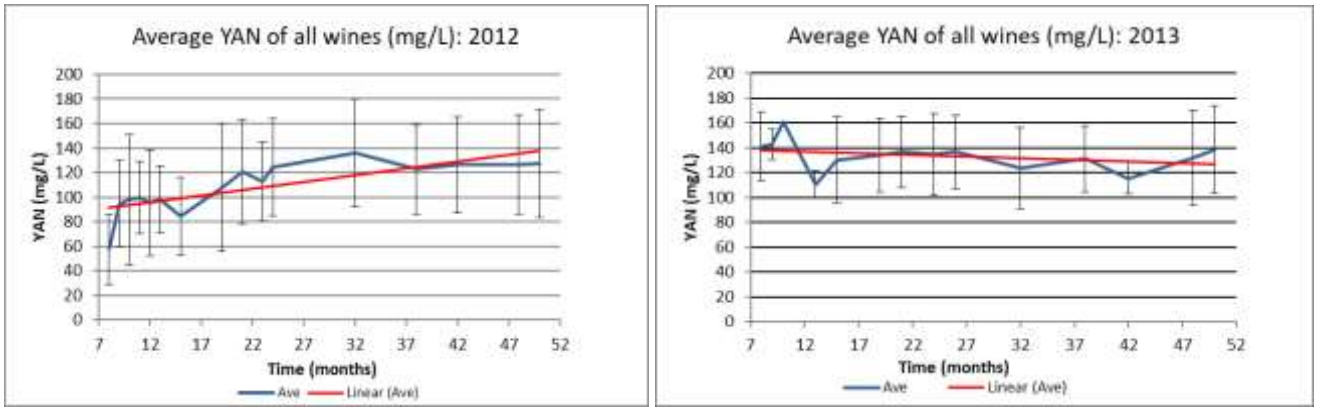


(a) (b)

Fig. 2. Principal component analyses of spectral fingerprints of MCC wines after 10 (indicated in blue font) and 50 months (indicated in green font) on the lees for (a) 2012 wines; and (b) 2013 wines.

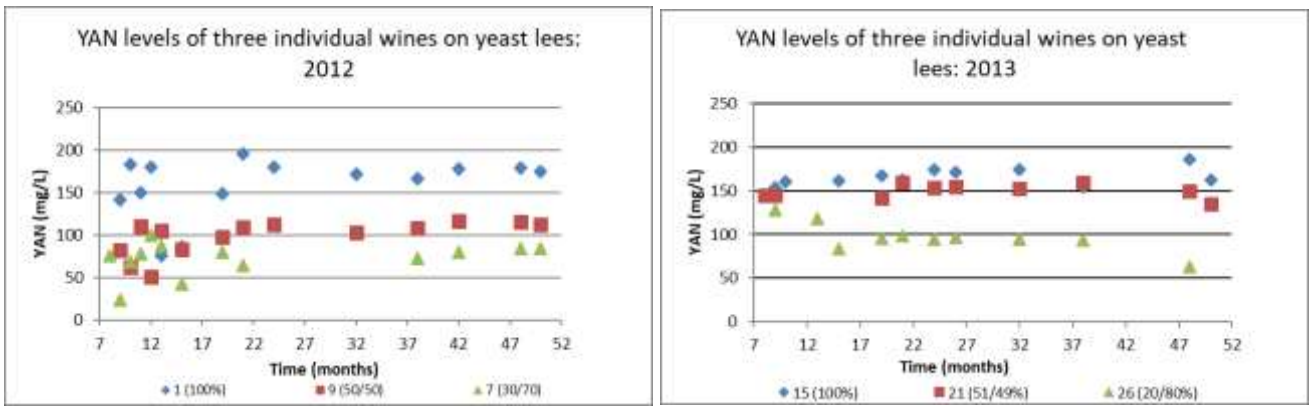
Yeast autolysis and total nitrogen Monitoring the progress of yeast autolysis is important and can be measured as an increase in nitrogen content of the wine. Three different methods were investigated: total nitrogen, yeast assimilable nitrogen (YAN) and individual amino acids. The total nitrogen (Lecco method) was measured for the 2012 and 2013 wines from nine to 26 months (Addendum 4). For the 2012 wines there was an initial high standard deviation amongst the repetitions. No consistent pattern could be observed for both vintages. For the 2012 wines, a downward trend and for 2013, an upward trend was observed. Due to these conflicting results and high cost of the analyses, this technique was not investigated further.

Yeast assimilable nitrogen (YAN) is an analyses used for determining the nitrogen available for yeast metabolism in grape juice prior to fermentation and is not used post fermentation. However, in this project the YAN levels measured by the Formol titration technique were investigated as a tool to monitor changes in nitrogen arising from autolysis. The average value of the 2012 wines showed an upward trend until 37 months on the lees, where after the YAN levels stabilised (Fig. 3a). In contrast, the 2013 wines, on average, had considerably higher initial levels of nitrogen at nine months (Fig. 3b) compared to the 2012 wines, and subsequently showed very little change, or even a slight downward trend during ageing. This may be a vintage effect. Despite these differences, this analytical method may have value in monitoring individual wines for autolyses development (as illustrated for three pairs of wines in Figs 4a and b). This method, although labour intensive, is easily carried out with basic laboratory equipment.



(a) (b)

Fig. 3. Total fermentable nitrogen (YAN) of MCC wines on yeast lees (a) 2012 and (b) 2013 vintage.

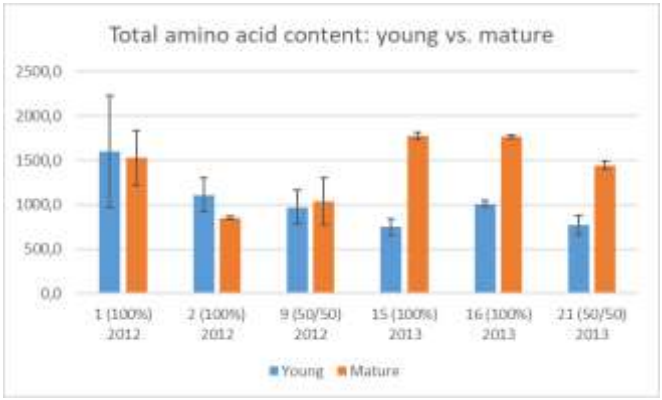


(a) (b)

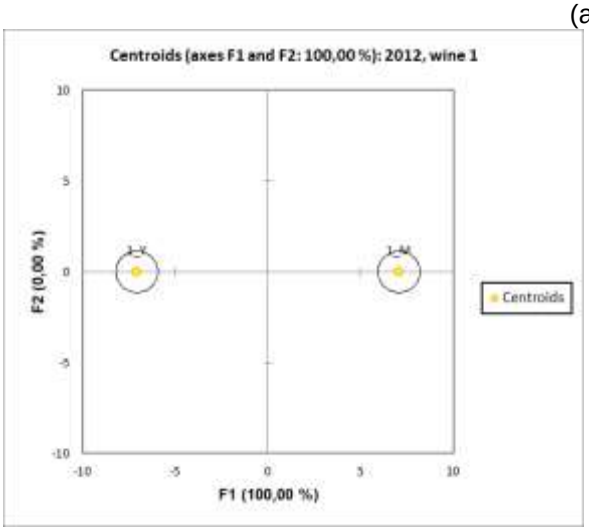
Fig. 4. Total fermentable nitrogen (YAN) of six individual MCC wines on yeast lees over time (a) 2012 and (b) 2013 vintage. Wines 1 and 15 = Blanc de Blanc; wines 9 and 21 = blends; and wines 7 and 26 = rosé

Individual amino acid measurements are expensive to perform therefore this analytical method was limited to only six wines (three from each vintage) from the same producer, respectively. These wines had the same composition over the two vintages and included two Blanc de Blanc wines and one 50/50 Chardonnay/Pinot noir blend. The 2013 wines showed an increase in total amino-acid content (Fig. 5a) when comparing young (10 month on lees) to mature wines (38 months on lees). The same trend was not observed for the 2012 wines, where only one wine had an increase in total amino-acid content, while the other two stayed at a similar level.

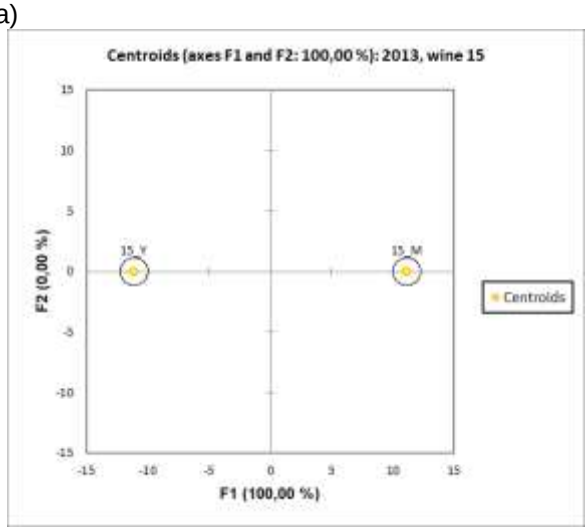
Discriminant analyses of the three MCC wines showed that individual amino acid profiles differ (as illustrated in Figs 5b and c for a 2012 and 2013 Blanc de Blanc). However, no one specific amino acid was implicated, and between one and three amino acids could be used to discriminate between the young and mature wines. The same trend was observed for 2012 and 2013 wines. It can therefore be concluded that amino acid profiles could be used as a tool to distinguish young from mature wines. However, the high costs and limited laboratories available to do these analyses make it inaccessible to most MCC producers.



(a)



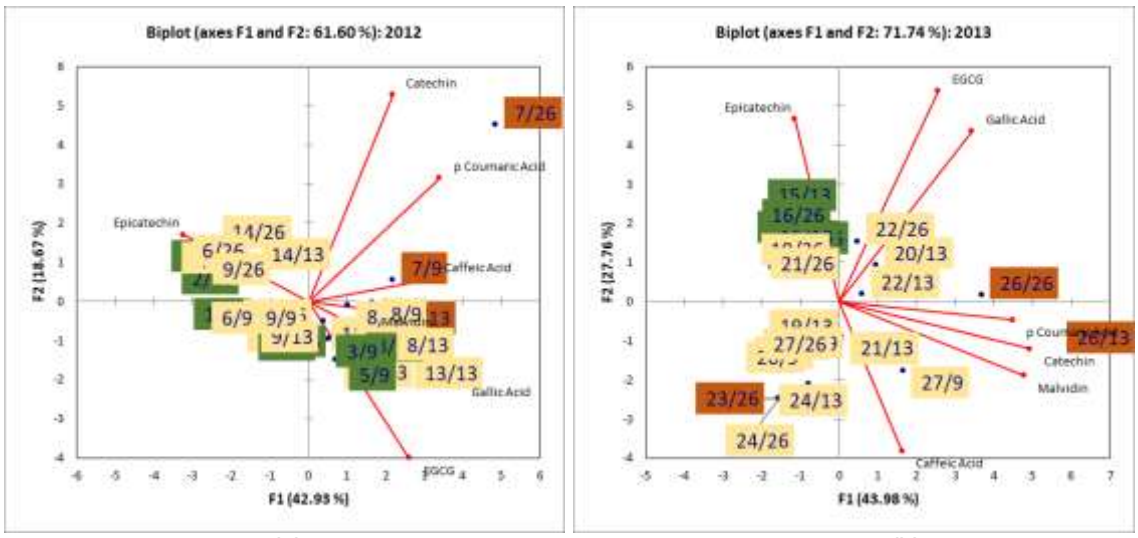
(b)



(c)

Fig. 5 Total amino-acid content of three wines from (a) the 2012 and 2013 vintages when young (10 months on lees) and mature (38 months on lees). Wines 1 and 15, 2 and 16, and 9 and 21 are from the same producer, respectively. Discriminant analyses of individual amino acid concentrations of two Blanc de Blanc wines (wines 1 and 15) from the same producer for (b) 2012 and (c) 2013 vintages when young (Y = 10 months on lees) and mature (M = 38 months on lees).

Polyphenols Polyphenols (gallic acid, catechin, caffeic acid, epicatechin, EGCG,epigallocatechin-3-O-gallate] p-coumaric acid, malvidin) were detected and measured on young (9-13 months on lees) and matured wines (26 months on lees) for 2012 (n= 10) and 2013 (n=10), respectively. The polyphenol levels did not show changes as the wines aged, but a general association with specific polyphenols according to wine style was observed (Fig. 6a and b).



(a) (b)

Fig. 6. Principal component analyses of polyphenols (gallic acid, catechin, caffeic acid, epicatechin, EGCG [epigallocatechin-3-O-gallate], p-coumaric acid, malvidin) of (a) 2012 and (b) 2013 wines on the yeast lees. Green = Blanc de Blanc, yellow = Chardonnay/Pinot noir blends and Brown = rosé wines.

Volatile aroma compounds Volatile aroma components were measured on a selection of nine-month on the lees wines and the data subjected to principle component analyses. The results indicate that some wines generally grouped together based on their cultivar composition (Fig. 7), somewhat similar to the polyphenol results i.e. Blanc de Blanc (group B), Pinot noir dominated (> 75%) blends (group C) and blends with equal quantities of Chardonnay and Pinot noir (group A). However, a number of wines did not follow an association based on cultivar composition. During the latter part of this project, this analyses became unavailable due to staff changes at Stellenbosch University. As MCC wines age, their fruit character lessens, so it can be speculated that association based on cultivar will become less important. This type of analyses is also not easily assessable to the wine industry due to high costs and limited facilities available to do these analyses.

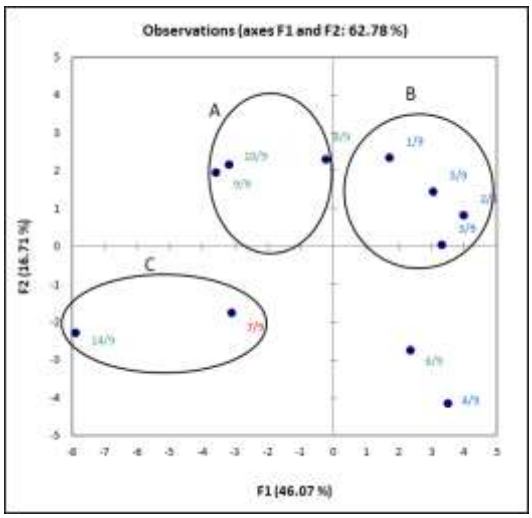


Fig. 7. Principal component analyses of GC-FID data of MCC wines after nine months on the yeast lees. Circles for illustrative purposes only.

Total polysaccharides Total polysaccharides were measure by the Usseglio-Tomasset method that precipitates these macromolecules with alcohol, before filtration and weighing. It is therefore a rather crude method, but requiring very little in the way of sophisticated laboratory equipment, albeit a four decimal balance.

As yeast autolyses should lead to an increase in compounds and molecules in the wine, it was expected that the total polysaccharide content would increase with longer ageing on lees. However, Fig. 8a b, c and d show no increase in average polysaccharide content. In some individual wines there was a tendency towards a decrease in polysaccharide content (Fig. 8e and f). This method is therefore unsuitable for monitoring autolyses of yeast during ageing of MCC.

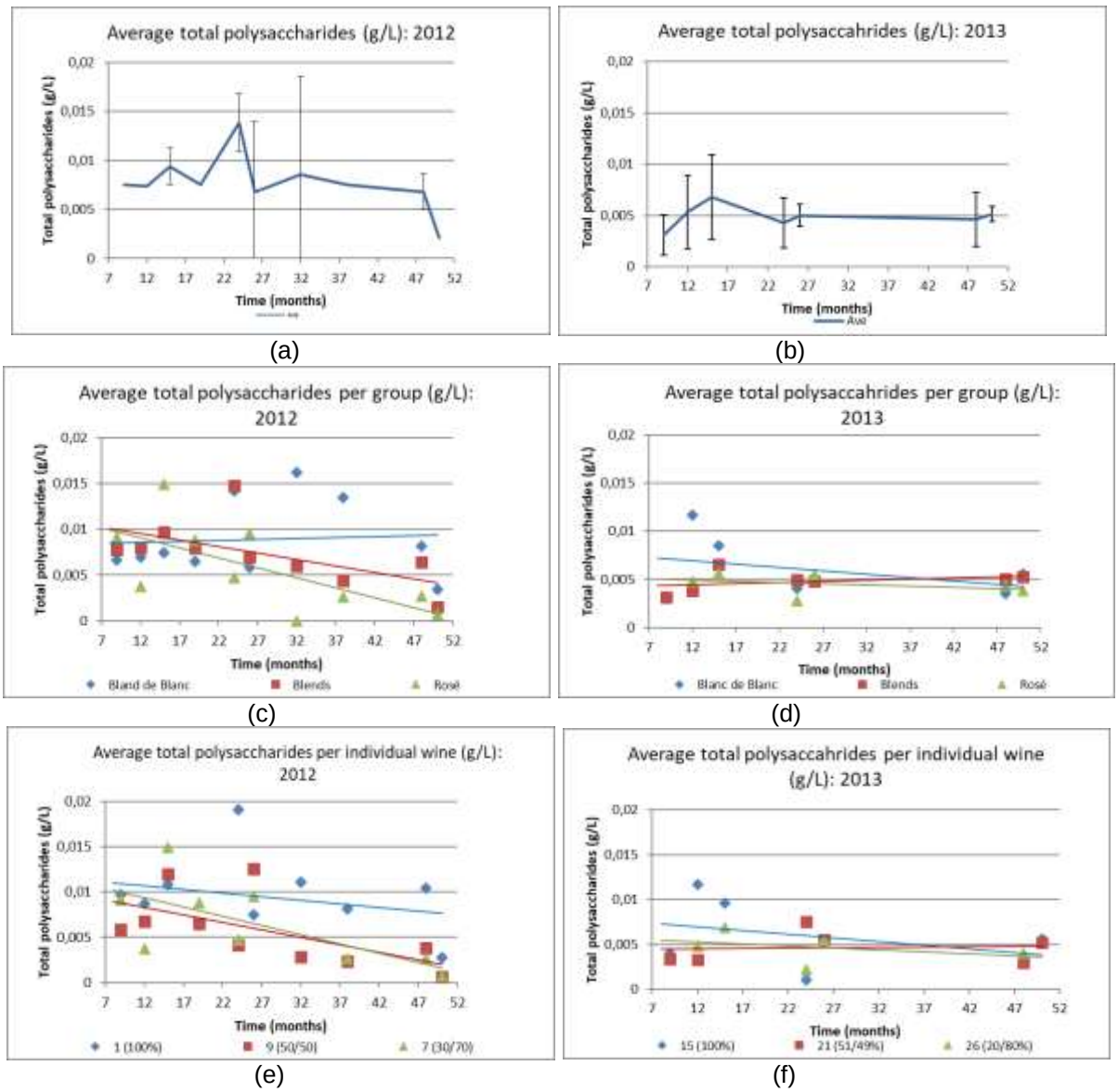


Fig. 8. Polysaccharide levels in MCC wines aged on lees from 9 to 52 months for 2012 and 2013 vintages. (a) and (b) = Total polysaccharides; (c) and (d) = Total polysaccharides per wine style; (e) and (f) = Total polysaccharides for three individual wines (a Blanc de Blanc and two blends).

Proteins Protein extraction was done on a young wine (12 months on lees) and compared to an older wine (42 months on lees). All extracted protein lysates were shown to have one distinctive protein band (10 – 20 kDa) following SDS-PAGE (Fig. 9). The marginal variation in protein band intensity can be indicative of differences in protein content. It is therefore possible that more

than one protein is present within the respective bands observed. However, proteins were only resolved using molecular weight (kDa), and so are observed as one band. Therefore, based on this method, there was no differences between the young and old wines.

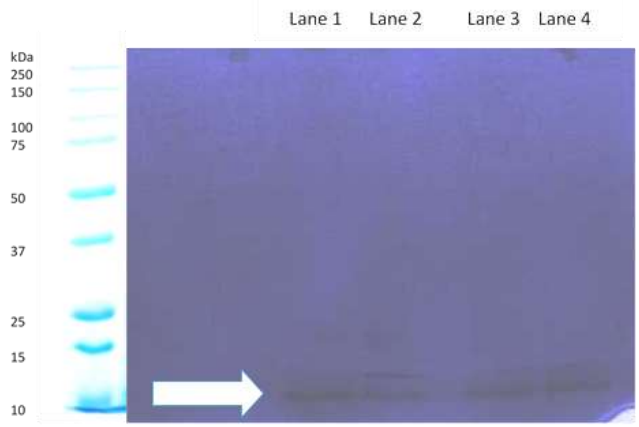
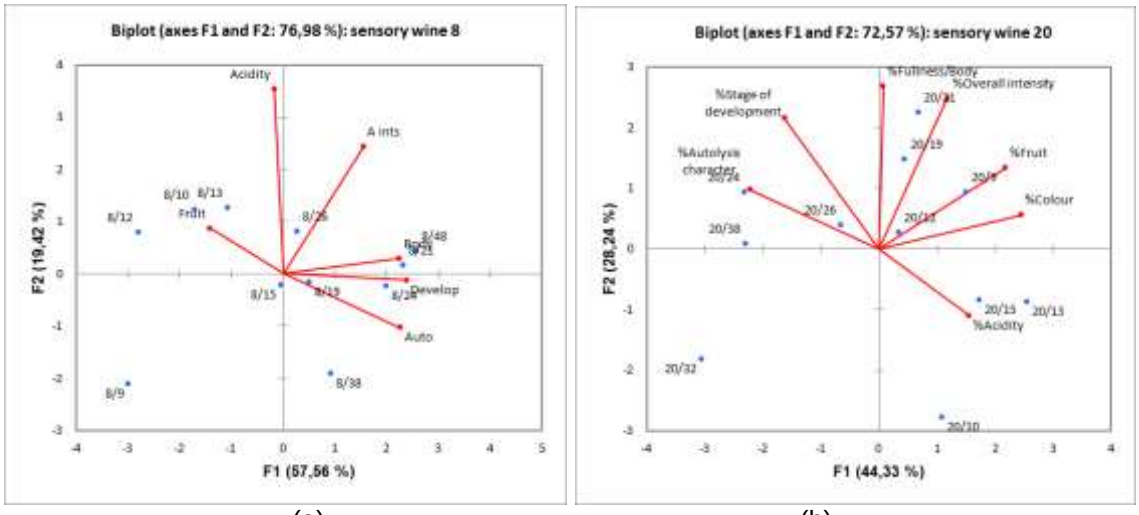


Fig. 9. Coomassie brilliant blue-stained gel following sodium dodecyl sulfate polyacrylamide gel electrophoresis (SDS-PAGE) of protein lysates originating from various MCC wines. Lanes 1 - 4: wine 1/42A, wine 1/42B, 1/12A and 1/12B, respectively. Protein bands are indicated by white arrow.

9.2 Sensory data: 2012 and 2013 wines

Principal component analyses of the combined 8-9 months to 48-50 months 2012 and 2013 sensory data, respectively, showed a general association of younger wines with the fruity descriptor (Addendum 5). Individually, the 2012 sensory data showed a consistent pattern over all wines. Young wines of nine to 19 months associated with higher fruity and acidity levels (as illustrated in Fig. 10 for wines 8 and 20 for a Chardonnay/Pinot noir blend from the same producer; Addendum 6 and 7). The matured wines (32 to 50 months) associated with higher levels of all the other attributes i.e. autolyses character, stage of development, aroma intensity and body. This is empirical evidence that extended maturation of MCC wines on their lees lead to a more complex product, with the desired flavour properties as sought by the industry.

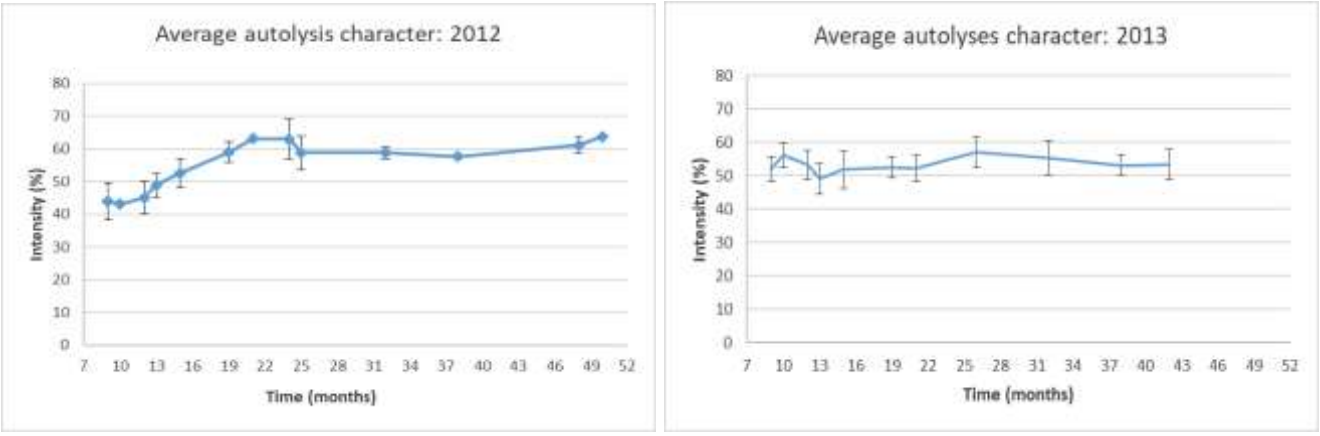


(a) (b)

Fig. 10. Principle component analyses bi-plot of sensory data of wine 8 from 2012 (a) and wine 2013 from 2013 (b) from 8 to 48 months on the lees. Wines 8 and 20 are from the same producer.

The sensory attribute 'autolysis' is a desired and important characteristic of bottled fermented sparkling wine so this data subset was investigated in more depth. The sensory data showed there was a sharp increase in the average autolytic character of the wines after nine months. This peaked at between 22 and 25 months (2012) (Fig. 11a). This was followed by a slight

decrease before increasing again at 49 to 52 months. The same trend was not as apparent for the 2013 wines, although there was also a slight peak in autolytic character at 25-28 months, slightly later than the 2012 wines (Fig. 11b).



(a) (b)

Fig. 11. Devlopment of autolytic sensory character of (a) 2012 and (b) 2013 MCC wines on yeast lees (9 to 52 months).

The autolytic data of the individual wines (Fig. 12) showed that the autolytic character for most wines increase sharply after nine months and peaked at about 25 to 30 months on lees, followed by a decline before increasing again. This up and down trend has also been observed by producers of South African MCC wines (P. Gerber, personal communication, 2018).

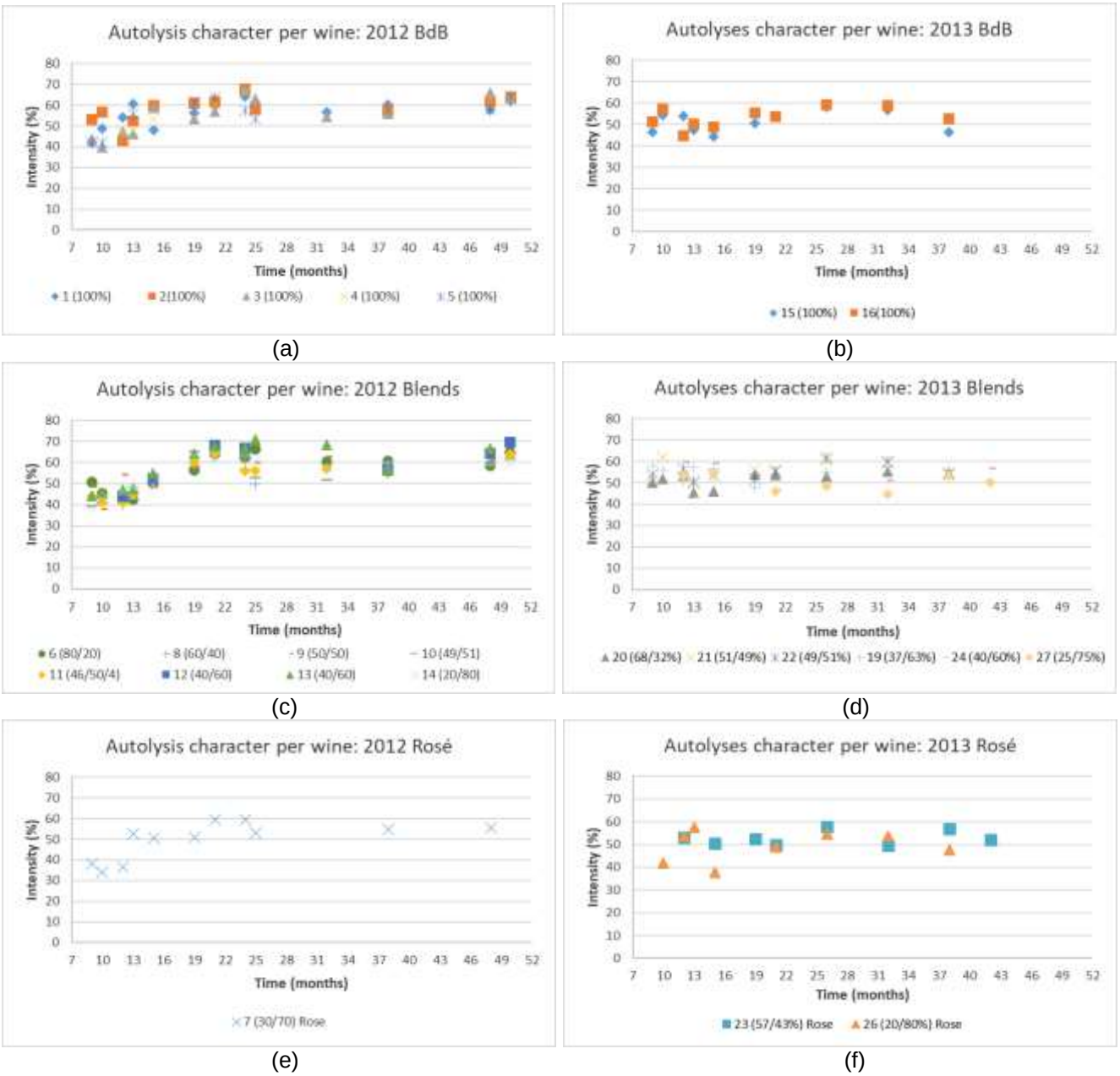
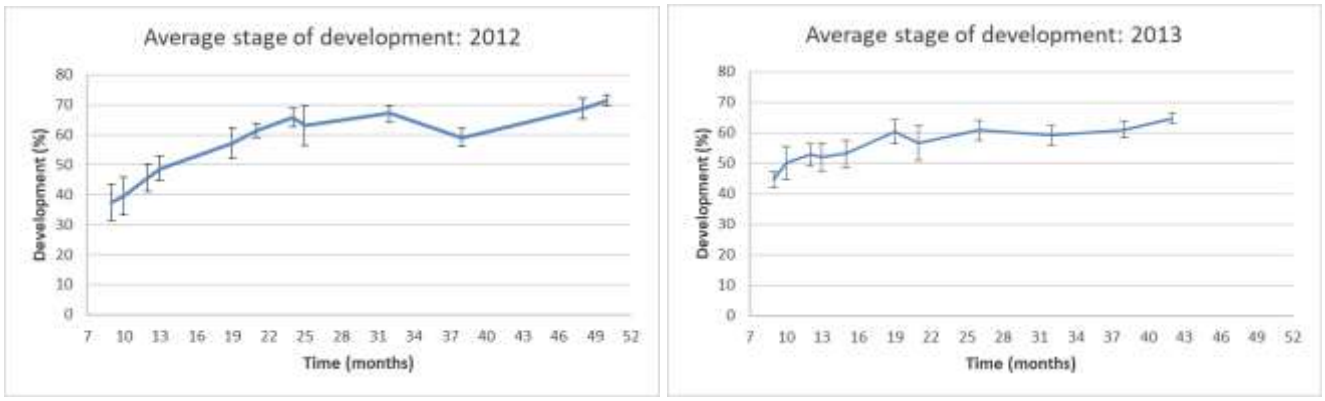


Fig. 12. Devlopment of autolytic character of 2012 and 2013 Blanc de Blanc, blends and rosé MCC wines during ageing on lees (9 to 52 months).

The development of the sensory aspect ‘Stage of development’, which incorporates the overall “image” of the wine’s development from young to mature, broadly reflects that of the autolyses character (a peak followed by a trough before increasing again) (Fig. 13). However, for the 2013 wines there is stronger increase in ‘Stage of development’ (Fig. 13b), not seen in the 2013 autolytic character data (Fig. 11b). This is evidence that in the 2013 wines, the autolytic character was more integrated in an overall complex aroma, whereas in the 2012 wines, the autolytic character was a more defined single flavour aspect.



(a) (b)

Fig. 13. Average stage of development of (a) 2012 and (b) 2013 MCC wines ageing on lees.

Individually, the Blanc de Blanc's, blends and rosés followed the same overall trend in their maturity development (Fig. 14). Their development is also remarkably similar considering that the composition of the wines range from 100% Chardonnay to blends with increasing proportions of Pinot noir, and here and there, some other cultivars in small percentages (Table 1).

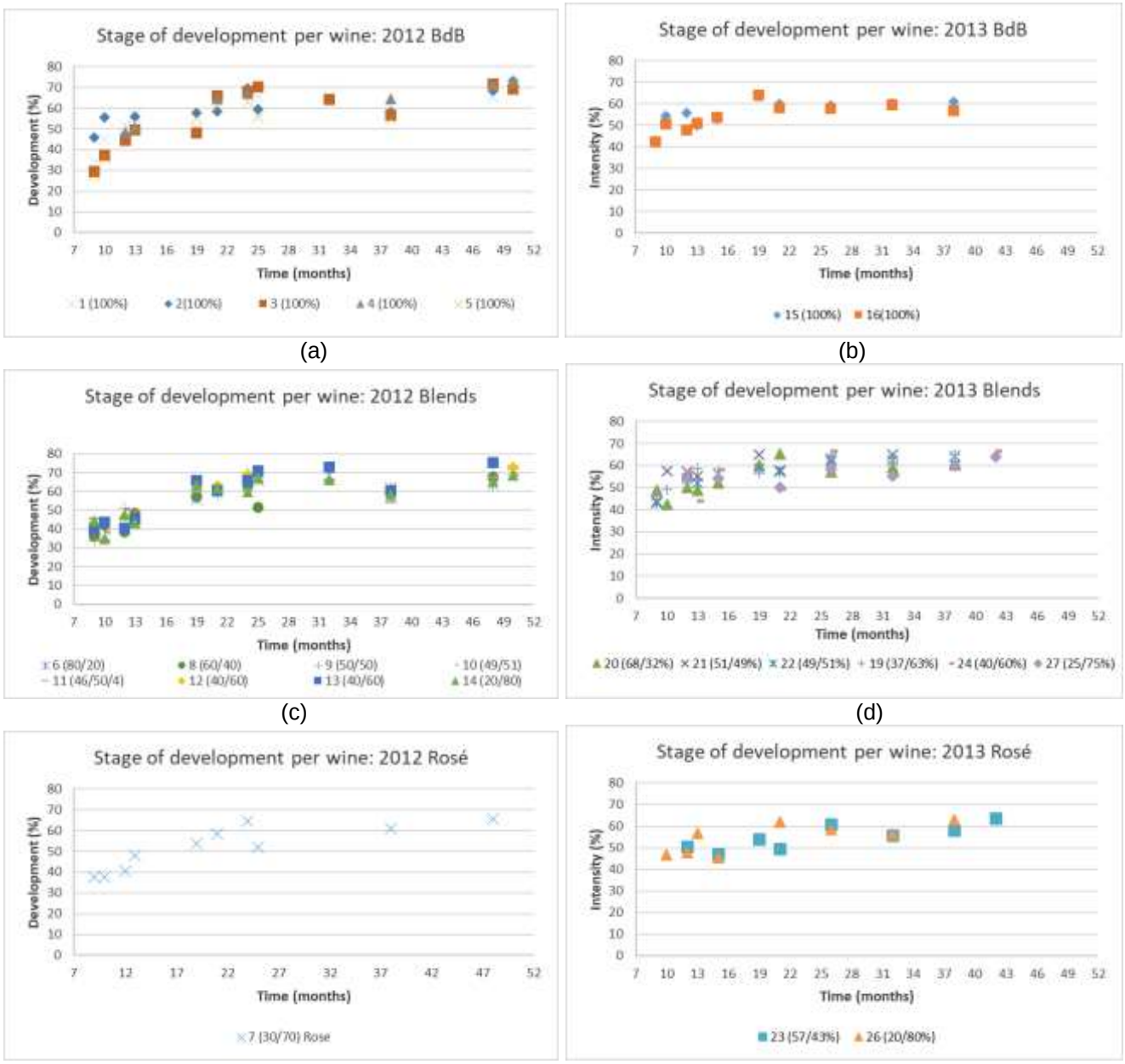


Fig. 14. Development maturity ('Stage of development') of 2012 and 2013 MCC wines during ageing on lees (9 – 50 months). (a) and (b): Blanc de Blanc; (c) and (d): blends; and (e) and (f): rosé.

Based on the observations of 'autolysis' and 'Stage of development' data, it therefore makes sense to increase the legislated minimum current nine months lees ageing time by at least 3-4 months for an entry level/standard MCC (12-13 months on the lees). This will take advantage of the sharp increases in autolytic and maturity sensory development. A second category could be considered at 25 to 30 months, however, care should be taken not to disgorge wines when in the flavour trough. An alternative for a second tier could be after 48 to 50 months. These tiered categories will improve the consumer understanding of the product. However, the style that individual producers are striving for will also play a role in determining the length of lees contact. Optimal and desired flavour development will also vary between vintages, so a controlled tasting by an industry panel, or Wine and Spirit Board panel would have to determine if the wine is stylistically correct. This could be something similar as is done for Noble Late Harvest vs. Natural Sweet wines. These panels would have to be knowledgeable in the style of wine being pursued, and agree on the characteristics of the various categories.

10. CONCLUSIONS AND RECOMMENDATIONS

The data generated during this investigation supports the concept of a multi-tier classification of MCC wines. This will bring about an overall improvement in the quality of the wines, and promote a better understanding by the consumer. Total amino acid profiles could be used as a tool to distinguish young from mature wines, but the high costs of the analyses makes this an impractical method for most MCC producers. An easy alternative would be to measure the yeast assimilable nitrogen that may have value for monitoring individual wines for autolyses development. This method is easily carried out, although labour intensive.

Infra-red fingerprinting and pattern recognition methods can be further investigated as a useful tool to categorise wines based on the time on yeast lees. Sensorially, MCC wines show positive development after the current minimum nine months on the lees. Favourable times to disgorge would be after 12-13 months, 25-30 months and after 50 months on the lees. However, due to vintages differences a controlled sensory evaluation would have to be carried out to determine if the MCC wines are stylistically correct according to the category characteristics.

11. ACCUMULATED OUTPUTS

a) TECHNOLOGY DEVELOPED, PRODUCTS AND PATENTS

-

b) SUGGESTIONS FOR TECHNOLOGY TRANSFER

- Presentation at the next Technical Day of the Cap Classique Association (19 September 2018). A preliminary invitation by the CCPA organising committee has been received.
- Popular publication in Wineland.
- Presentation and data sharing sessions with individual producers that took part in the project.
- Scientific publication in the South African Journal of Enology and Viticulture.

c) HUMAN RESOURCES DEVELOPMENT/TRAINING

Student Name and Surname	Student Nationality	Degree (e.g. MSc Agric, MComm)	Level of studies in final year of project	Total cost to industry throughout the project
Honours students				
Ucrecia Hutchinson[1]	South African	BTech	Graduated 2014	0
Masters Students				
Ucrecia Hutchinson[1]	South African	MEng	Graduated 2017	0
Ntombiyesicelo Dzedze[1]	South African	MSc	Final year	0
PhD students				
Postdocs				

Other				
Zanay Du Plessis	South African	NRF-DST intern		0
Bulelwa Fass	South African	NRF-DST intern		0
Louisa Beukes	South African	NRF-DST intern		0
Ntombiyesicelo Dzedze	South African	NRF-DST intern		0
Robyn-Lee Louw	South African	NRF-DST intern		0
Stephan Nortje	South African	Student intern		0
Melanie Vermeulen	South African	NRF-DST intern		0
Skye Meiring	South African	NRF-DST intern		0
Bianca Theunissen	South African	NRF-DST intern		0
Luaan Louw	South African	NRF-DST intern		0

[1]This student's main focus is on another project, and only assisted with analyses.

d) PUBLICATIONS (POPULAR, PRESS RELEASES, SEMI-SCIENTIFIC, SCIENTIFIC)

None.

e) PRESENTATIONS/PAPERS DELIVERED

Jolly N. (2012) Winetech Project Proposal: Effect of yeast contact time on the flavour profile and quality of Méthode Cap Classique wines. Presentation: 3rd Technical Day, Cap Classique Association, Klein Joostenberg Farm Conference Centre, Stellenbosch, 26 July 2012.

Jolly N, Van Breda V, Booyse M, Hutchinson U, Jooste A. (2013) Effect of yeast contact time on the flavour profile and quality of Méthode Cap Classique wines. Paper: 35th SASEV/Winetech International Conference: Winemaking Techniques and Practices Workshop, Lord Charles Hotel, Somerset West, South Africa, 13-15 November 2013.

Jolly N, van Breda V, Booyse M, Hutchinson U, du Plessis Z, Fass B, Jooste A. (2014) Effect of lees contact time on Méthode Cap Classique wines: preliminary observations. Paper: 5th Cap Classique Technical Day, Joostenberg Conference Centre, Stellenbosch, 18 July 2014.

Jolly N, van Breda V, Booyse M, Hutchinson U, du Plessis Z, Fass B, Jooste A. (2014) Effect of lees contact time on Méthode Cap Classique wines: preliminary observations. Presentation: Winetech - Winemaking Techniques and Practices Programme Workshop, Olive Grove, Stellenbosch, 2 October 2014.

Jolly N, van Breda V, Booyse M, Minnaar P, Harold G. (2016) Effect of lees contact time on the chemical and flavour profile of MCC wines. 6th Cap Classique Technical Seminar, Allee Bleue Wine Estate, Stellenbosch/Franschhoek, 22 July 2016.

12. PERSONS PARTICIPATING IN THE PROJECT (Excluding students)

Initials & Surname	Highest Qualification	Degree/ Diploma registered for	Race (1)	Gender (2)	Institution & Department	Position (3)	Cost to Project R
N. Jolly	PhD (Microbiology)	n/a	W	M	Post-Harvest & Agro-Processing, ARC Infruitec-Nietvoorbij	PL	
V. van Breda	MTech (Food Technology)	n/a	B	F	Post-Harvest & Agro-Processing, ARC Infruitec-Nietvoorbij	Co	
G. Harold	BSc Biotechnology	n/a	B	M	Post-Harvest & Agro-Processing, ARC Infruitec-Nietvoorbij	Co	
M. Booyse	PhD (Plant Breeding)	n/a	W	F	Biometry Unit, ARC Infruitec-Nietvoorbij	Co	
P. Adonis	Matric	n/a	B	F	Post-Harvest & Agro-Processing, ARC Infruitec-Nietvoorbij	RA	
P. Minnaar	MSc (Chemistry)	PhD (Chemistry/wine Biotechnology)[1]	W	M	Post-Harvest & Agro-Processing, ARC Infruitec-Nietvoorbij	Co	
R. Hart	PhD Biotechnology	n/a	B	M	Post-Harvest & Agro-Processing, ARC Infruitec-Nietvoorbij	Coll	

[1] This project is not the main focus of the PhD.

(1)Race B = African, Coloured or Indian
W = White

(2)Gender F = Female
M = Male

(3)Position Co = Co-worker (other researcher at your institution)
Coll = Collaborator (participating researcher that does not receive funding for this project from industry)
PF = Post-doctoral fellow
PL = Project leader
RA = Research assistant
TA = Technical assistant/ technician

13. BUDGET

TOTAL COST SUMMARY OF THE PROJECT

YEAR	CFPA	DFTS	Deciduous	SATI	Winetech	THRIP	OTHER	TOTAL
2013					245 335		255 347	500 681
2014					263 696		274 459	538 155
2015					284 943		296 573	581 516
2016					308 783		321 386	630 170
2017					235 184	86 239	244 784	566 207

EVALUATION BY INDUSTRY

This section is for office use only

Project number	P04000008 (000301; ww10/26)

Project name	Effect of yeast contact time on the flavour profile and quality of Méthode Cap Classique wines.

Name of Sub-Committee*	

Comments on project

Committee's recommendation (Review panel in the case of PHI)

- Accepted. ☐
- Accepted provisionally if the sub-committee's comments are also addressed. Resubmit this Final Report by_____ ☐
- Unacceptable. Must resubmit Final Report. ☐

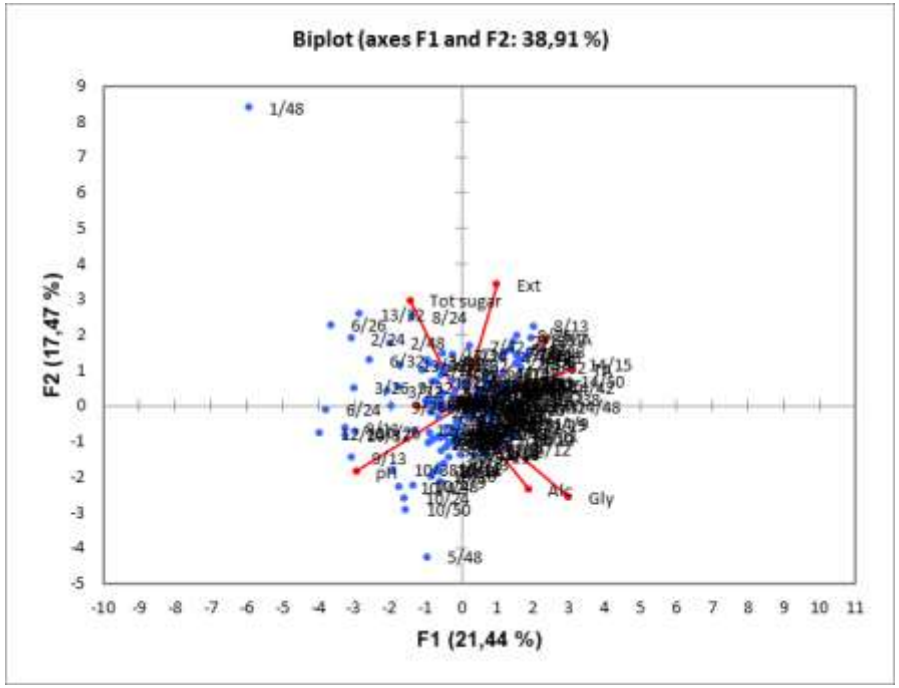
Chairperson_____ Date_____

*SUB-COMMITTEES
Winetech
Viticulture: Cultivation; Soil Science; Plant Biotechnology; Plant Protection; Plant Improvement;
Oenology: Vinification Technology; Bottling, Packaging and Distribution; Environmental Impact; Brandy and Distilling; Microbiology
Deciduous Fruit
Technical Advisory Committees: Post-Harvest; Crop Production; Crop Protection; Technology Transfer
Peer Work Groups: Post-Harvest; Horticulture; Soil Science; Breeding and Evaluation; Pathology; Entomology
SATI
Technical Committees
SATI Research and Development Committee

Industry allocated project number

ADDENDUM 1

PCA plot of all the 2012 data for total yeast counts, Winescan™ and extract data.



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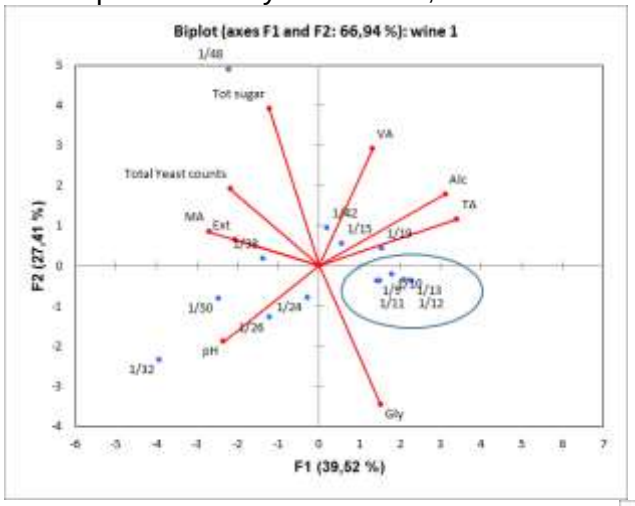
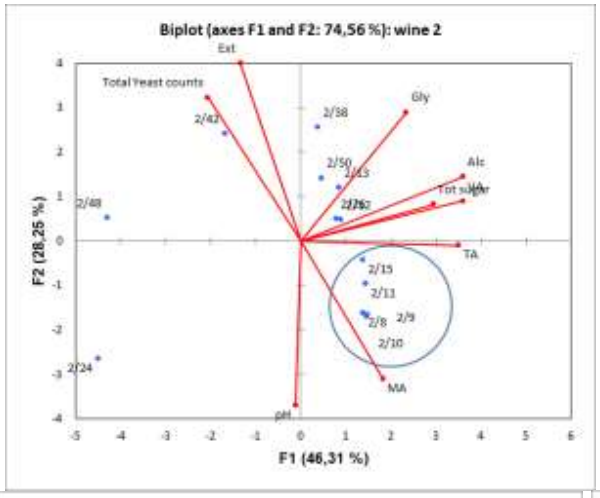
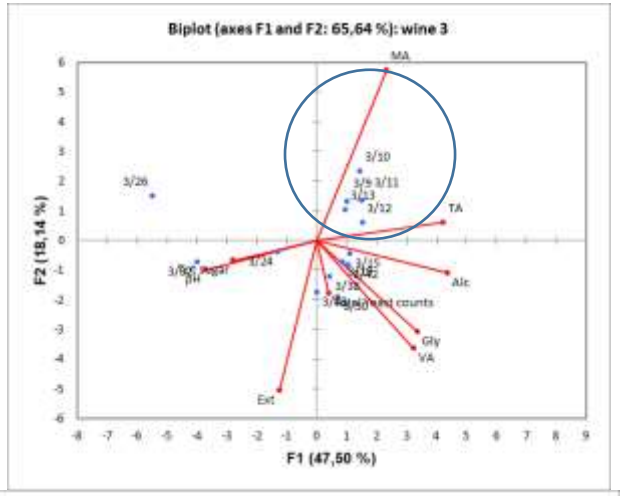
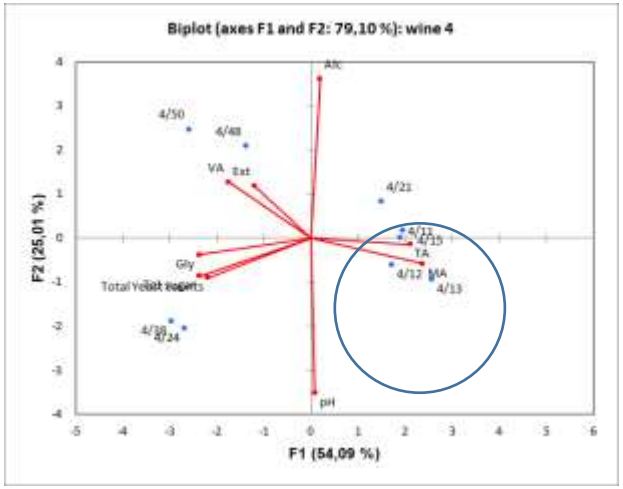
ADDENDUM 2

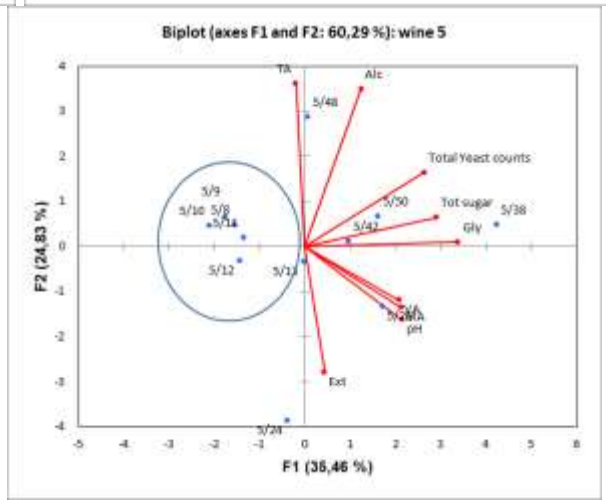
PCA bi-plots of total yeast counts, Winescan™ data and total extract of 2012 wines from young to mature (circles for illustrative purposes only).

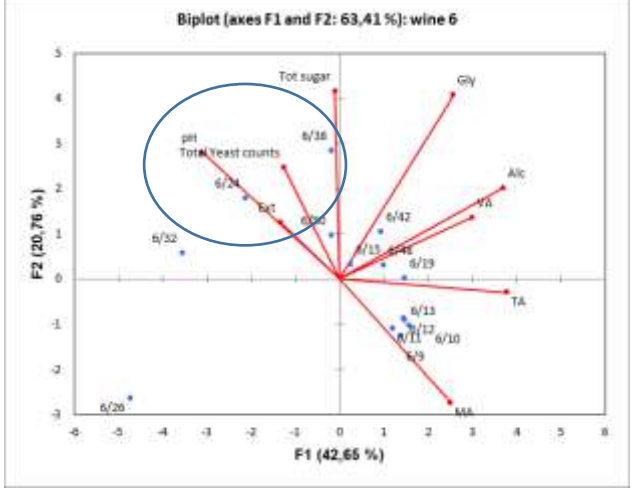


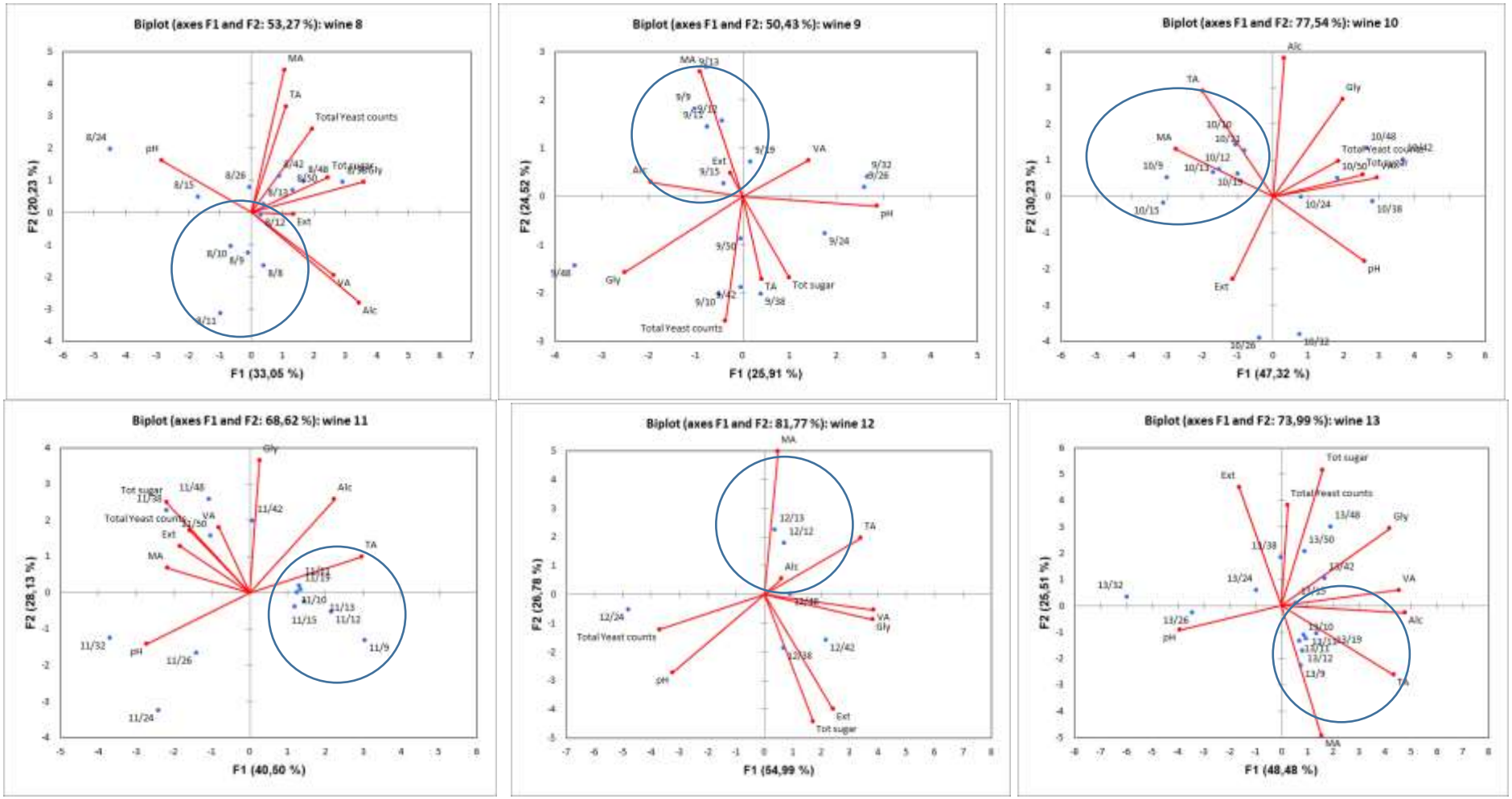


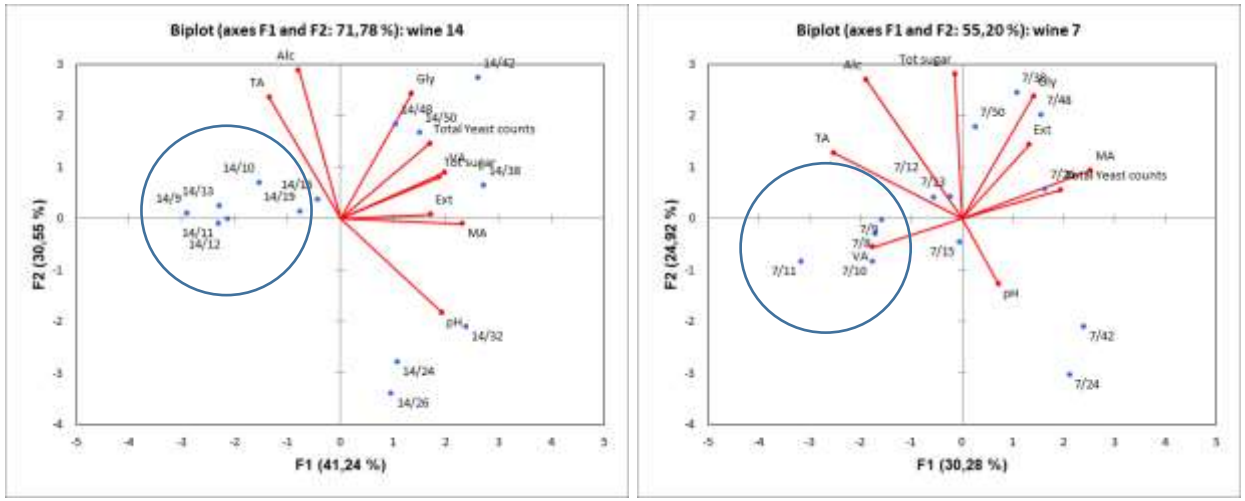












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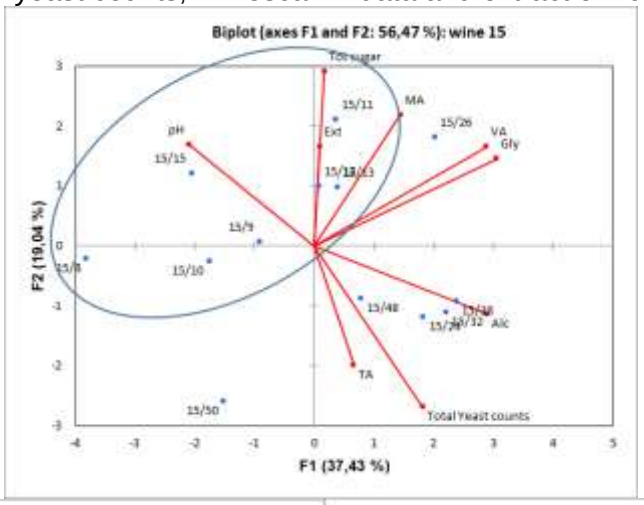
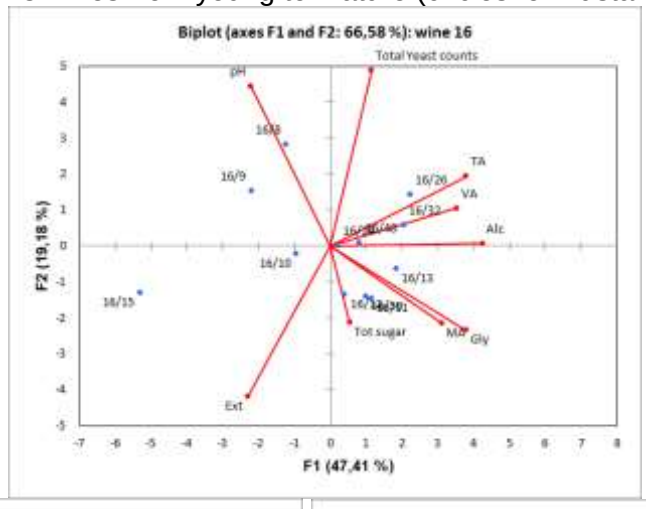
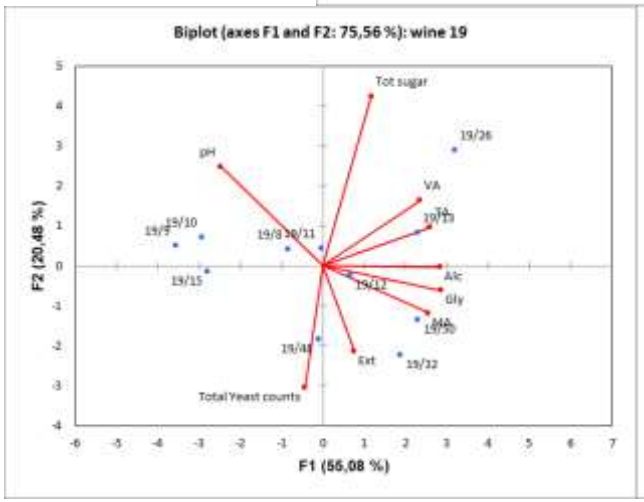
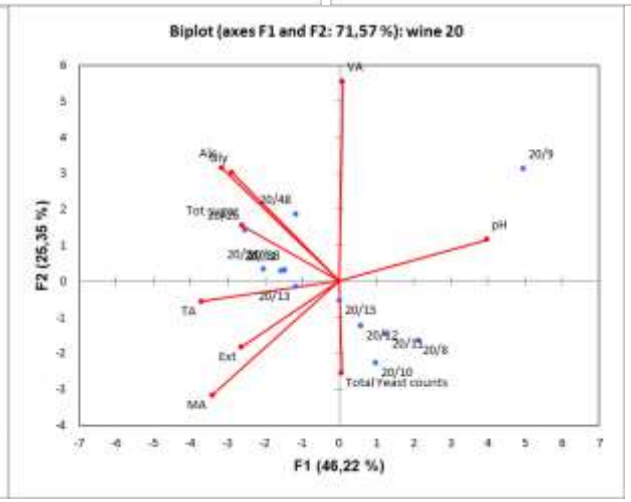
ADDENDUM 3

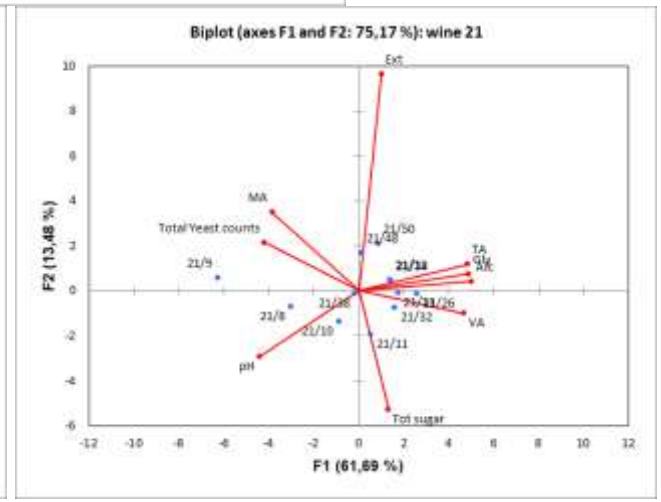
PCA bi-plots of total yeast counts, Winescan™ data and extract of 2013 wines from young to mature (circles for illustartive purposes only).

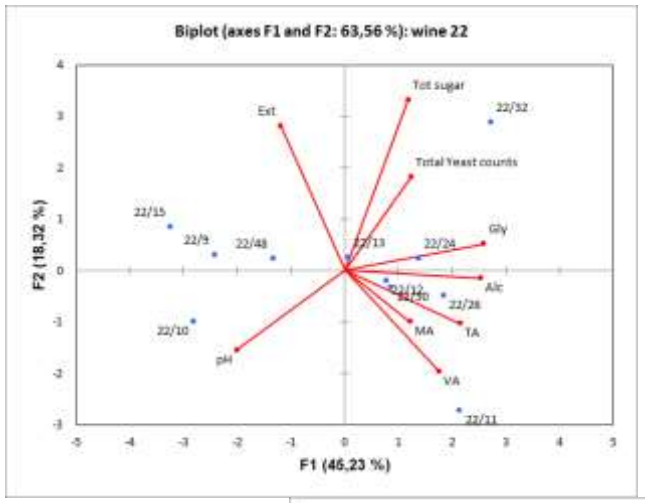


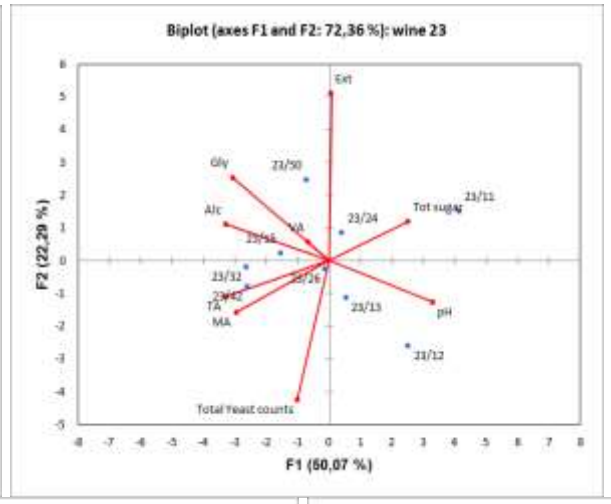


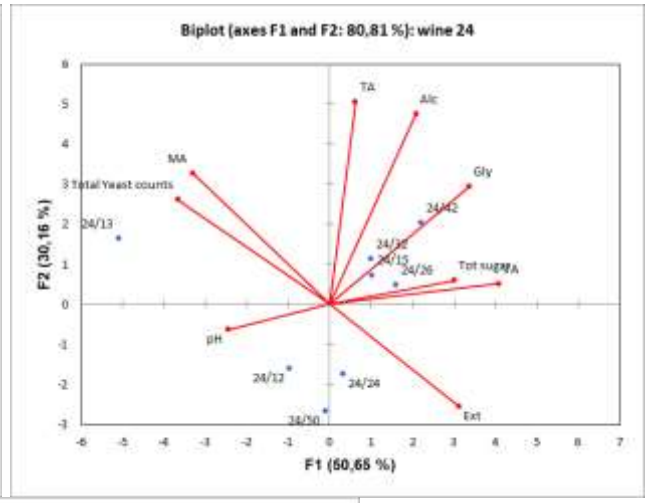


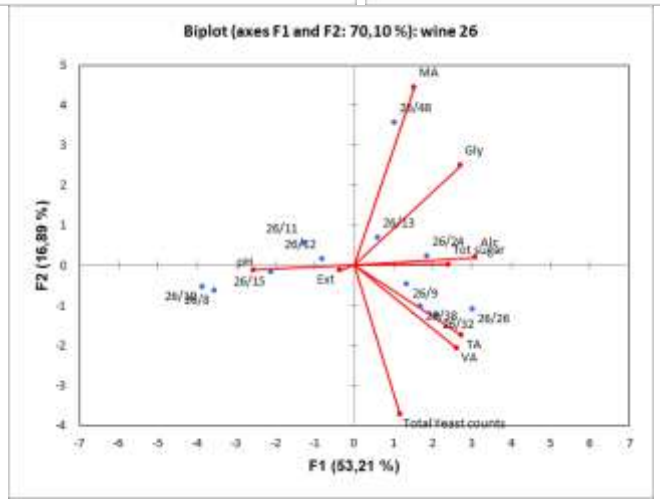


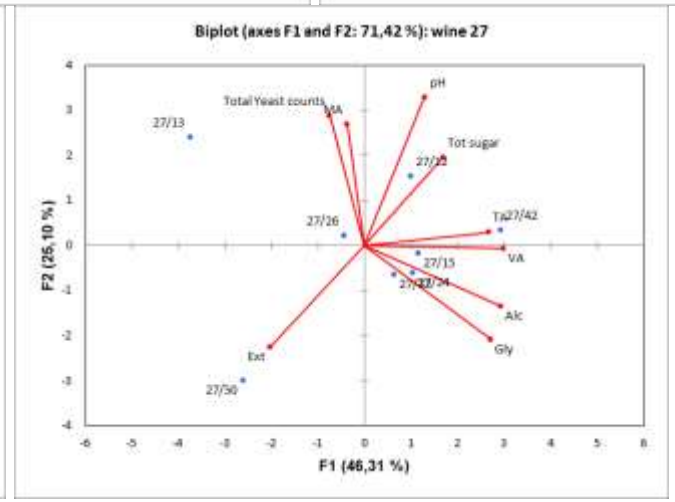












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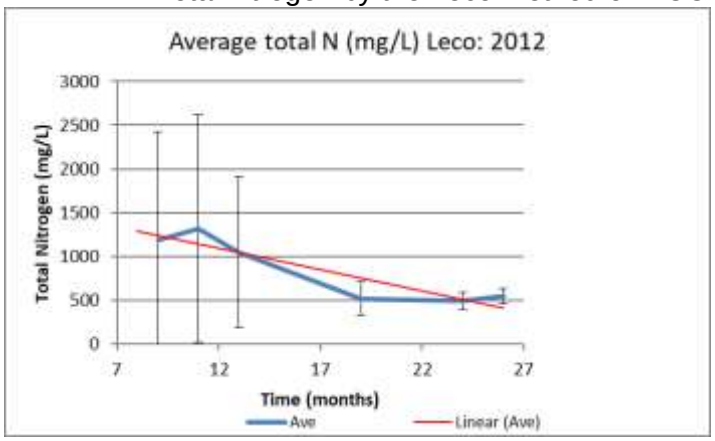
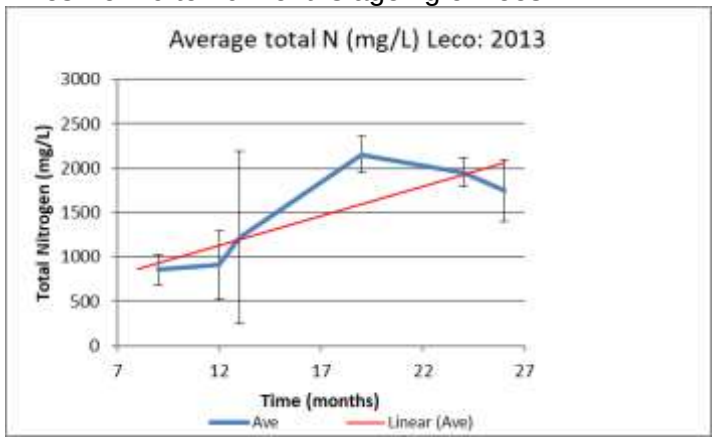
ADDENDUM 4

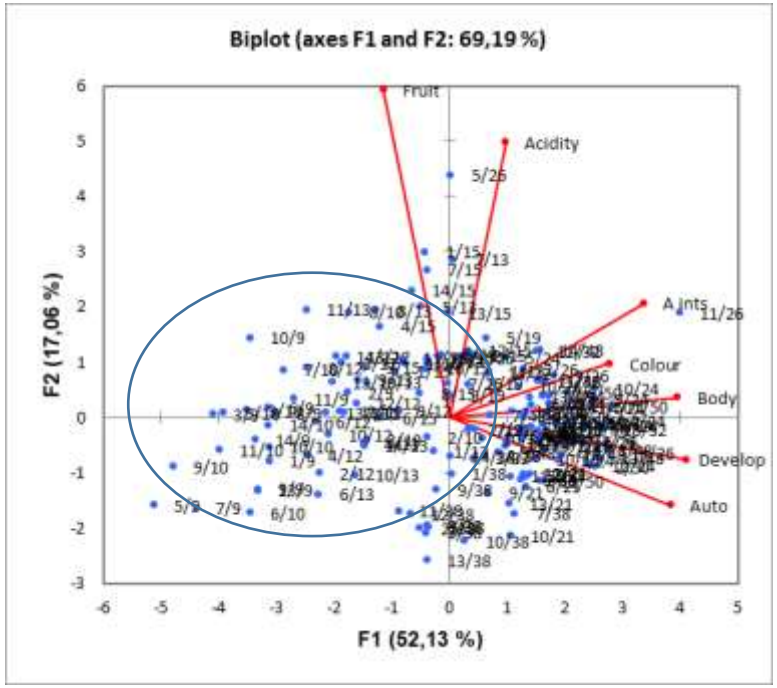
Total nitrogen by the Leco method of MCC wines from 9 to 26 months ageing on lees.



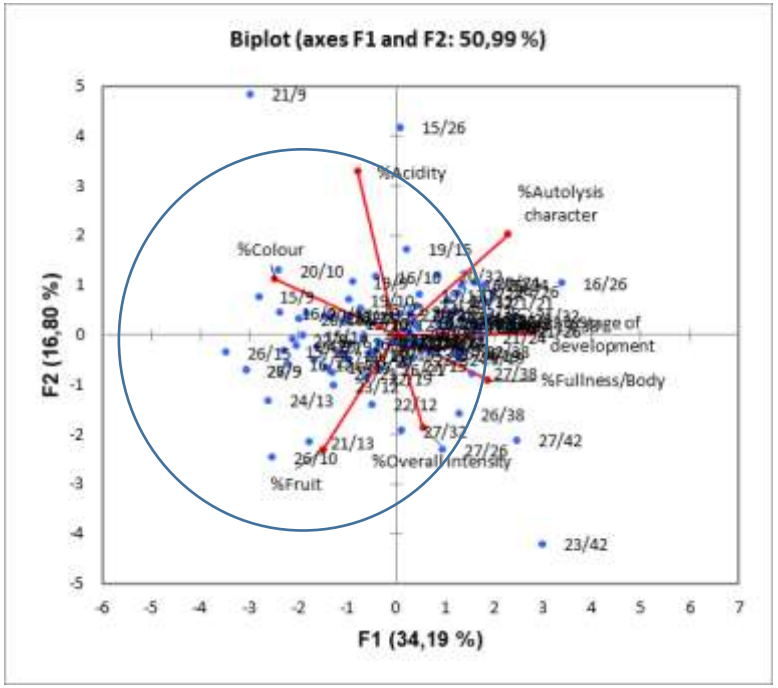


ADDENDUM 5

All sensory data 2012 and 2013 wines (circles for illustartive purposes only).



2012



2013

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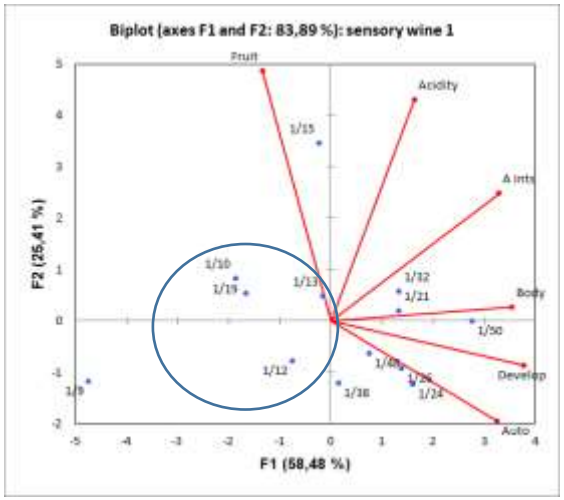
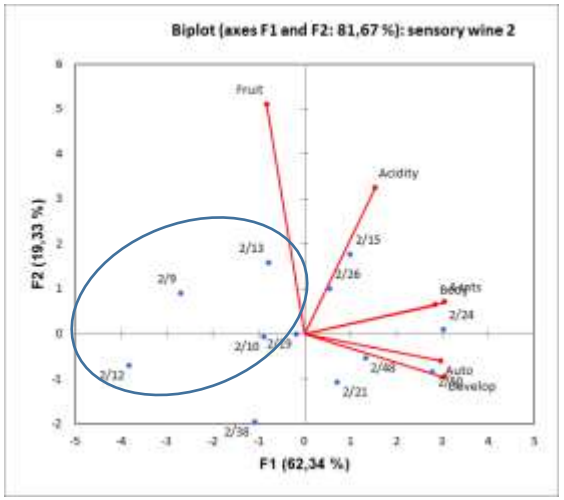
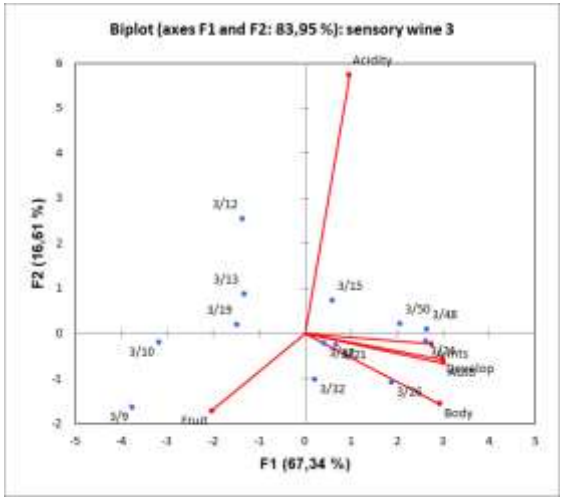
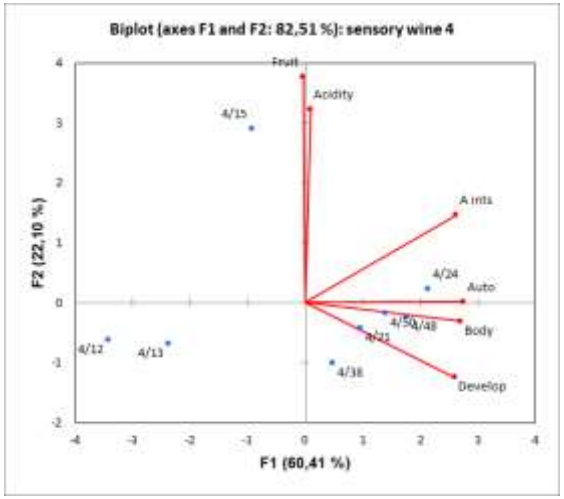
ADDENDUM 6

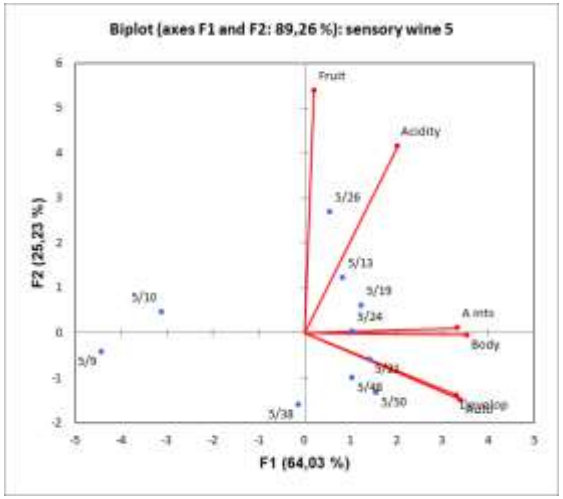
Sensory data per wine: 2012 (circles for illustartive purposes only).

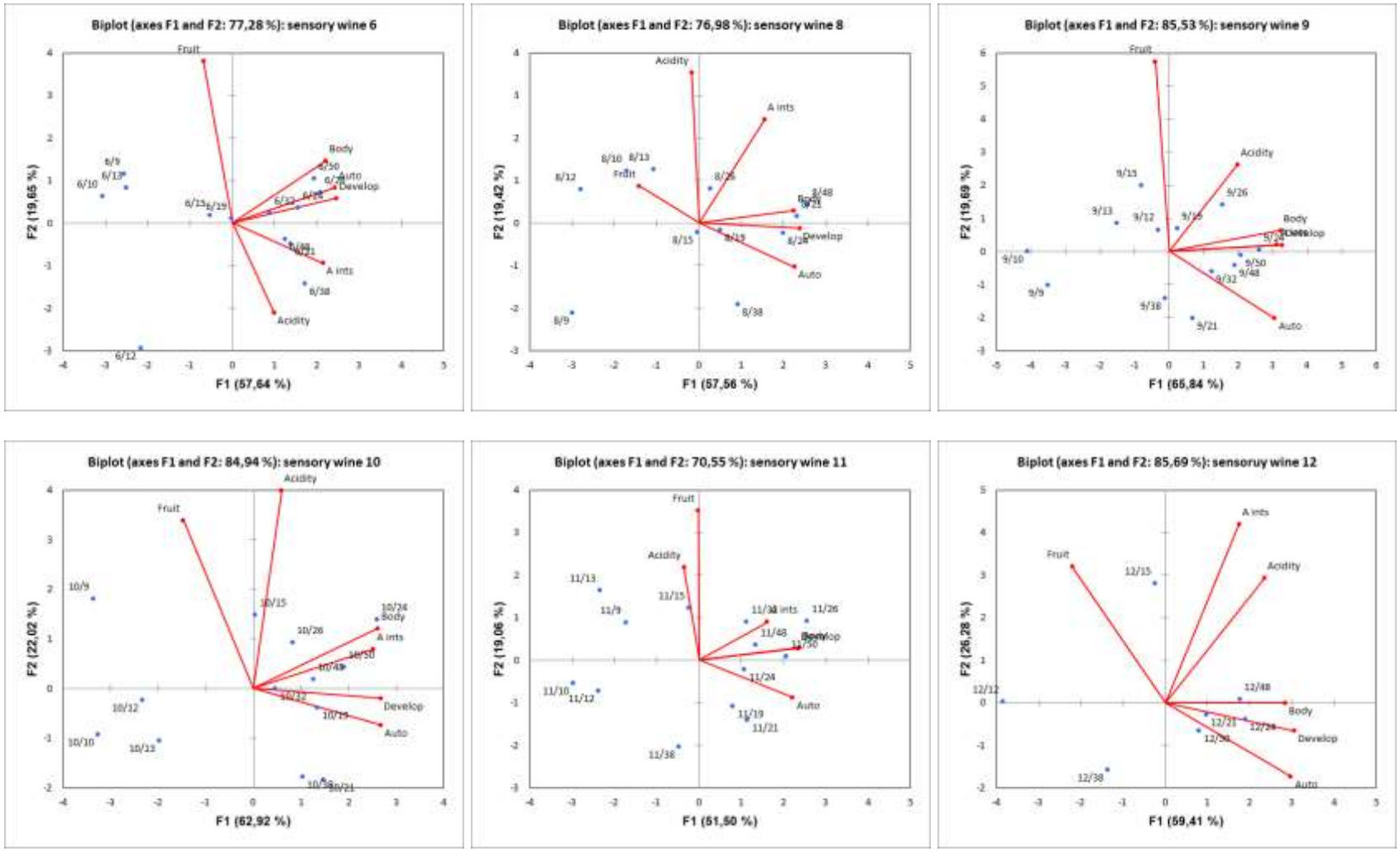


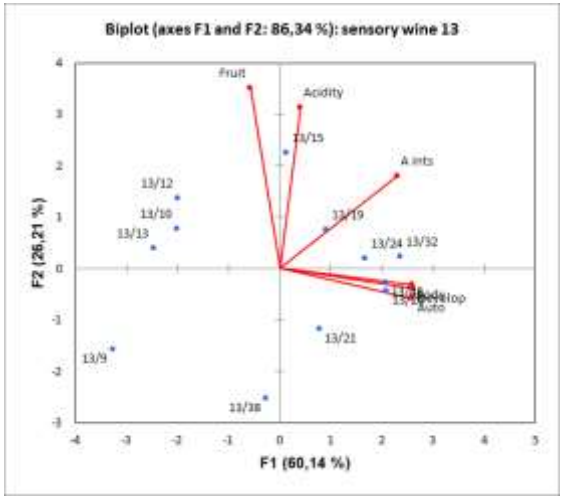


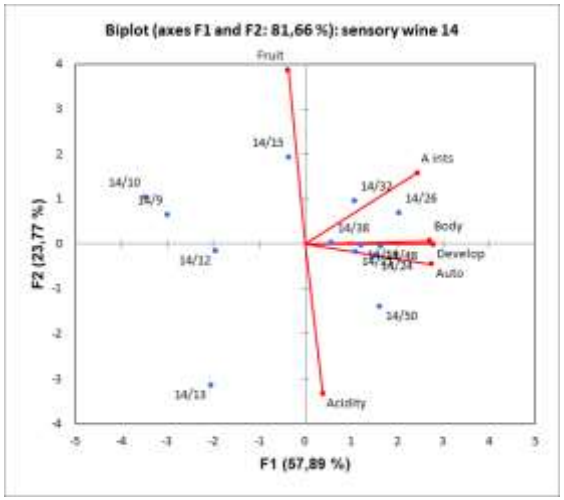


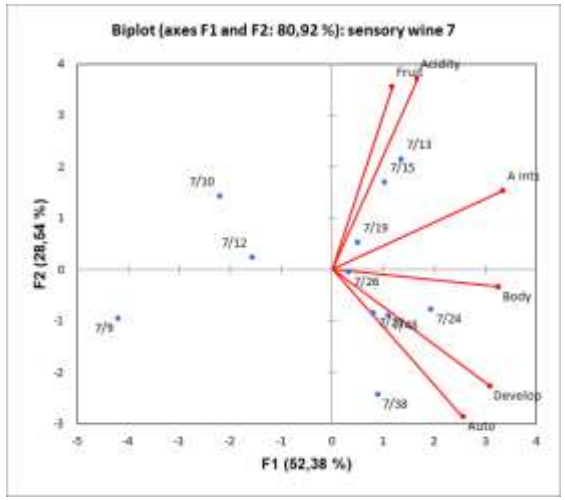












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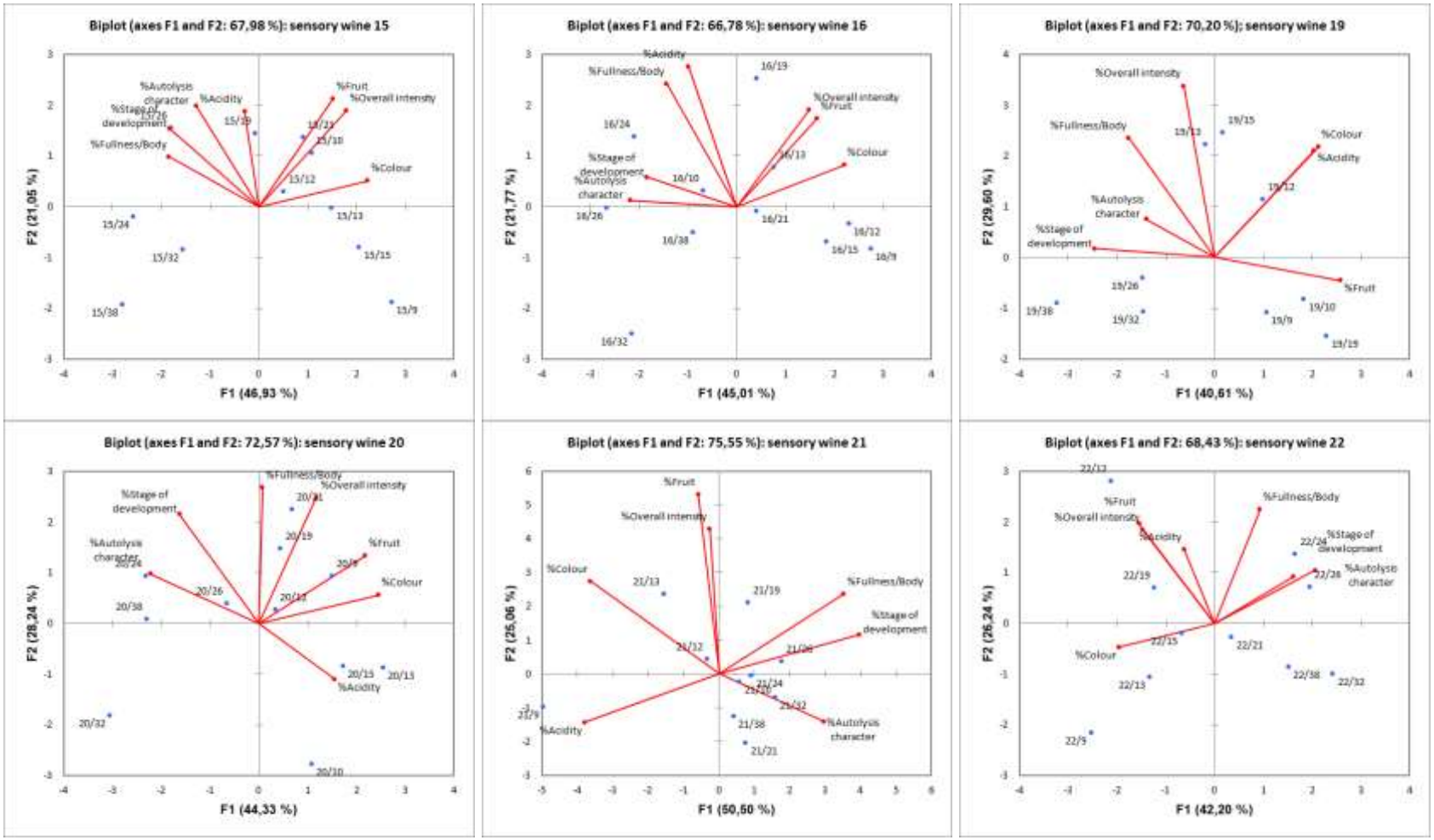
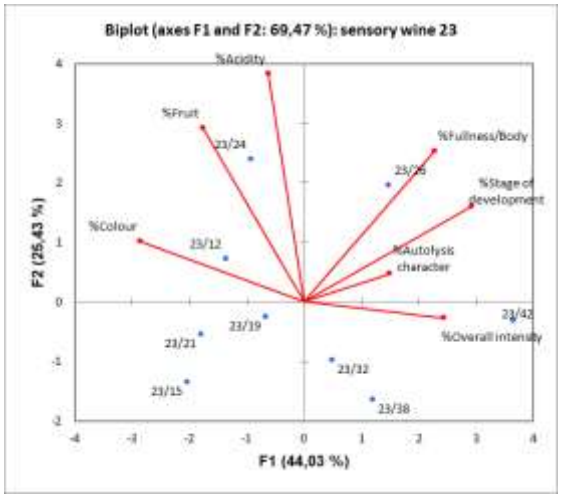
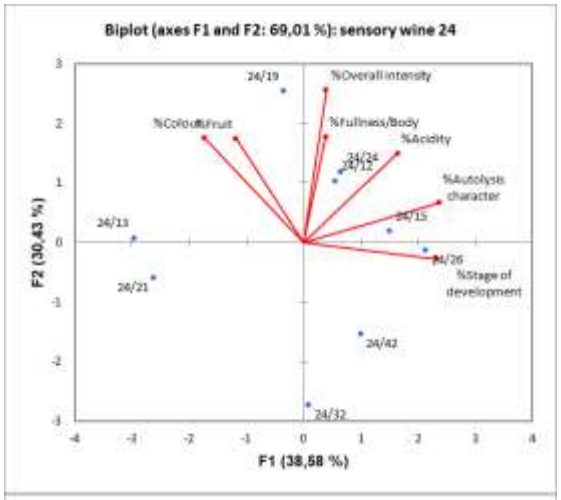
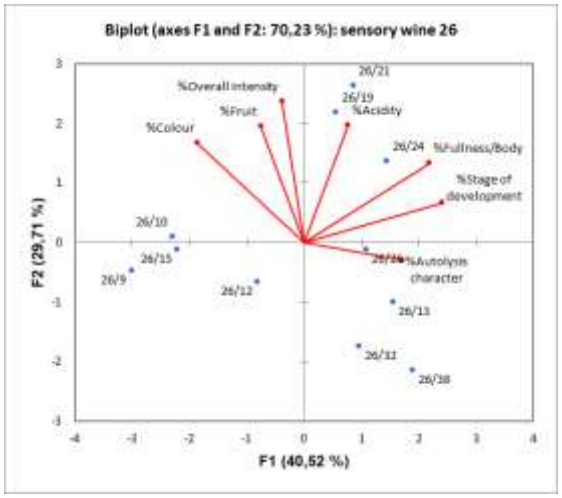
ADDENDUM 7

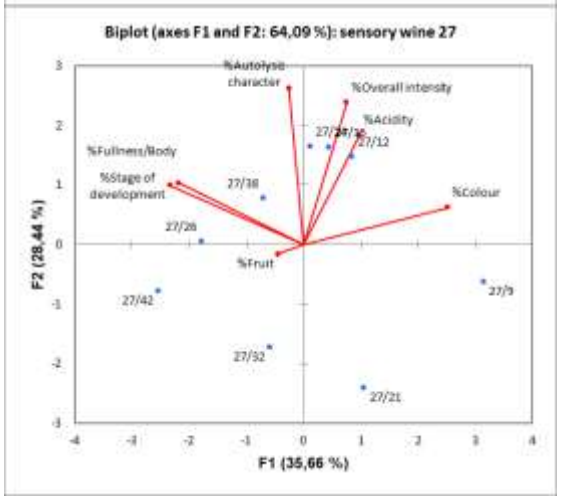
Sensory data per wine: 2013 (circles for illustrative purposes only).











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