Participation in 10th International Symposium on Grapevine Physiology and Biotechnology and Collaborative Links with researchers in Italy and France.



FINAL REPORT to

AUSTRALIAN GRAPE AND WINE AUTHORITY

Project Number: **AGT 1511**

Principal Investigator: **Dr Leigh Schmidtke**

Research Organisation: **Charles Sturt University**

Date: **11TH July 2016**

Project title:	Participation in 10th International Symposium on Grapevine Physiology and Biotechnology and Collaborative Links with researchers in Italy and France.
Project Number:	AGT 1511
Author:	Dr Leigh Schmidtke
Date:	11TH July 2016
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Abstract:

This travel grant assisted in funding Dr Leigh Schmidtke to travel to attend two international conferences and visit collaborators in Paris and Italy. The X International Symposium on Grapevine Physiology and Biotechnology was held at Palazzo della Gran Guardia Verona from June 13th to 18th 2016. This symposium focussed on: Plant and Fruit Development; Yield, Berry Ripening, Grape and Wine Quality; Environmental Interactions and Climate Change; Soil, Water Relations and Mineral Nutrition; Grapevine-Pathogen Interactions and Disease Resistance; Advances in phenotypes, -omic Technologies and Postharvest Physiology. Recent Wine Australia funded research outputs were presented in the form of an oral presentation titled *'Grapes to Wine: The Nexus Between berry Ripening, Composition and Wine Style'*, and a poster titled '*Study of Berry heterogeneity, Spatial Distribution and Ripening Within a Bunch: Potential Role of the Seed Content'.* The XVI Chemometrics in Analytical Chemistry (CAC) conference was held in Barcelona from June 6th to 10th. This international conference is the leading scientific symposium for chemometrics and focused on: Theory and Method Development; Large Data; Multiblock data Analysis; Design of Experiments; Statistical process Control; Hyperspectral image Analysis; Food and Sensory Analysis and Data Fusion. Research outputs were presented in poster format titled '*Grapes to Wine: Finding Contributors to Wine Style with Multiblock Analysis'.* Both conferences were well attended with approximately 250 delegates at each venue that allowed excellent opportunities for network with existing and potential collaborators. The travel grant also enabled an opportunity to liaise with Professor Douglas Rutledge from AgroParisTech on applications of several novel chemometric data methods for grape and wine composition and discussions with Fulvio Mattivi and Urska Vrhovsek from Fondazione Edmund Mach, San Michele, Italy on continuing collaborations.

Executive Summary

The X International Symposium on Grapevine Physiology and Biotechnology was held at Palazzo della Gran Guardia Verona from June 13th to 18th 2016 and was attended by approximately 250 delegates. The symposium focused on recent advances in grapevine research, biotechnology and physiology with 76 presentations and over 220 posters. This forum provided an excellent opportunity to be exposed to the latest technologies and research findings from the leading viticultural scientists in the world. Research outputs from the Wine Australia funded project NWG1301 *Optimising grape quality and value to improve vineyard profitability* and sustainability were presented by Dr Leigh Schmidtke as an oral presentation and a poster.

The Chemometrics in Analytical Chemistry conference was held at the World Trade Centre in Barcelona from June 6th to 10th. This forum is the leading symposium for presentation and exchange of recent developments in chemometric and large data analysis. Whilst the conference is specifically orientated to chemical data analysis several sessions were devoted to food, sensory and compositional data analysis. This symposium provide several opportunities to establish new contacts for potential collaborations. Two half day workshops were completed by Dr Leigh Schmidtke which provided insight to metabolomics data analysis and multiblock data fusion methods. Research outcomes from the Wine Australia funded project NWG1301 were presented as a poster.

Prior to the CAC conference several days in Paris enabled continued liaison and collaborations with Professor Douglas Rutledge at AgroParisTech. This period of time was most valuable for arranging transfer of data pertaining to multiple blocks of analysed samples from a number of wine related projects. Furthermore, consideration of cross validation procedures for Soft Independent Modelling of Class Analogy (SIMCA) data sets were considered and some preliminary data analysis routines written that with some additional

coding will enable these routines to be regularly employed for the purposes of supervised classification.

Travel outcomes:

Of particular value was the collaborative time and discussions on ComDim Path Modelling with Professor Douglas Rutledge (Paris) and Mustafa El Qannari (CAC, Barcelona). This new chemometric method is of considerable interest as it is a technique that enables variables responses from several data blocks pertaining to the same samples to be defined in a manner that shows a sequential influence of each variable. For example the influence of grape metabolites upon wine composition could be more clearly described using such techniques. The deployment of ComDim path modelling is therefore expected to become a more important tool in the decomposition of grape and wine data and is a natural extension to the methods already used within the National Wine and Grape Industry Centre (NWGIC).

Conference presentations provided excellent opportunities to develop research strategies particular in experimental design and data analysis. The latter consideration is important as research evolves from traditional measures of grape composition and vine performance to sophisticated untargeted metabolomics and transcriptomics, and finding the most useful means of data fusion.

Verona – X International Symposium on Grapevine Physiology and Biotechnology

Conference presentation were grouped according to important developing themes of research for vine physiologists. A large number of presentations described the application of transcriptomic gene expression methods for developing insight to vine performance in relation to biotic and abiotic factors. This was a significant strength of the symposium and reflects the substantial area of expertise within the organising committee at Verona. Of personal interest, was the number of projects that focused solely on vine growth and regulation with transcriptomic analysis of gene regulation but without poorly developing links to grape and wine composition and wine sensory profiles. The integration of measures

of plant performance with fruit and wine composition is challenging and few organisations have the necessary expertise to explore these relationships to in a meaningful and interpretable manner.

Several opportunities to liaise with researchers who attended this conference and are located at Australian institutions were possible. Discussions with Dr's Paul Boss and Chris Davis from CSIRO, Cassandra Collins, University of Adelaide were progressed several ideas for collaborative research projects and help to strength ties between organisations. Opportunities for research and strategies for ongoing collaboration, including staff and student exchanges, were also made with Professor Fulvio Mattivi and Dr Urska Vrhovsek from Foundazione Edmund Mach.

Conference presentations that were of particular interest to researchers at NWGIC were focused upon the interaction of plants and environmental factors and the experimental approaches to separate plant and abiotic influence upon vine phenotype and grape composition. Whilst several presentations provided some insight in determining plant versus environmental influence on grape composition, a considerable quantum of work must still be completed to more clearly define how vines will respond to environmental signals. Presentations that described state-of-the-art transcriptomic experiments clearly showed that network analysis will be an important experimental approach to assist in separating and defining the interactions of these factors.

Barcelona – XVI Chemometrics in Analytical Chemistry June 6 – 10, 2016.

Two workshops each of 4 hours were attended. The first workshop consisted of the theoretical presentation of ANOVA Simultaneous Components Analysis and was conducted by Age Smilde, the inventor of this data decomposition technique. This was a valuable workshop in which the principles of ANOVA fixed and mixed models were explained along with the geometry associated with multivariate ANOVA models. The second workshop was a theoretical and practical exposure to multiblock methods for data analysis when those data

blocks pertain to the same samples. This workshop was of interest for comparing the most common data decomposition methods and data fusion approaches for modelling multiple data sets.

Conference presentations were focused upon a wide range of chemometric methods and tools and organised into 'Theory and Method Development'; Design of Experiments, Statistical process Control & Process Analytical Technology'; 'Omics and Forensics'; Spectroscopic and Image Analysis'; Environmental and Separation' and 'Food and Sensory Analysis'. A large poster display comprising over 200 submissions was also presented. Most presentations where of high quality especially those presented by plenary and invited delegates. Sessions devoted to the application of data methods to large data sets derived from high resolution mass spectroscopy instruments were of particular relevance to the analysis of wine using untargeted metabolomic studies.

The opportunity to be exposed to world leading experts in chemometric method and data analysis was inspiriting and enabled me to make contact with several researchers with specific expertise in particular fields; including Alan Ryder, Galway (small protein analysis); Sarah Rutan, Virginia Commonwealth University, USA (application of MCR-ALS to high dimensional data); Mostafa El Qannari and Evelyne Vigneau, Oniris National College of Veterinary Medicine, Food Science and Engineering (multiblock path-modelling). Furthermore contact and discussions for collaborations with Emeritus Professor Marcel Maeder, University of Newcastle. Marcel has a well-established presence within the chemometrics community in Barcelona and has offered to collaborate in the application of chemometrics data analysis within grape and wine related projects.

Appendix 1: Communication:

Manuscripts based on oral presentations given at X International Symposium on Grapevine Physiology and Biotechnology will be submitted for publication in ACTA Horticulutra.

Appendix 2: Intellectual Property:

Not applicable.

Appendix 3: References:

Not applicable.

Appendix 4: Staff

Dr Leigh Schmidtke, Charles Sturt University.

Chemometrics in Analytical Chemistry 2016

GRAPES TO WINE: FINDING CONTRIBUTORS TO WINE STYLE WITH MULTIBLOCK ANALYSIS

Katja Šuklje, Guillaume Antalick, Campbell Meeks, John W. Blackman, Alain Deloire and Leigh M. Schmidtke.

National Wine and Grape Industry Centre,Charles Sturt University, Locked Bag 588, Wagga Wagga, New South Wales 2678, AUSTRALIA.
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There is a complex association between grape composition and perceived quality with subsequent wine composition and style. Grape composition results from numerous interactions between cultivar, growing conditions, water, temperature, and the level of berry ripeness. A temporal and spatial investigation of berry composition and subsequent wine style was undertaken for two consecutive vintages in climatically diverse regions of Australia. Controlled triplicate fermentations of Shiraz or Cabernet Sauvignon grapes harvested at a measured berry maturity based upon a sugar accumulation model [1] to target wine styles from *Fresh* to *Mature* was undertaken. Sensory descriptive analysis of wines enabled different styles to be readily identified. Comprehensive metabolomic profiling of the grape composition (amino acids, carbohydrates, organics acids, volatile compounds, anthocyanins), wine chemical and volatile composition, winemaking inputs and wine sensory scores was undertaken. Using multiblock decomposition based upon Common Components and Specific Weights Analysis and PARAFAC the nexus between berry metabolites, wine making inputs and wine style were determined. As expected, clear markers associated with each variety were apparent, with the impact of vintage the predominant influence of within-variety differences. The effect of site was also evident, however differences associated with grape maturity and subsequent wine style were less obvious.

Acknowledgements: This work was funded by the grape growers and wine makers of Australia through the Australian Grape and Wine Authority, the Australian Federal Government and Charles Sturt University.

References:

[1] K. Šuklje, G. Antalick, C. B. Meeks, J. W. Blackman, A. Deloire, L. M. Schmidtke In *Optimising harvest date through use of an integrated grape compositional and sensory model : a proposed approach for a better understanding of ripening of autochthonous varieties ?* Exploitation of autochthonous and more common vine varieties Genetic pedigree and phenotyping, tolerance and stress, diseases to control, rootstocks: 2nd Oenoviti International Symposium, Geisenheim, 2014; Teissedre, P.-L., Ed. Oenologues de Bordeaux: Geisenheim, 2014; pp 44-49.

Grapes to Wine: Finding Contributors to Wine Style with Multiblock Analysis

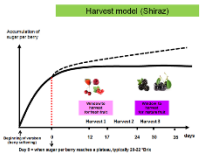
Katja Šuklje[a], Guillaume Antalick[a], Campbell Meeks[a], John W. Blackman[ab], Alain Deloire[a] and Leigh M. Schmidtke[ab]

[a] *National Wine and Grape Industry Centre, Charles Sturt University, Locked Bag 588, Wagga Wagga, NSW 2678, Australia.*
[b] *School of Agricultural and Wine Sciences, Charles Sturt University, Locked Bag 588, Wagga Wagga, NSW 2678, Australia,*

Introduction

There is a complex association between grape composition and perceived quality with subsequent wine composition and style. Grape composition results from numerous interactions between cultivar, growing conditions, water, temperature, and the level of berry ripeness. A temporal and spatial investigation of berry composition and subsequent wine style was undertaken for two consecutive vintages in climatically diverse regions of Australia. Controlled triplicate fermentations of grapes harvested at a measured berry maturity based upon a sugar accumulation model [1] to target wine styles from *Fresh* (harvest 1) to *Mature* (harvest 3) were undertaken. Sensory descriptive analysis of wines enabled different styles to be readily identified. Comprehensive metabolomic profiling of the grape composition (amino acids, carbohydrates, organics acids, volatile compounds, anthocyanins), wine chemical and volatile composition, winemaking inputs and wine sensory scores were undertaken. Using multiblock decomposition based upon Common Components and Specific Weights Analysis (ACOMDIM) and PARAFAC the nexus between berry metabolites, wine making inputs and wine style were determined. As expected, clear markers associated with the impact of vintage were the predominant influence. The effect of site was also evident, however differences associated with grape maturity and subsequent wine style were less obvious but could be tentatively identified.

Sample & Data Collection



Shiraz grapes were harvested according to a berry ripening model of sugar accumulation [1] from vineyards located in the Griffith and Orange regions of New South Wales.

Ripening days post sugar accumulation plateau

2014	Griffith	Orange
Harvest 1	11	
Harvest 2		
Harvest 3	24-25	

2015	Griffith	Orange
Harvest 1	12	11
Harvest 2	17-19	17-18
Harvest 3	24	24-25

Griffith

Mechanical pruning
Number of shoots: 92
Double cordon,
Open sprawling canopy
Yield/vine 18.6 kg
Flowering:
15th October to 1st November
Temperature:
Annual mean minimum 10.6 °C
Annual mean maximum 25.6 °C
Annual mean rainfall 390 mm



Orange

Manual pruning
Number of shoots: 21
Double cordon,
Vertical shoot positioning
Yield/vine 4.3 kg
Flowering:
15th November to 1st December
Temperature
Annual mean minimum 6.4 °C
Annual mean maximum 18.5 °C
Annual rainfall 665 mm

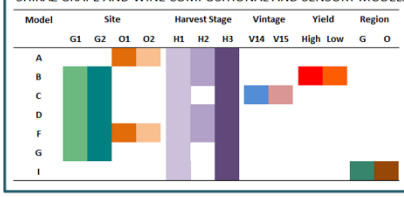
Comprehensive grape metabolite profiling, wine making and sensory assessment was completed for each harvest.

Eight data blocks of analysis were completed for 66 samples:

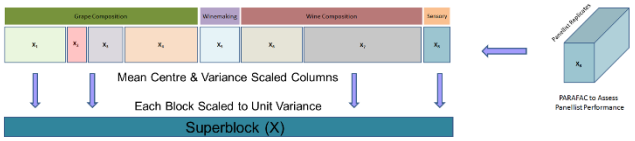
- Block X_1: Grape amino acids (66 x 14)
- Block X_2: Grape carbohydrates and organic acids (66 x 5)
- Block X_3: Grape colour constituents (66 x 8)
- Block X_4: Grape volatile compounds (66 x 28)
- Block X_5: Winemaking (66 x 9)
- Block X_6: Wine chemistry (66 x 14)
- Block X_7: Wine volatile compounds (66 x 45)
- Block X_8: Wine sensory scores (66 x 11 x 36)

A series of designed experiments were constructed from varying sample selection to model experimental factors associated with *Site, Harvest Stage, Vintage, Yield* and *Region*.

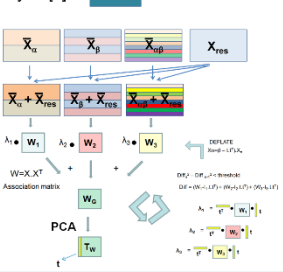
SHIRAZ GRAPE AND WINE COMPOSITIONAL AND SENSORY MODELS



Data Analysis Workflow



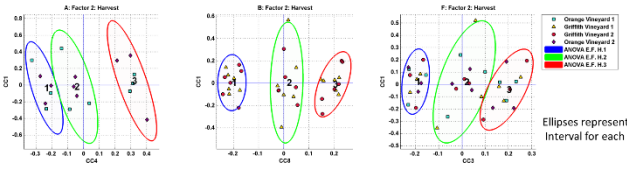
ACOMDIM Data Analysis [2]



ACOMDIM Results

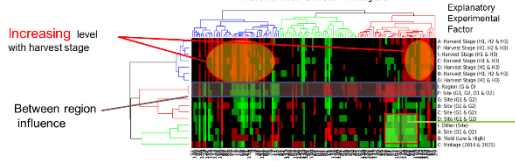
Model	Experimental Factor	Common Component	Explained Variance
A	Site (O1 & O2)	CC2	7.9
A	Harvest Stage (H1, H2 & H3)	CC4	3.2
B	Site (G1 & G2)	CC2	3.5
B	Yield (Low & High)	CC5	2.0
B	Harvest Stage (H1, H2 & H3)	CC8	1.2
C	Vintage (2014 & 2015)	CC3	7.1
C	Harvest Stage (H1 & H3)	CC4	4.3
C	Site (G1 & G2)	CC5	2.6
D	Site (G1 & G2)	CC2	7.5
D	Harvest Stage (H1 & H3)	CC4	2.3
F	Site (G1, G2, O1 & O2)	CC2	6.7
F	Harvest Stage (H1, H2 & H3)	CC3	2.0
G	Site (G1 & G2)	CC2	9.3
G	Harvest Stage (H1 & H3)	CC4	5.2
I	Other (Site)	CC1	88.8
I	Region (G & O)	CC3	5.4
I	Harvest Stage (H1 & H3)	CC4	2.0

ACOMDIM Score Plots: Explanatory Factor Harvest Stage

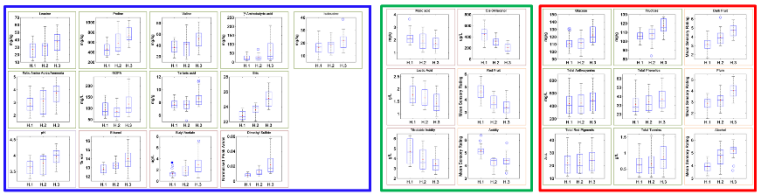


Ellipses represent the 95% Confidence Interval for each factor level.

Model Loadings from ACOMDIM Common Components Hierarchical Cluster Analysis



Box Plots of Variables with Consistent Variation Identified by HCA of Loadings



Conclusion

Linking wine composition, sensory characterisation, grape berry development and maturation is an intrinsically complex phenomenon. Using a metabolomic workflow approach that incorporates block scaling and ANOVA variance partitioning to multiple data matrices that represent experimental factors, the putative links between berry composition, winemaking and wine sensory attributes were identified. Grape berry flavour development which occurs during berry development can be linked to specific maturation times associated with a plateau of berry sugar accumulation, fresh mass and volume.

Acknowledgements
This work was funded by the grape growers and wine makers of Australia through Wine Australia, the Australian Federal Government and Charles Sturt University.

References
[1] Deloire, A. (2013). Proceedings Australian Wine Industry Technical Conference 13-18 July 2013, pp. 47-50.
[2] Bouveresse, D. J.-R., *et al.*, (2011). *Chemometrics and Intelligent Laboratory Systems, 106(2), 173-182.*

X International Symposium on Grapevine Physiology and Biotechnology

GRAPES TO WINE: THE NEXUS BETWEEN BERRY RIPENING, COMPOSITION AND WINE STYLE

Katja Šuklje, Guillaume Antalick, Campbell Meeks, Alain Deloire, John W. Blackman and Leigh M. Schmidtke.

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email: lschmidtke@csu.edu.au

There is a complex association between wine composition and style with grape composition and quality. Grape composition results from numerous interactions between cultivar, growing conditions, water, temperature, and the level of berry ripeness. A temporal and spatial investigation of berry composition and subsequent wine style was undertaken for two consecutive vintages in climatically diverse regions of Australia. Shiraz and Cabernet Sauvignon wines were made using controlled triplicate fermentations from grapes harvested at a measured berry maturity based upon a sugar accumulation model to target wine styles from *Fresh* to *Mature*. Sensory descriptive analysis of wines enabled different styles to be readily identified. Shiraz wines from early harvested grapes (*Fresh*) typically expressed characters of red fruit, with higher acidity whilst later harvested grapes (*Mature*) expressed dark fruit, plum characters with higher astringency and perceived alcohol. Cabernet Sauvignon wines followed a similar pattern, in addition to a significant reduction of herbaceous character (tomato leaf and capsicum) in the more mature wines. Comprehensive metabolomic profiling of volatile and non-volatile grape and wine components was undertaken. As expected, clear markers associated with each varietal were apparent, with the impact of vintage the predominant influence of within-variety differences. The effect of site was also evident, however differences associated with grape maturity and subsequent wine style were less obvious. It would appear that the observed sensory differences resulted from the complex interactions between many metabolites. Whilst the effect of both volatile and non-volatile components requires further investigation, this study has already demonstrated the use of berry sugar accumulation as a tool to better understand the potential wine composition and wine style from particular harvest periods.

Acknowledgements: This work was funded by the grape growers and wine makers of Australia through the Australian Grape and Wine Authority, the Australian Federal Government and Charles Sturt University.

Study of berry heterogeneity, spatial distribution and ripening within a bunch: potential role of the seed content?

Elena Kraeva-Deloire, Alain Deloire and Leigh M. Schmidtke

National Wine and Grape industry Centre, Charles Sturt University, Wagga Wagga, New South Wales, 2678, Australia,

Berry morphology and composition, heterogeneity versus homogeneity, within single bunches remain an important scientific research question with potential practical implications on vineyard management and wine making processes. The goal of this study is to assess the spatial and temporal differences in individual fruit from single bunches at two developmental stages: Veraison and mid ripening (CV Shiraz, *Vitis Vinifera* L.). Twenty berry parameters were analysed. The preliminary results suggested that berry position within bunches and branches did not influence the targeted physiological parameters. Strong interrelationship between berry seed number and sugar concentration, fresh and dry mass of the pericarp was found. The study showed a correlation between the number of seeds per berry and skin colour at veraison, suggesting an important role of the seeds in the timing of ripening. We hypothesize that berry seed number influences berry size by alteration of cell number in the pericarp at early stage of berry development (post flowering).

Study of berry heterogeneity, spatial distribution and ripening within a bunch: potential role of the seed content?

Elena KRAEVA-DELOIRE[a], Alain DELOIRE[a], Leigh M. SCHMIDTKE[a,b]

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Karel Reinilov. The Italian middey. 1827.

Introduction

Berry morphology and composition, heterogeneity versus homogeneity, within single bunches remain an important scientific research question with potential practical implications on vineyard management and wine making processes. The goal of this study is to assess the spatial and temporal differences in individual fruit from single bunches at two developmental stages: Veraison and mid ripening (CV Shiraz, *Vitis Vinifera* L.). The idea came from the open discussion about how the berry size and position could influence the quality of the grapes and wines. Wide ranging research has been made during the last few years on berry size and sugar content, berry position and maturity, resource competition between berries during their development, the effect of bunch heterogeneity on wine composition, etc. [1,2,3,4,5,6]. But still, this topic remains as a matter of debate. Our results could be an interesting part of the actual discussion.

Materials and Methods

The study was done in Griffith and Orange regions NSW, Australia; very different in climate and cultural practices.

Mechanical pruning
Number of shoots: 92
Double cordon, open sprawling canopy
Yield/vine 18.6 kg
Flowering conditions: From the 15th of Oct to the 1st of Nov
Temperature min ave 10.9 °C
Temperature max ave 30.3 °C
Rain 0 mm



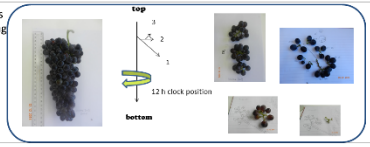
Griffith



Orange

Manual pruning
Number of shoots: 21
Double cordon, VSP
Yield/vine 4.3 kg
Flowering conditions: From the 15th of Nov to the 1st of Dec
Temperature min ave 12.1 °C
Temperature max ave 28.3 °C
Rain 14.6 mm

607 berries from 4 different bunches sampled at veraison and midripening harvest were analysed. Each single berry was removed from the stem according to the position on the rachis including ramification. Clock wise position corresponds to the exposed and shadowed sides.



Twenty parameters, for each single berry were measured and calculated.

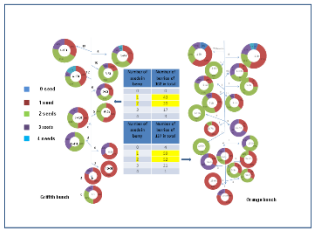
11533 values in total...



- Number-Position
- Fresh mass berry, seeds, pericarp
- Dry mass berry, seeds, pericarp
- Seed content and seed weight
- Colour
- Total Soluble solids (Brix),sugar concentration per g of berry
- Water concentration
- Seed/berry ratio (SB) [7]
- Others

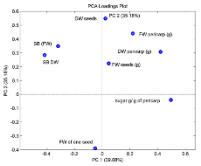
Results

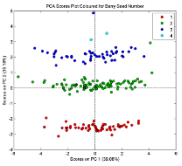
Spatial distribution of the berries on the primary side branches within the bunch at harvest.



A starting point for our study was a creation of a "map" of spatial distribution. The arrows show the rachis and small branches with a number of berries on each. Circles are the groups of berries on each side branch regarding the number on the rachis and a clock position. The colours correspond to percentage of one, two, three and four seeded berries in the group. The majority of berries have one and two seeds randomly situated within the bunch. There is no gradient or apparent continuity in distribution. We didn't find any influence of berry position on the physiological parameters studied.

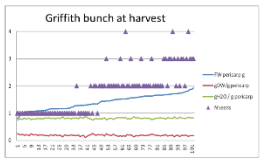
Principal component analysis

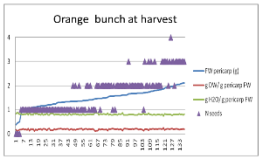




PCA was conducted on berry composition. We found that the seeds could play an important role for other berry characteristics. These plots shows well defined sample clusters for each group of berries with a different seed content.

How different are the berries within the bunch?

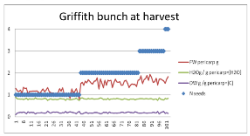


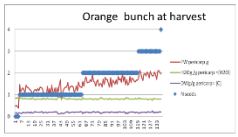


	Ave of 10% lowest FW (g) pericarp	Ave of 10% highest FW (g) pericarp	Difference %
FW pericarp g	1.0	1.8	+80
DWg (C) / pericarp FW g	0.212	0.174	-17.9
H2O %	79%	83%	+5.01
Brix	26.3	23.4	-11
Seed content N	1	2.9	+190

	Ave of 10% lowest FW(g) pericarp	Ave of 10% highest FW(g) pericarp	Difference %
FW pericarp g	1.02	2.03	+99
DWg (C) per g pericarp FW	0.180	0.199	+10.5
H2O %	82.1%	80.2%	-2.3
Brix	25.9	23.9	-7.7
Seed content N	1	3	+200

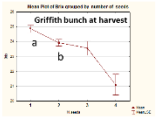
The berries of each bunch were classified from the lowest to highest pericarp fresh mass. We found that the difference of almost 100% in fresh mass is correlated with a seed content but not with a water or carbon (dry weight) concentration. To confirm this, berries were classified according the seed number.

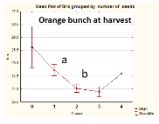




We found that the concentration of water or the concentration of dry mass didn't change in 1 gram of pericarp tissue in small or in big berries independently of seed content. We hypothesised that seeds may stimulate pericarp cell division soon after fertilisation possibly through the release of hormonal signals and therefore increase the capacity for greater final fruit size. This indirect indication has to be verified by direct methods.

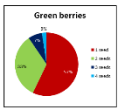
Seed content and sugar (Brix, g sugar per berry, g sugar per g pericarp)

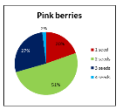


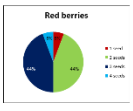


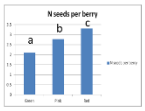
A significant difference in sugar concentration between one and two seeded berries , the major classes within the bunch were found . The difference could reach 0.7 Brix = 7 g/L (0.3-0.4 % alc.)

Seed content and berry colour at Veraison. Orange bunch. The most ripe berries had the highest seed content.



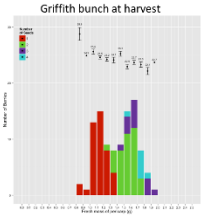


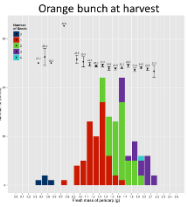




Seed content is well correlated with berry colour and could play a major role in the timing of ripening. The majority of berries with one seed are green, two seeded berries are pink and red, three and four seeded berries are mostly red. This may be the result of seeds triggering the earlier onset of veraison, however this needs to be confirmed. The difference between green, pink and red berries at veraison was significant for number of seeds, water and dry matter content in pericarp (data not shown).

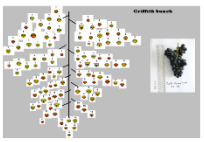
Examples of the different levels of heterogeneity within the single bunch.





The histograms show the berry distribution per class within the bunch and how the seed content changes from small to large berries. Colour corresponds to the number of one, two, three and four seeded berries within each class. This could be interesting and useful for grouping and sampling strategies as, for example, two major classes within the same cluster could be very different in Brix and seed content, which has consequences.

Conclusion



The preliminary results showed that berry position within bunches and branches did not influence the targeted physiological parameters. Strong interrelationship between berry seed number and sugar concentration, fresh and dry mass of the pericarp were found. The study showed a correlation between the number of seeds per berry and skin colour at veraison, suggesting an important role of the seeds in the timing of ripening. We hypothesize that berry seed number influences berry size by alteration of cell number in the pericarp at early stage of berry development (post flowering).

Single bunch represented with Chernoff faces. Each face is one single berry. Each face characteristic corresponds to one of the berry parameters. Face color is an average of sets of variables.

[1]. Matthews M. and Nuerns V. (1988) Acta Hort. 473-479. [2]. Keller M. et al., (2016) S. Afr. J. Enol Viticult., vol 35, No 1, 103-111.[3]. Dal Pal et al., (2006). Journal of Agricultural and Food Chemistry. [4]. Friend et al., (2009) Australian Journal of Grape and Wine research 15, 160-174. [5]. Tisnéhi et al., (2014) S. Afr. J. Enol Viticult 35, No 1. [6]-Friend et al., (2014) Australian Journal of Grape and Wine research [7]. Gaudio S and Delos L. (2015). BMC Plant Biology 15:46.

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