

# **The Analysis of Grapevine Response to Smoke Exposure**

**A thesis presented in fulfilment of the requirements for the  
degree of Doctor of Philosophy**

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## **Abstract**

Smoke taint is a fault found in wines made from grapes exposed to bushfire smoke. It is characterised by objectionable smoky and ashy aromas and flavours, which have been attributed to the presence of smoke derived volatile phenols, in free and glycoconjugate forms. Chapter 1 comprises a summary of the impact of bushfires on the wine industry and a review of previous smoke taint research, which includes many investigations into the composition of wine produced from smoke-affected fruit. Gaps of knowledge are identified in Chapter 1, and the issues addressed in this thesis are identified and summarised in the research aims.

Chapter 2 describes a field trial that investigated the accumulation of smoke taint precursors in three *Vitis vinifera* cultivars, Sauvignon Blanc, Chardonnay and Merlot, at different time points, following grapevine exposure to smoke under experimental conditions. Varietal differences in volatile phenol glycoconjugate profiles were observed; interestingly, these profiles also differed between samples harvested 1 day after smoke exposure and samples harvested at maturity. An evaluation of the effect of an agrichemical applied to grapevine fruit and foliage as a physical barrier to prevent the uptake of smoke is also reported; together with the results of an investigation into the potential for reflectance spectroscopy, measured using a handheld spectrometer, to detect smoke-affected fruit. A subsequent field trial sought to further verify the use of a second agrichemical to mitigate the impacts of grapevine exposure to smoke; and reflectance spectroscopy to evaluate smoke exposure in the vineyard and is also included in Chapter 2.

Whereas the glycosylation of smoke derived volatile phenols in grapevine fruit and leaves following exposure to smoke is reasonably well understood, the biochemical and

molecular consequences of grapevine smoke exposure have received comparatively little consideration. The research described in Chapter 3 endeavours to address this knowledge gap through investigations into the expression of grapevine glycosyltransferases (GTs) following smoke exposure. Higher expression profiles of certain sets of genes (including heat shock proteins and putative GTs) were identified through RNA sequencing of two grape cultivars grown as potted grapevines in a growth room. Selected GT candidates were analysed in a subsequent field trial, in which Q-PCR expression analysis showed higher expression of two GT1 family genes at specific time points; with differential expression found to be highest in skin, rather than pulp, fractions following smoke exposure.

To date, the occurrence of smoke taint has not been reported in crops other than grapes, despite the proximity of bushfires in regions comprising broader agricultural production. The final chapter of experimental work in this thesis, Chapter 4, describes analysis of a field trial involving the application of smoke to apple trees, to investigate whether or not apples can be similarly affected by smoke.

Chapter 5 reflects on the experimental work described in this thesis, including a discussion towards challenges and future directions in the research of smoke taint.

## **Declaration**

I certify that this work contains no material which has been accepted for the award of any other degree or diploma in my name in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text. In addition, I certify that no part of this work will, in the future, be used in a submission in my name for any other degree or diploma in any university or other tertiary institution without the prior approval of the University of Adelaide and where applicable, any partner institution responsible for the joint award of this degree.

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Lieke van der Hulst

Date:

17/11/2017



## **Publications**

This thesis comprises a collection of manuscripts prepared for submission to peer-reviewed scientific journals. Authorship statements are included in chapters which incorporate a manuscript.

In chapter 2: **Accumulation of volatile phenol glycoconjugates in grapes, following the application of kaolin and/or smoke to grapevines (*Vitis vinifera* cv Sauvignon Blanc, Chardonnay and Merlot).**; prepared for submission to *Frontiers in Plant Science*.

In chapter 3: **Transcription profiling of glycosyltransferases in *Vitis Vinifera* cultivars following smoke exposure.**; prepared for submission to *Frontiers in Plant Science*.

Chapter 4: **Smoke exposure influences the composition of apples (*Malus domestica* Borkh cv Sundowner).**; prepared for submission to the *Journal of Agricultural and Food Chemistry*.

An additional paper, published in the *Journal of Agricultural and Food Chemistry*, concerning the stability of smoke derived volatile phenols and their precursors, and the persistence of smoke taint in wine following bottle aging, is included in the appendices:

Ristic, R., van der Hulst, L., Capone, D.L., Wilkinson, K.L., *Impact of Bottle Aging on Smoke Tainted Wines from Different Grape Cultivars*. *Journal of Agricultural and Food Chemistry*, 2017.

## Symposia

### *Scientific conferences*

Ristic, R., **van der Hulst, L.**, Wilkinson, K. (2016) *Stability of smoke taint during the aging of smoke-affected wine*, 252nd ACS National Meeting, Philadelphia (PA), US (oral presentation)

**Van der Hulst, L.**, Ford, C., Burton, R., Lloyd, N., Wilkinson, K. (2016), *Potential for kaolin application to grapevines to mitigate smoke taint*, 16th Australian Wine Industry Technical Conference, Adelaide, Australia (poster presentation)

**Van der Hulst, L.**, Ford, C., Burton, R., Lloyd, N., Wilkinson, K. (2016), *Impact of smoke exposure on the chemical composition of grapes*, Macrowine 2016, Changins (Nyon), Switzerland (oral presentation)

**Van der Hulst, L.**, Ford, C., Burton, R., Lloyd, N., Wilkinson, K. (2016) *Impact of smoke exposure on the composition of different fruit*, 11th Wartburg Symposium on Flavor Chemistry & Biology, Eisenach, Germany (oral presentation)

**Van der Hulst, L.**, Ford, C., Burton, R., Lloyd, N., Wilkinson, K. (2015) *Uptake and glycosylation of smoke-derived volatile compounds in grapevines*, Crush Grape and Wine Symposium, Adelaide (oral presentation)

### *Industry workshops*

**Van der Hulst, L.**, Ristic, R. (2017) *The chemical markers of smoke taint*, Smoke taint symposium – Vinos de Chile / Wines of Chile, Mar 2017

**Van der Hulst, L.**, Ford, C., Burton, R., Wilkinson, K. (2016) *Biochemical response of grapevines to smoke exposure*, ARC Training Centre industry visit - Limestone Coast Grape and Wine Council, Coonawarra, Oct 2016

**Van der Hulst, L.,** Ford, C., Burton, R., Ristic, R., Wilkinson, K. (2016) *Biochemical response of grapevines to smoke exposure*, ARC Training Centre Workshop – Charles Sturt University, Wagga Wagga, May 2016

**Van der Hulst, L.,** Ford, C., Burton, R., Lloyd, N., Wilkinson, K. (2015) *Biochemical response of grapevines to smoke exposure*, ARC Training Centre Workshop – Launceston, Tasmania

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