Project Report – May 2016

*We realize that this is a final report. We have all data collection completed, specifically all wine samples have been analyzed. However the data analysis and final sensory analysis have been postponed. The student working on this project has been put on bed rest due to concerns with her pregnancy and progress has slowed. We anticipate all data analysis and sensory will be completed this fall and upon request would be happy to submit an additional report with all results from the project.

1. Summary

Project: Chiral Terpenes - Quantitation, Threshold Determination and Sensory Impact on Aromatic White Wines

Principal Investigator: Elizabeth Tomasino, Ph.D. Oregon Wine Research Institute, Department of Food Science & Technology, Oregon State University, 100 Wiegand Hall, (541)- 737-4866, elizabeth.tomasino@oregonstate.edu

A successful method to measure chiral terpenes in aromatic white wines has been successfully developed and published. This method is robust, accurate and reproducible and was used for further chiral terpene analysis in this project. Over 50 Pinot gris wines and more than 120 Riesling wines were collected and chiral terepene content was analyzed. Wines were chosen to represent different geographical areas, vintages and styles. Both Pinot gris and Riesling wines have different chiral monoterpene composition based on place of origin. Specifically wines from hotter climates contained higher levels of chiral monoterpenes. This was anticipated due to the known relationship of ripeness and terpene content of grapes. Riesling wines also have different chiral monoterpene composition based on vintage and style. Possible interactions with place of origin, style and vintage are being investigated. Eighty white varietal wines were collected (10 bottles of each varietal) do determine if chiral terpene profiles vary based on varietal. Wines investigated include Gewürztraminer, Viognier, Riesling, Sauvignon blanc, Moscato, Chardonnay and Torrontes have been completed. Preliminary data analysis does show that despite place of origin, vintage or style differences there are chiral monoterpene profiles based on grape varietal. The sensory impact of 10 different chiral terpene profiles taken from Pinot gris wines were investigated. These profiles were added to three different matrices to also

investigate any possible important interactions that may influence sensory perception. Preliminary sensory results show that chiral terpenes does impact the aroma of wine but only in combination with other aroma compounds, suggesting that their role in Pinot gris is due to interactions rather than direct effects.

2. This is a FINAL REPORT

3. Project Title Chiral Terpenes - Quantitation, Threshold Determination and Sensory Impact on Aromatic White Wines, 2016-1516

4. Principal Investigator: Elizabeth Tomasino, Ph.D. Oregon Wine Research Institute, Department of Food Science & Technology, Oregon State University, 100 Wiegand Hall, (541)- 737-4866, elizabeth.tomasino@oregonstate.edu

5. Objectives*

Objective 1 - Development of methodology using multi-dimensional gas chromatography-mass spectrometery to measure chiral terpenes in aromatic white wines.

A success fully HS-SPME-MDGC-MS method was developed.

Objective 2 – Determine chiral terpene profiles from different varietal white wines and determine if chiral terpene profiles of Pinot gris and Riesling wines differ based on place of origin.

Method developed in Objective 1 was used to measure chiral terpene composition in the white wines. Data analysis included ANOVA with Tukey multiple-comparisons and discriminant analysis.

Objective 3 – Determine the sensory impact of chiral terpenes to Pinot gris aroma also investigating possible matrix effects.

Addition tests and triangle tests were used to determine the impact of chiral terpenes and different matrices on sensory perception.

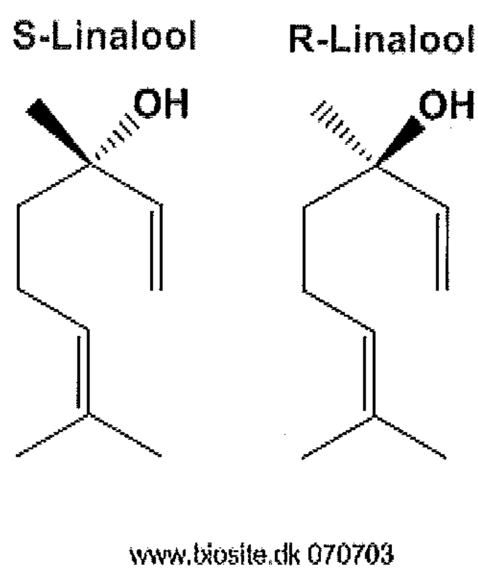
*Objectives have shifted slightly from original grant. Objective 1 is the same. The original objectives 2 & 3 have been combined into Objective 3 as stated above. Objective 2 as stated above was added/expanded form the original objective 1 as we realized we needed much more information about chiral terpenes in wines before we could proceed to Objective 3.

6. Summary of major research accomplishments and results by objective

Below are a few definitions for frequently used terms.

Chiral – molecules that have identical composition but are arranged in non-super imposable mirror images, due to an asymmetric carbon.

Isomer – molecules that contain the same number of atoms of each element but have different arrangements in space. Therefore chiral compounds have several different isomers.
An example of chiral linalool with its 2 isomers.



Perception threshold – the lowest level at which a compound can be detected.

Objective 1 – **Development of methodology using multi-dimensional gas chromatography-mass spectrometery to measure chiral terpenes in aromatic white wines.**

A method to measure chiral terpenes in aromatic white wine has been completed and published. Please see Table 1 for the compounds included in the method, their known aroma descriptors and perception thresholds in water or ethanol solution has been included.

The methodology paper was publishedhttp://www.mdpi.com/1420-3049/20/4/7359in an open access journal and can be viewed at the following link.

http://www.mdpi.com/1420-3049/20/4/7359

Table 1 – Chiral monoterpenes included in the HS-SPME-MDGC-MS method with their aroma descriptors and known perception thresholds

Compound	**Aroma descriptor**	**Perception threshold (µg/L)**
(S)-(-)-Limonene	Lemon, turpentine	500
(R)-(+)-Limonene	Orange	200
(-)-(2S,4R)-cis-rose oxide	Herbal, green, hay	50
(+)-(2R,4S)-cis-rose oxide	Floral, green, clean	0.5
(+)-(2R,4R)-trans-rose oxide	Floral, green, minty	160
(+)-(2S,4S)-trans-rose oxide	Herbal, bitter peel	80
(2R,5R)-(+)-trans-linalool oxide	Earthy, leafy	3,000-4,000*
(2R,5S)-(-)-cis-linalool oxide	Stronger earthy, leafy	3,000-4,000*
(2S,5S)-(-) trans-linalool oxide	Sweet, floral	3,000-4,000*
(2S,5R)-(+)-cis-linalool oxide	Sweet, floral	3,000-4,000*
(R)-(-)-Linalool	Woody, lavender	0.8
(S)-(+)-Linalool	Sweet, petigrain	7.4
(-)-α-terpineol	Coniferous, tar	300,000*
(+)-α-terpineol	Heavy floral, lilac	300,000*
(R)-(+)-β-citronellol	Rose-leafy, petal-like	50

*perception thresholds determined in racemic (mix of all isomers) solutions.

Objective 2a - Does place of origin influence chiral monoterpene content?

PINOT GRIS RESULTS

50 Pinot gris wines were collected/donated in total.

5 from New York
21 from Oregon
3 from Washington
7 from Australia
12 from New Zealand
3 from Italy

Yes, the wines can be separated based on place of origin!

The following compounds were not found in the analyzed Pinot gris wines
(+)-(2R,4S) – cis-rose oxide
(-)-(2S,4S)-trans rose oxide

Not all wines contained all of the measured chiral monoterpenes. Complete data for each compound can be provided upon request.

<u>In summary</u>
Linalool oxides and α-terpineol isomers were present in all Pinot gris wines.
Both Linalool isomers were found in half of the New Zealand and Australian wines
Both Limonene isomers were found in half of the Australian and 1/3 of the Oregon wines.

Discriminant analysis (Figure 1) shows separation based on place of origin. Specifically the circles (representing the 95% confidence intervals) that are not overlapping or touching are considered significantly different. In summary, Oregon Pinot gris is different from NZ, NY and Italian wines. NZ wines are different from OR, Australian, NY and Italian wines. NY wines are different from AU, NZ and OR wines etc.

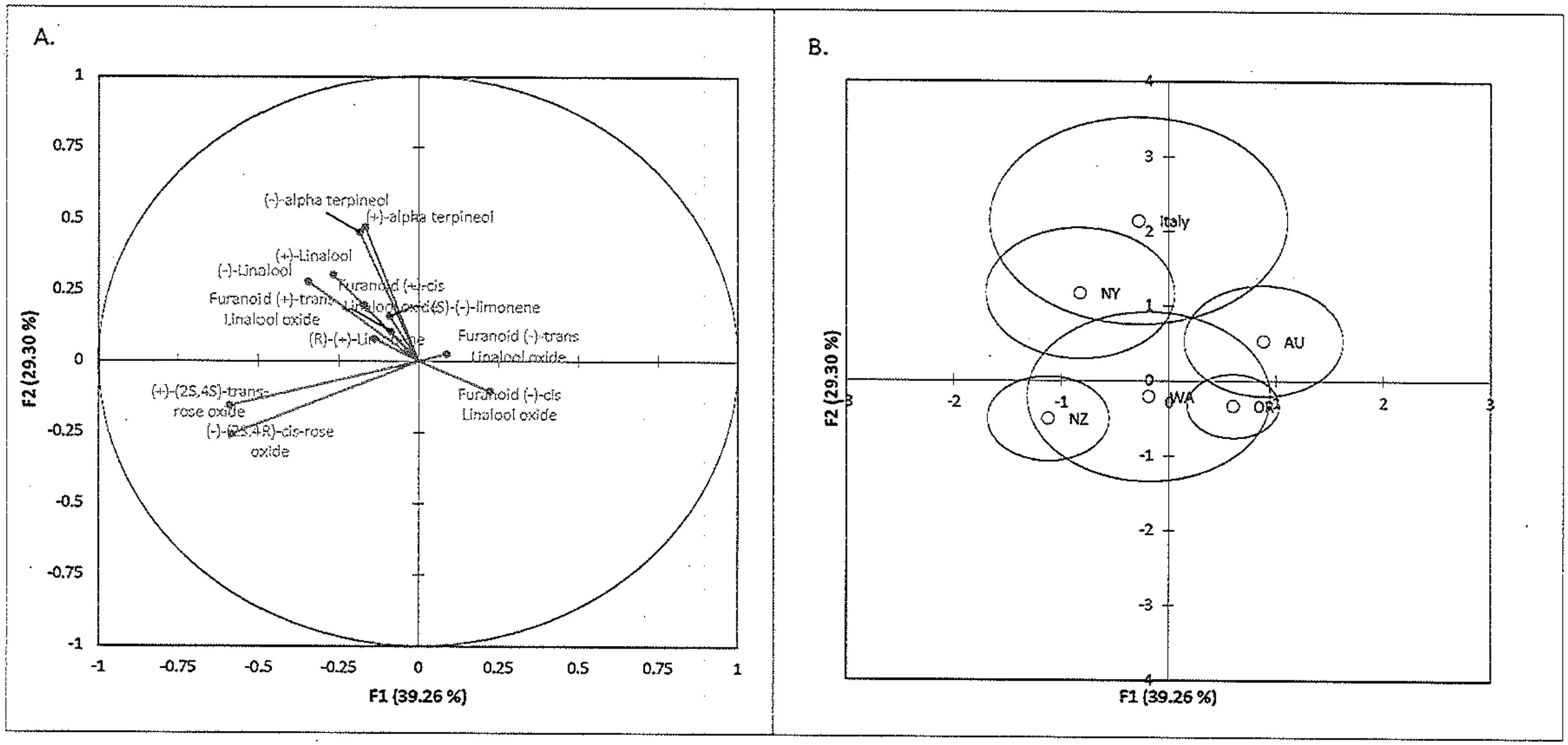


Figure 1 – Separation of Pinot gris wines by place of origin (AU-Australia, NY-New York, USA, NZ –New Zealand, OR – Oregon, USA, WA – Washington, USA) using discriminant analysis. Places are positioned using centroids for the wines and circles represent 95% confidence intervals surrounding the centroid means. Loadings for the chiral monoterpenes are to the left (A) and scores are plotted to the right (B). Dimensions for F1 and F2 represent 69% of the variance.

In summary from Figure 1.

- Oregon (OR) Pinot gris wines are characterized by higher levels of (2R,5S)-(-)-cis-linalool oxide.
- New Zealand (NZ) Pinot gris wines are characterized by higher levels of (+)-(2R,4S)-trans-rose oxide and (-)-(2S,4R)-cis-rose oxide.
- Washington (WA) Pinot gris wines are fairly balanced and not characterized by any one specific chiral monoterpene.
- (Australian) AU Pinot gris wines are characterized by high levels of (2S,5S)-(-)- trans linalool oxide
- Italian (IT) Pinot grigio wines are characterized by high levels of both α-terpineol isomers.
- Italian and New York (NY) Pinot gris wines also contain the greater variety of chiral monoterpenes.

Objective 2a - Does place of origin influence chiral monoterpene content?

RIESLING RESULTS

138 Riesling wines were collected/donated and run through the same chiral terpene analysis as Pinot gris wines.

12 Australian wines
3 Californian wines
24 Canadian wines
23 German wines
31 Wines from the Fingerlakes, New York
12 wines from New Zealand
30 wines from Oregon
21 Wines from Washington

Riesling wines also were from a number of vintages

4 wines from 2008
3 wines from 2009
11 wines from 2010
18 wines from 2011
73 wines from 2012
32 wines from 2013

The following compounds were not found in the analyzed Riesling wines.
(+)-(2R,4S)-cis-rose oxide

Very few wines contained
(-)-(2S,4R)-cis-rose oxide
(-)-(2R,4R)-trans-rose oxide
(+)-(2S,4S)-trans-rose oxide

Complete data for each compound can be found in the appendix (Table 1 and 2) at the end of this report.

In summary

Unlike Pinot gris wines, the majority of the Riesling wines contained all of the measured chiral monoterpenes, except those mentioned above.

About ½ of all of the dry style Riesling wines did not contain any of the Linalool isomers.

Due to the number of Riesling wines analyzed we investigated 3 different factors

1. Place of origin (or region) (Figure 2)
2. Vintage (Figure 3)
3. Style (based on EU regulation 743/2002) (Figure 4)

Separation based on place of origin did occur but what is interesting is that 2 large groups appear in Figure 2, B. To the right all the wines are from regions considered cold climate and on the left the wines are from regions considered hot climates. This was expected as sunlight and heat are known to contribute to terpene synthesis in grapes, with higher temperatures related to greater terpene content.

Riesling wines from cooler climates had higher levels of all linalool oxide isomers and warmer climates produced wines with higher levels of linalool isomers, α-terpineol isomers and limonene isomers.

Younger wines from 2013 and 2012 are characterized by more linalool isomers, α-terpineol isomers and Limonene.

Wines from 2010 are characterized by (+)-(2R,4S)-cis-rose oxide and (+)-(2S,4S)-trans rose oxide

Wines from 2009 and 2008 are characterized by all linalool oxide isomers and (-)-(2R,4R)-trans-rose oxide

Wine styles have been differentiated by EU standards of residual sugar.

sweet	≥45g/L
medium sweet	12>--≤45g/L
Medium dry	4>--≤12g/L
Dry	≤4g/L

Sweet wines are characterized by Linalool and limonene isomers.

Medium sweet wines are characterized by α-terpineol isomers and (-)-(2S,4R)-cis-rose oxide and (-)-(2R,4S)-cis-rose oxide

Medium dry wines are characterized by linalool oxide isomers.

Dry wines were not characterized by any of the chiral monoterpenes measured.

*We are currently investigating any interactions between place of origin, vintage and style for Reisling wines. Results are pending at this time.

Due to difficulties reading the labels in the following figures we have assigned numbers to each terpene isomer. The key is as follows;

2. (S)-(-)-Limonene
4. (R)-(+)-Limonene
5. (-)-(2S,4R)-cis-rose oxide
6. (+)-(2R,4S)-cis-rose oxide
7. (2R,5R)-(+)-trans-linalool oxide
8. (2R,5S)-(-)-cis-linalool oxide
9. (-)-(2R,4R)-trans-rose oxide
10. (+)-(2S,4S)-trans-rose oxide
11. (2S,5S)-(-)-trans-linlool oxide
12. (2S,5R)-(+)-cis-linalool oxide
14. R-(-)-Linalool
16. (S)-(+)-Linalool
18. (-)-α-Terpineol
20. (+)-α-Terpineol
21. (R)-(+)-β-citronellol

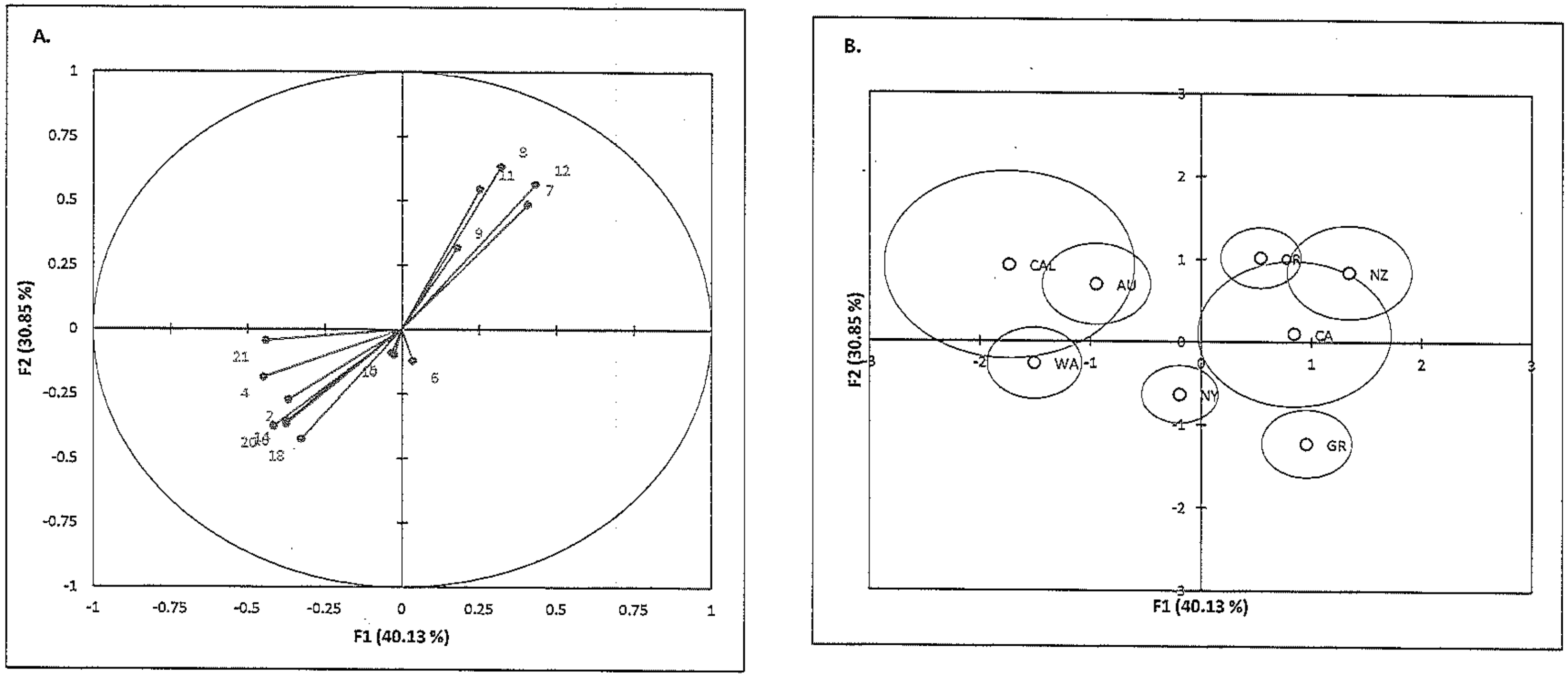


Figure 2 – Separation of Riesling wines by place of origin (AU-Australia, CA-Canada, CAL-California, GR – Germany, NY-New York, USA, NZ –New Zealand, OR – Oregon, USA, WA – Washington, USA) using discriminant analysis. Places are positioned using centroids for the wines and circles represent 95% confidence intervals surrounding the centroid means. Loadings for the chiral monoterpenes are to the left (A) and scores are plotted to the right (B). Dimensions for F1 and F2 represent 71% of the variance.

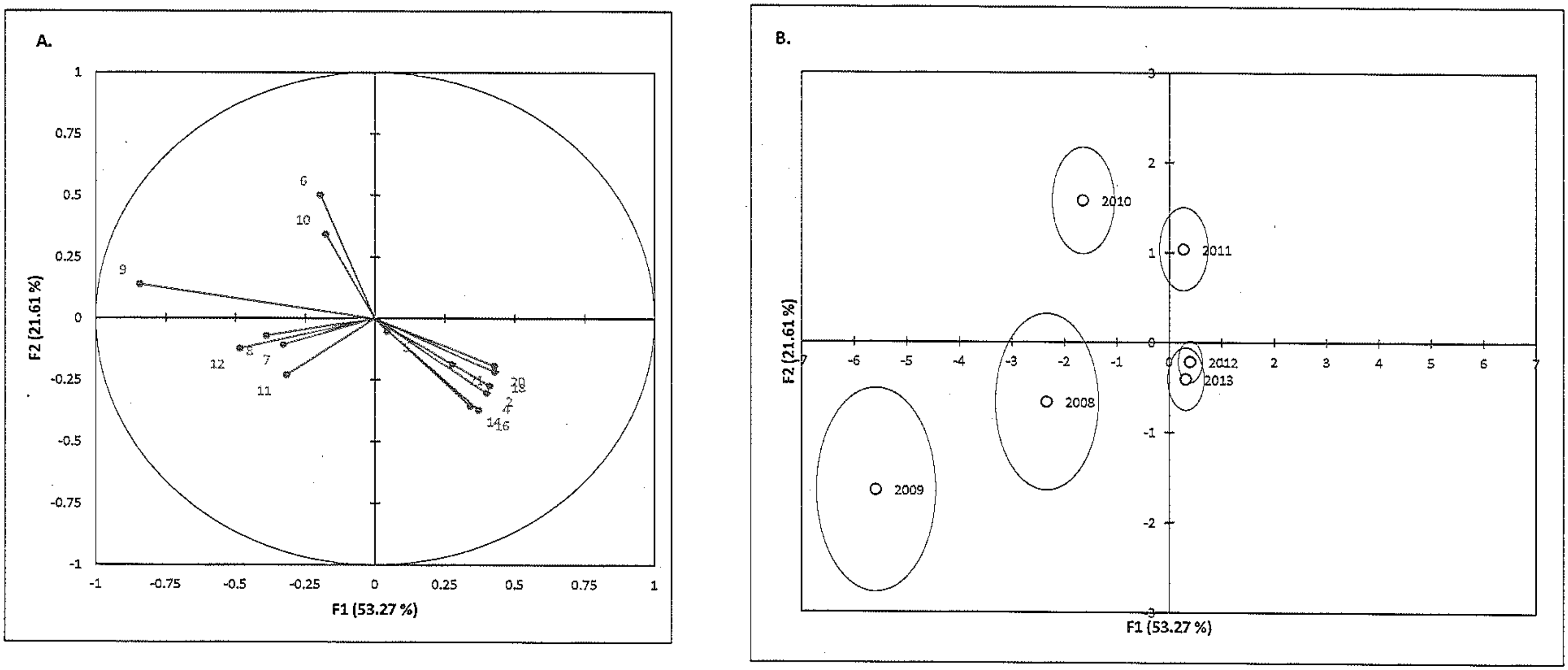


Figure 3 – Separation of Riesling wines vintage using discriminant analysis. Places are positioned using centroids for the wines and circles represent 95% confidence intervals surrounding the centroid means. Loadings for the chiral monoterpenes are to the left (A) and scores are plotted to the right (B). Dimensions for F1 and F2 represent 75% of the variance.

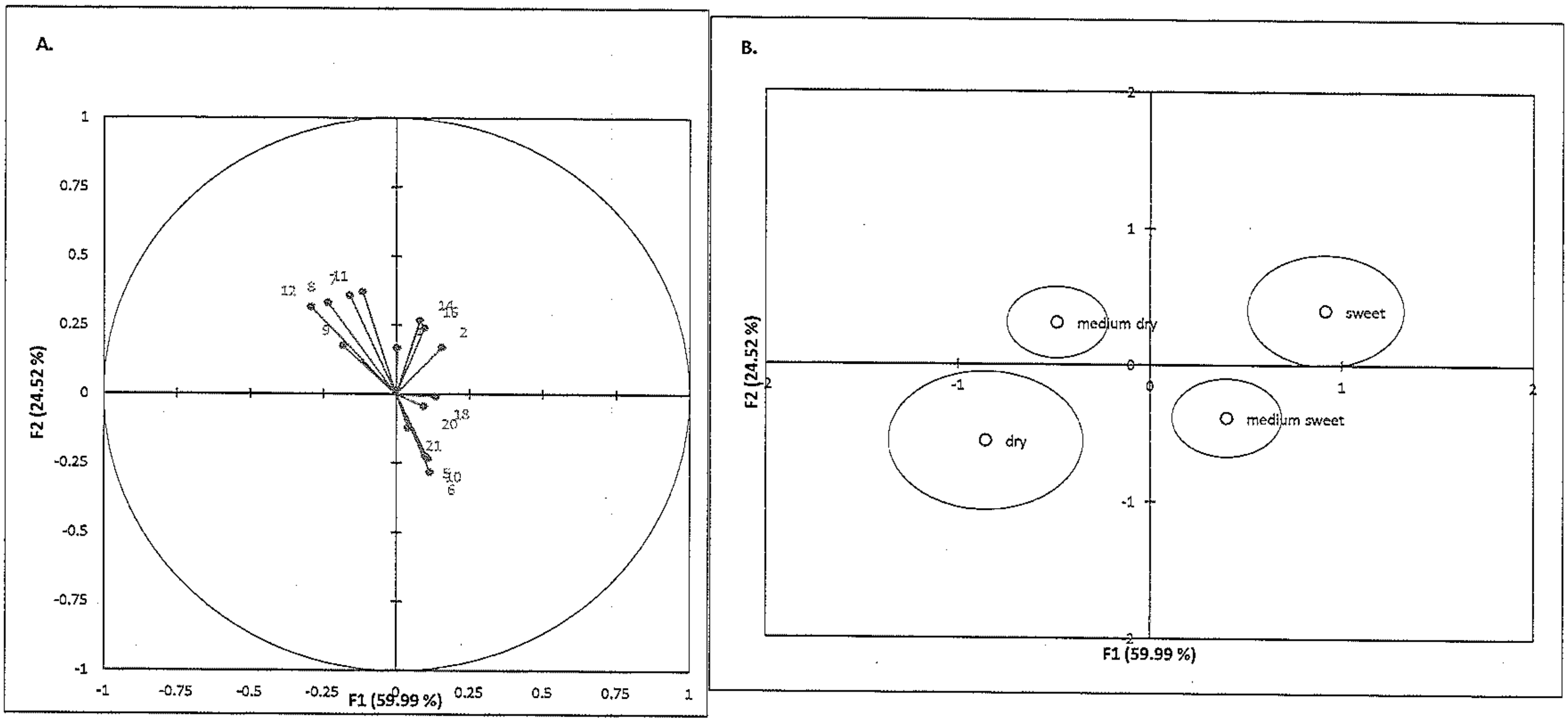


Figure 4 – Separation of Riesling wines based on style (sweet = ≥45 g/L residual sugar, medium sweet = 12> - ≤45 g/L residual sugar, medium dry = 4> - ≤12 g/L residual sugar, and dry = ≤4 g/L residual sugar) using discriminant analysis. Places are positioned using centroids for the wines and circles represent 95% confidence intervals surrounding the centroid means. Loadings for the chiral monoterpenes are to the left (A) and scores are plotted to the right (B). Dimensions for F1 and F2 represent 75% of the variance.

Objective 3 – Sensory impact of chiral terpenes and investigation of matrix interactions

The role of chiral terpenes on aroma apperception of Pinot gris wines was investigated. Pinot gris was chosen due to its importance to Oregon. Ten chiral terpene profiles (Table 3) were chosen from the chiral terpene Pinot gris measurements. These profiles cover the complexity of concentrations of these compounds found in Pinot gris. Not all isomers were able to be evaluated as several compounds, such as (+)-linalool are currently not available.

As can be seen in Table 3, the majority of chiral terpenes are found at levels below their known perception thresholds. If they are having an impact to aroma then this is likely due to interactions with other components of wine.

To determine the sensory impact of these compounds and the role of the matrix the 10 different concentrations will be added to three different "matrices. Triangle tests will be used to determine which profiles are perceived as different from the control (matrix with no terpenes).

Matrix 1 – A model wine, consisting of a water solution with ~11% ethanol, 6 g/L acid and a pH of about 3.5.

Matrix 2 – A Pinot gris wine that has all its aromas removed using a rotovap, therefore the wine only contains the nonvolatile or mouthfeel components.

Matrix 3 - Pinot gris wine with low/no chiral terpenes. Pinot gris wine was made during the 2015 vintage to meet this needs. We successfully made a wine that did not contain any chiral terpenes. However while this wine was thought to be slightly more neutral it was still characteristic of Pinot gris (determined through preliminary testing).

Two different comparisons will occur, within each matrix and then between the different matrixes.

In preliminary tastings we have found that chiral terpenes at concentrations found in Pinot gris do not have a direct effect to sensory perception, as profile sin Matrix 1 were not perceieved as different from the control. However it does appear that there are some nonvolatile and aromatic interactions that occur with these compounds, as differences were perceived when terpenes were added to Matrix 2 and 3. This is significant as it shows that even compounds at very low concentrations (below their perception threshold) are important to wine aroma. This also provides information on which profiles are influencing sensory perception and are important for place of origin differentiation.

Table 3. Average concentration of monoterpene isomers in Pinot Gris wines (µg/L)

	(S)-(-)-limonene	(R)-(+)-Limonene	(-)-rose oxide	Linalool oxide	(-)-Linalool	linalool	(-)-α-terpineol	(+)-α-terpineol	(R)-(+)-β-citronellol
base									
Spiked 1							1.89	3.04	7.46
Spiked 2				19.36			5.01	7.04	4.44
Spiked 3			0.36	18.63			4.94	8.30	4.11
Spiked 4				21.92		5.83	4.78	7.36	5.05
Spiked 5			0.25	23.11			5.14	8.57	3.03
Spiked 6	1.48	1.53		20.11			6.80	8.58	5.63
Spiked 7			0.50	27.74		12.83	6.86	8.77	6.38
Spiked 8	0.63	0.17		18.31	5.54		7.10	9.59	3.88
Spiked 9	1.54	1.58		22.63		16.22	8.24	10.57	6.02
Spiked 10	4.90	4.02	0.34	46.46		45.74	29.02	33.25	5.39

Numbers in red color are concentrations of compounds above detection threshold.

6. Summary of Major Research Accomplishments by Results

Objective 1 –

- A successful method to measure chiral terpenes in aromatic white wines has been successfully developed and published.

Objective 2

- Both Pinot gris and Riesling wines have different chiral monoterpene composition based on place of origin.
- Riesling wines also have different chiral monoterpene composition based on vintage and style. Possible interactions with place of origin, style and vintage are being investigated.
- The chiral monoterpene content of other white varietal wines, including gewürztraminer, viognier, sauvignon blanc, moscato, chardonnay and torrontes have been completed. Preliminary data analysis does show that despite place of origin, vintage or style differences there are chiral monoterpene profiles based on grape varietal.

Objective 3

- Preliminary sensory results show that chiral terpenes does impact the aroma of wine but only in combination with other aroma compounds, suggesting that their role in Pinot gris is due to interactions rather than direct effects.

7. Outside presentation of Research

M. Song, Y. Xia, J. Osborne and **E. Tomasino** (2016) Perception of Chiral Terpenes in Pinot gris wine, 11th Wartburg Symposium on Flavor Chemistry and Biology, June 21-24, Eisenach, Germany

M. Song, Y. Xia and **E. Tomasino** (2016) Chemodiversity of Monoterpene enantiomers in Riesling wine from different geographic areas, vintages and wine style, 9th International Cool Climate Wine Symposium, May 26-29, Brighton, United Kingdom

M. Song, Y. Xia and **E. Tomasino** (2015) Investigation on the Quantitative Method for Chiral Mono-terpenes in white wine by Headspace-Solid-Phase Microextraction-MDGC-MS with Stable Isotope Dilution Analysis in Different Wine Matrix, Molecules, 20, 7359-7378

M. Song*, Y. Xia†, and **E. Tomasino** (2015) Chiral Mono-terpene Profile in Pinot gris and Riesling wines Determined by Head-Space Solid-Phase-Micro-Extraction Multidimensional Gas Chromatography-Mass Spectrometry (HS-SPME-MDGC-MS), 250th American Chemical Society National meeting, August 16-20, Boston, Massachusetts

M. Song and **E. Tomasino** (2015) Chiral monoterpene content of Pinot gris wines, 9th In Vino Analytica Scientia, July 14-17, Trento, Italy

M. Song*, Y. Xia† and **E. Tomasino** (2015) Quantitative Method for Chiral Mono-terpenes in White Wine by HS-SPME-MDGC-MS in Different Wine Matrix, 66th ASEV National Conference, June 15-18, Portland, Oregon

8. Research Success Statement

This research provides evidence that wines are unique based on varietal and place of origin. Providing additional proof that place of origin can be measured. Resulting information can be utilized by the winery to show how their wines differ from others. The sensory results provide evidence that challenges the more traditional concepts of aroma chemistry, i.e. that compounds need to be above their perception threshold to contribute to aroma. Specifically our results will demonstrate which terpenes play a role in aroma perception providing more specific targets for winemakers trying to achieve specific styles.

9. Funds Status

The majority of funds were used in support of the student working on the project as a stipend. Additional funds were used for the chemical analysis of wines.

APPENDIX Table 1 – Alcohol content (% v/v)and chiral Limonene, Linalool, α-terpineol, β-citronellol and cis-rose oxide content (μg/L) of Riesling wines from different locations (AU, Australia, CA – Canada, CAL – California, USA, GR – Germany, NY – New York, USA, OR – Oregon, USA, NZ – New Zealand, WA – Washington, USA)

Wine	vintage	ALC analyzer	(S)-(-)-limonene	(R)-(+)-Limonene	(-)-Linalool	(+)-Linalool	(-)-alpha terpineol	(+)-alpha terpineol	(R)-(+)-beta-citronellol	(+)-(2R,4S)-cis-rose oxide	(-)-(2S,4R)-cis-rose oxide
AU1	2008	12.49%	nd	nd	nd	nd	7.14	11.02	nd	nd	nd
AU2	2012	12.50%	4.12	4.35	12.54	13.53	29.25	33.35	3.78	nd	nd
AU3	2012	10.22%	2.27	1.44	nd	nd	17.43	19.81	nd	nd	nd
AU4	2012	10.78%	14.59	11.36	23.18	23.20	80.82	91.06	nd	nd	nd
AU5	2013	11.95%	1.93	1.18	9.12	9.34	26.20	26.91	4.05	nd	nd
CA1	2013	12.33%	7.93	6.38	48.94	42.70	42.36	45.54	6.07	nd	nd
AU6	2013	9.87%	3.21	2.42	8.82	9.81	26.11	30.51	3.23	nd	nd
CA1a	2013	12.52%	7.59	5.96	41.20	38.05	43.18	44.64	7.01	nd	nd
AU7	2013	12.48%	1.57	1.49	11.80	12.48	38.50	42.24	4.19	nd	nd
AU8	2013	11.63%	4.29	3.62	10.82	11.54	31.08	35.71	3.62	nd	nd
AU9	2013	12.87%	4.48	3.80	16.10	17.53	33.46	38.70	3.59	nd	nd
CA1b	2013	12.16%	5.38	4.57	38.38	33.37	39.38	42.91	4.61	nd	nd
AU10	2013	11.80%	6.36	5.71	8.40	9.98	31.55	35.48	nd	nd	nd
AU11	2013	9.79%	3.32	3.28	nd	nd	14.01	14.70	nd	0.04	nd
AU12	2013	7.85%	1.76	0.89	nd	nd	12.64	15.43	nd	nd	nd
CA2	2008	8.07%	1.97	0.69	nd	nd	7.09	11.24	nd	nd	nd
CA3	2011	11.70%	5.79	4.31	nd	nd	25.92	29.66	nd	nd	nd
CA4	2012	10.38%	4.50	3.72	nd	nd	25.57	27.58	nd	nd	nd
CA5	2012	11.69%	8.16	6.23	nd	nd	44.29	47.23	nd	nd	nd
CA6	2013	10.19%	9.24	7.25	16.11	17.11	46.56	48.51	nd	nd	nd
CAL1	2012	9.72%	7.85	6.52	14.91	14.79	48.26	53.09	3.86	nd	nd
CAL2	2013	12.84%	5.86	4.64	26.07	25.23	35.19	39.95	4.75	nd	nd

Table 1 – continued

Wine	vintage	ALC analyzer	(S)-(-)-limonene	(R)-(+)-Limonene	(-)-Linalool	(+)-Linalool	(-)-alpha terpineol	(+)-alpha terpineol	(R)-(+)-beta-citronellol	(+)-(2R,4S)-cis-rose oxide	(-)-(2S,4R)-cis-rose oxide
GR1	2010	12.47%	2.30	1.23	14.92	15.03	43.64	37.01	4.79	nd	0.45
GR2	2010	5.55%	2.84	0.75	8.36	9.75	27.62	23.78	1.42	nd	nd
GR3	2010	7.50%	1.57	0.45	6.22	5.82	16.50	14.53	1.54	nd	nd
GR4	2011	4.51%	5.10	3.07	nd	nd	47.04	53.40	nd	nd	nd
GR5	2011	6.84%	1.99	nd	5.91	6.28	23.62	24.92	nd	nd	nd
GR6	2012	12.54%	6.48	4.67	28.83	27.36	36.27	35.31	3.90	nd	nd
GR7	2012	11.68%	1.48	0.90	17.96	18.09	42.17	45.20	2.14	nd	nd
GR8	2012	12.13%	20.24	17.81	94.92	92.89	125.16	134.15	4.61	nd	nd
GR8a	2012	12.97%	10.27	7.61	91.50	83.37	121.63	121.46	4.95	nd	nd
GR9	2012	12.82%	7.05	5.47	34.08	32.69	40.08	40.41	4.11	nd	nd
GR9a	2012	12.93%	12.86	10.28	48.66	45.27	50.35	48.82	3.70	nd	nd
GR10	2012	10.98%	3.11	1.72	6.82	7.83	21.56	21.00	nd	nd	nd
GR11	2012	10.24%	1.66	0.75	8.59	9.03	19.94	18.01	nd	nd	nd
GR12	2012	9.34%	2.90	0.64	13.74	15.52	25.46	25.01	nd	nd	nd
GR13	2012	1nd%	4.34	1.85	18.03	18.31	37.55	30.39	nd	nd	nd
GR14	2012	7.49%	1.48	0.97	nd	7.67	16.44	16.37	nd	nd	nd
GR15	2012	7.04%	1.36	0.46	nd	nd	14.86	12.60	nd	nd	nd
GR16	2012	8.48%	0.83	nd	nd	nd	12.18	11.66	nd	nd	nd
GR17	2012	7.11%	2.46	1.23	10.47	11.08	25.20	23.98	1.51	nd	nd
GR18	2012	9.44%	5.35	3.81	30.82	27.48	30.07	32.65	1.93	nd	nd
GR19	2012	6.77%	3.22	1.80	13.32	12.98	23.54	23.40	1.99	nd	nd
GR20	2012	7.73%	3.38	0.32	12.84	13.55	30.60	30.79	nd	nd	nd
GR21	2013	11.71%	2.71	1.19	9.37	10.74	15.49	14.87	4.87	nd	nd
NY1	2008	13.90%	1.66	nd	nd	nd	25.62	24.32	nd	nd	nd

Table 1 – continued

Wine	vintage	ALC analyzer	(S)-(-)-limonene	(R)-(+)-Limonene	(-)-Linalool	(+)-Linalool	(-)-alpha terpineol	(+)-alpha terpineol	(R)-(+)-beta-citronellol	(+)-(2R,4S)-cis-rose oxide	(-)-(2S,4R)-cis-rose oxide
NY3	2010	12.22%	1.36	0.89	nd	nd	13.44	19.91	3.57	nd	nd
NY4	2010	8.36%	3.22	2.28	nd	nd	23.86	23.31	3.12	nd	1.20
NY5	2011	12.00%	7.82	6.75	10.48	10.71	63.93	71.72	3.12	nd	nd
NY6	2011	10.49%	3.07	2.69	nd	nd	26.30	29.80	nd	nd	nd
NY7	2011	11.53%	2.75	nd	nd	nd	26.97	32.01	nd	nd	nd
NY8	2011	11.00%	5.29	3.23	21.45	21.36	42.98	45.93	4.61	nd	0.34
BY8	2012	10.65%	5.31	4.18	8.92	9.28	47.72	50.92	nd	nd	nd
NY10	2012	11.40%	6.43	5.17	12.47	12.06	51.55	61.40	3.22	nd	nd
NY11	2012	10.85%	5.11	3.66	8.68	10.04	34.69	38.33	nd	nd	nd
NY12	2012	12.33%	11.19	10.05	25.43	28.77	75.75	82.80	5.30	nd	nd
OR1a	2012	11.08%	3.48	2.57	11.76	11.64	23.89	23.70	4.20	nd	nd
NY13	2012	12.25%	3.92	3.25	19.40	19.30	69.38	76.19	nd	nd	nd
NY14	2012	11.76%	2.95	1.98	9.04	8.84	60.42	62.09	nd	nd	nd
NY15	2012	11.95%	6.72	5.83	nd	11.15	46.98	52.40	nd	nd	nd
NY16	2012	11.12%	10.49	8.73	20.78	23.60	72.46	73.72	3.93	nd	nd
NY17	2012	9.90%	3.95	2.90	nd	nd	27.21	28.74	nd	nd	nd
NY18	2012	11.43%	8.92	7.24	7.67	9.67	58.46	64.83	3.75	nd	nd
NY19	2012	12.76%	2.20	1.88	19.10	19.95	51.92	55.40	4.97	0.61	nd
NY20	2012	10.86%	2.50	2.11	17.78	18.71	52.63	56.99	nd	nd	nd
NY21	2012	11.25%	4.56	3.24	nd	nd	31.81	34.38	nd	nd	nd
NY22	2012	7.82%	3.02	0.67	nd	nd	39.32	43.71	nd	nd	nd
NY23	2012	11.72%	10.78	9.16	22.31	23.59	69.35	77.73	2.82	nd	nd
NY24	2012	10.91%	5.39	4.16	8.28	8.91	42.02	50.36	nd	nd	nd
NY25	2012	9.63%	6.64	5.55	54.73	49.17	39.61	39.40	6.24	nd	nd

Table 1 – continued

Wine	vintage	ALC analyzer	(S)-(-)-limonene	(R)-(+)-Limonene	(-)-Linalool	(+)-Linalool	(-)-alpha terpineol	(+)-alpha terpineol	(R)-(+)-beta-citronellol	(+)-(2R,4S)-cis-rose oxide	(-)-(2S,4R)-cis-rose oxide
NY26	2012	12.22%	22.61	16.02	120.92	107.73	92.61	86.76	9.65	nd	nd
NY27	2012	12.61%	18.10	14.89	31.73	32.61	108.34	120.54	20.66	nd	nd
NY28	2013	11.66%	6.03	4.96	34.24	30.81	34.90	37.47	4.71	nd	nd
NY29	2013	10.14%	3.94	2.87	60.95	50.42	40.21	37.57	6.24	nd	nd
NY30	2013	10.08%	8.49	7.01	20.23	20.16	48.79	50.13	4.79	nd	nd
NY31	2013	10.76%	4.22	2.58	38.72	35.16	30.33	31.79	4.40	nd	nd
NZ1	2009	12.91%	nd	nd	nd	nd	14.85	14.94	nd	nd	nd
NZ2	2009	11.63%	3.06	2.03	nd	nd	21.77	21.77	nd	nd	nd
NZ3	2010	13.01%	5.85	4.75	6.01	6.63	51.14	52.42	2.83	nd	nd
NZ4	2010	12.42%	3.33	2.37	nd	nd	25.77	28.14	3.05	nd	nd
NZ5	2011	11.60%	3.30	2.29	nd	nd	24.79	25.78	nd	nd	nd
NZ6	2012	7.54%	2.24	1.01	nd	nd	20.83	16.92	nd	nd	nd
NZ7	2012	6.53%	2.62	2.14	nd	nd	21.75	27.48	nd	nd	nd
NZ8	2013	11.50%	2.06	1.24	nd	nd	17.02	19.63	nd	nd	nd
NZ9	2013	13.38%	14.89	11.62	35.72	36.51	58.69	61.87	3.47	nd	nd
NZ10	2013	9.23%	2.89	0.92	6.27	6.62	22.78	19.03	3.11	nd	nd
NZ11	2013	11.50%	2.40	nd	7.88	7.83	34.57	30.75	3.27	nd	nd
NZ12	2013	10.56%	3.55	2.70	5.49	6.11	28.52	31.55	2.40	nd	nd
OR1	2008	11.09%	nd	nd	nd	nd	6.60	9.10	nd	nd	nd
OR2	2009	11.46%	nd	nd	nd	nd	10.23	14.42	nd	nd	nd
OR3	2010	11.55%	nd	nd	nd	nd	9.11	12.32	nd	nd	nd
OR4	2010	10.43%	0.71	0.54	nd	nd	8.00	12.43	nd	nd	nd
OR5	2011	11.66%	2.31	1.79	nd	nd	17.04	20.53	nd	nd	nd
OR6	2011	12.08%	0.33	nd	nd	nd	8.19	8.54	nd	nd	0.22

Table 1 – continued

Wine	vintage	ALC analyzer	(S)-(-)-limonene	(R)-(+)-Limonene	(-)-Linalool	(+)-Linalool	(-)-alpha terpineol	(+)-alpha terpineol	(R)-(+)-beta-citronellol	(+)-(2R,4S)-cis-rose oxide	(-)-(2S,4R)-cis-rose oxide
OR7	2011	11.14%	nd	nd	nd	nd	9.77	12.33	nd	nd	nd
OR8	2011	10.34%	0.31	0.20	nd	nd	10.55	10.98	2.21	nd	nd
OR9	2012	12.48%	0.85	0.46	16.06	15.37	29.42	30.38	4.40	nd	nd
OR10	2012	10.52%	4.75	3.88	10.85	12.94	33.12	38.60	3.27	nd	nd
OR11	2012	11.69%	5.63	4.53	13.83	13.81	36.67	40.89	4.10	nd	nd
OR12	2012	12.18%	5.77	4.34	14.61	15.46	36.14	37.90	3.50	nd	nd
OR13	2012	12.17%	4.96	4.86	11.96	14.19	37.93	42.33	4.01	nd	nd
OR14	2012	12.40%	1.40	0.92	13.98	15.81	36.45	38.81	3.82	nd	nd
OR15	2012	11.30%	7.21	5.38	12.75	14.76	46.60	48.88	nd	nd	nd
OR16	2012	11.05%	0.65	0.45	9.70	10.57	34.29	37.20	4.01	nd	nd
OR17	2012	10.92%	4.20	3.62	nd	nd	30.31	36.23	nd	nd	nd
OR19	2012	10.71%	3.77	3.25	nd	nd	29.87	35.36	nd	nd	0.24
OR20	2012	11.28%	5.64	5.33	7.36	8.69	30.14	36.26	nd	nd	nd
OR21	2012	11.02%	5.16	4.70	8.43	9.79	35.54	41.57	nd	nd	nd
OR22	2012	8.82%	3.89	2.96	nd	nd	28.40	31.12	3.03	nd	nd
OR23	2012	10.28%	6.97	4.35	11.26	15.86	31.00	43.02	4.15	nd	nd
OR24	2012	8.01%	4.22	2.90	12.59	14.04	41.68	42.08	5.20	nd	nd
OR25	2013	11.81%	7.57	4.30	19.78	28.04	45.33	33.96	4.45	nd	nd
OR26	2013	12.45%	4.65	3.49	19.93	18.79	29.07	29.04	5.63	nd	nd
OR27	2013	10.50%	2.13	0.93	23.88	20.89	40.25	35.39	5.33	nd	nd
OR28	2013	9.28%	0.33	nd	11.72	11.52	22.47	19.79	5.20	nd	nd
OR29	2013	11.14%	1.98	1.69	11.54	12.70	20.86	21.11	2.92	nd	nd
OR30	2013	5.06%	3.65	2.39	21.02	19.07	21.32	20.97	3.41	nd	nd
WA1	2010	13.00%	2.14	1.29	nd	nd	20.43	23.17	3.03	nd	nd

Table 1 – continued

Wine	vintage	ALC analyzer	(S)-(-)-limonene	(R)-(+)-Limonene	(-)-Linalool	(+)-Linalool	(-)-alpha terpineol	(+)-alpha terpineol	(R)-(+)-beta-citronellol	(+)-(2R,4S)-cis-rose oxide	(-)-(2S,4R)-cis-rose oxide
WA2	2011	11.00%	3.77	2.96	8.08	9.12	27.02	30.30	nd	nd	nd
WA3	2011	11.00%	3.31	2.27	8.12	8.39	26.90	30.22	3.18	nd	nd
WA4	2011	11.50%	7.01	4.37	24.00	24.03	63.58	72.40	4.84	nd	nd
WA5	2011	1nd%	4.76	3.96	13.86	15.02	32.89	40.40	2.74	nd	nd
WA6	2011	11.00%	7.43	5.45	42.44	40.90	58.27	65.26	5.11	nd	nd
WA7	2011	11.50%	3.79	2.98	10.81	12.52	27.81	31.92	nd	nd	nd
WA8	2012	12.92%	9.19	8.22	39.65	37.99	54.09	58.66	5.72	nd	nd
WA9	2012	13.07%	6.26	5.43	24.00	23.93	48.41	54.52	3.55	nd	nd
WA10	2012	12.77%	4.88	4.03	18.77	18.38	34.00	35.52	4.53	nd	nd
WA11	2012	12.46%	4.90	4.21	16.48	16.52	48.61	54.75	3.68	nd	nd
WA12	2012	12.52%	10.56	9.10	26.93	29.17	65.52	76.12	4.03	nd	nd
WA13	2012	11.88%	5.21	4.37	23.50	22.75	38.05	42.52	4.31	nd	nd
WA14	2012	12.00%	4.87	3.99	11.00	12.38	45.33	49.51	3.24	nd	nd
WA15	2012	11.41%	5.35	4.27	15.06	15.52	33.64	36.81	3.86	nd	nd
WA16	2012	12.50%	10.88	9.22	42.60	41.65	59.80	68.54	12.79	nd	nd
WA17	2012	10.90%	15.10	12.30	61.75	58.11	75.19	85.21	4.15	nd	nd
WA18	2012	9.84%	6.52	5.25	18.62	19.43	41.58	50.53	2.39	nd	nd
WA19	2012	7.53%	7.22	5.61	42.68	39.60	39.02	43.69	6.27	nd	nd
WA20	2013	12.12%	9.91	8.64	62.49	50.86	58.18	57.75	9.16	nd	nd
WA21	2013	7.07%	11.88	10.94	78.43	71.44	62.06	69.18	2.99	nd	nd

Table 2 – Chiral trans-linalool oxide, trans-rose oxide, cis-linalool oxide and linalool content (µg/L) of Riesling wines from different locations (AU, Australia, CA – Canada, CAL – California, USA, GR – Germany, NY – New York, USA, OR – Oregon, USA, NZ – New Zealand, WA – Washington, USA)

Wine	vintage	Furanoid (+)-trans Linalool oxide	Furanoid (-)-cis Linalool oxide	(-)-(2R,4R)-trans-rose oxide	(+)-(2S,4S)-trans-rose oxide	Furanoid (-)-trans Linalool oxide	Furanoid (+)-cis Linalool oxide	(-)-Linalool	(+)-Linalool
AU1	2008	31.88	28.93	0.36	nd	12.16	15.72	nd	nd
AU2	2012	32.93	20.72	nd	nd	8.13	13.01	12.54	13.53
AU3	2012	41.38	30.16	nd	nd	13.64	18.92	nd	nd
AU4	2012	54.94	43.91	0.35	nd	20.30	20.59	23.18	23.20
AU5	2013	23.43	18.37	nd	nd	9.67	14.05	9.12	9.34
CA1	2013	24.02	14.85	nd	nd	6.68	10.41	48.94	42.70
AU6	2013	20.94	16.47	nd	nd	nd	8.12	8.82	9.81
CA1a	2013	35.98	25.34	nd	nd	12.11	15.30	41.20	38.05
AU7	2013	22.02	17.75	nd	nd	12.43	14.90	11.80	12.48
AU8	2013	30.39	20.62	nd	nd	4.86	13.27	10.82	11.54
AU9	2013	19.03	12.94	nd	nd	nd	9.02	16.10	17.53
CA1b	2013	11.19	7.17	nd	nd	nd	7.31	38.38	33.37
AU10	2013	40.55	24.66	nd	nd	8.04	16.67	8.40	9.98
AU11	2013	59.33	49.02	nd	nd	13.60	28.56	nd	nd
AU12	2013	38.27	30.31	nd	nd	13.15	16.80	nd	nd
CA2	2008	92.56	48.78	nd	nd	19.21	37.82	nd	nd
CA3	2011	39.59	19.44	nd	nd	7.64	15.46	nd	nd
CA4	2012	46.33	34.82	nd	nd	14.38	20.98	nd	nd
CA5	2012	35.54	21.02	nd	nd	8.20	13.77	nd	nd
CA6	2013	33.83	16.23	nd	nd	6.48	12.42	16.11	17.11
CAL1	2012	36.37	31.59	nd	nd	14.63	16.23	14.91	14.79
CAL2	2013	31.57	22.83	nd	nd	10.45	14.13	26.07	25.23

Table 2 – continued

Wine	vintage	Furanoid (+)-trans Linalool oxide	Furanoid (-)-cis Linalool oxide	(-)-(2R,4R)-trans-rose oxide	(+)-(2S,4S)-trans-rose oxide	Furanoid (-)-trans Linalool oxide	Furanoid (+)-cis Linalool oxide	(-)-Linalool	(+)-Linalool
GR1	2010	30.76	26.50	nd	nd	6.92	39.98	14.92	15.03
GR2	2010	15.38	11.32	nd	nd	2.00	3.75	8.36	9.75
GR3	2010	nd	nd	nd	nd	nd	nd	6.22	5.82
GR4	2011	19.52	16.14	nd	nd	7.50	7.36	nd	nd
GR5	2011	7.95	8.45	nd	nd	3.22	5.84	5.91	6.28
GR6	2012	31.93	12.81	nd	nd	5.66	12.18	28.83	27.36
GR7	2012	17.16	5.80	nd	nd	nd	9.80	17.96	18.09
GR8	2012	55.43	31.10	nd	nd	17.33	19.60	94.92	92.89
GR8a	2012	76.92	42.85	nd	nd	21.07	28.45	91.50	83.37
GR9	2012	38.99	14.13	nd	nd	6.15	14.65	34.08	32.69
GR9a	2012	29.08	11.70	nd	nd	3.94	11.08	48.66	45.27
GR10	2012	36.42	19.32	nd	nd	7.55	13.33	6.82	7.83
GR11	2012	36.25	15.69	nd	nd	6.46	12.19	8.59	9.03
GR12	2012	23.97	7.22	nd	nd	3.61	5.05	13.74	15.52
GR13	2012	35.96	19.85	nd	nd	3.42	21.31	18.03	18.31
GR14	2012	83.37	33.26	nd	nd	10.35	27.25	nd	7.67
GR15	2012	42.93	16.45	nd	nd	5.44	13.95	nd	nd
GR16	2012	20.07	6.25	nd	nd	0.37	4.73	nd	nd
GR17	2012	5.71	2.65	nd	nd	nd	3.23	10.47	11.08
GR18	2012	15.17	0.39	nd	nd	0.12	2.56	30.82	27.48
GR19	2012	27.35	7.82	nd	nd	1.30	7.21	13.32	12.98
GR20	2012	13.60	5.26	nd	nd	2.38	3.54	12.84	13.55
GR21	2013	16.40	11.03	nd	nd	nd	8.53	9.37	10.74
NY1	2008	32.97	27.62	0.30	nd	14.01	13.28	nd	nd

Table 2 – continued

Wine	vintage	Furanoid (+)-trans Linalool oxide	Furanoid (-)-cis Linalool oxide	(-)-(2R,4R)-trans-rose oxide	(+)-(2S,4S)-trans-rose oxide	Furanoid (-)-trans Linalool oxide	Furanoid (+)-cis Linalool oxide	(-)-Linalool	(+)-Linalool
NY3	2010	46.54	23.15	0.32	nd	4.64	22.49	nd	nd
NY4	2010	221.85	130.60	0.89	1.29	55.44	74.95	nd	nd
NY5	2011	49.57	23.98	nd	nd	6.16	19.51	10.48	10.71
NY6	2011	41.20	22.47	nd	nd	9.15	16.92	nd	nd
NY7	2011	0.25	2.53	nd	nd	1.64	0.98	nd	nd
NY8	2011	2.72	3.28	nd	nd	2.16	1.66	21.45	21.36
BY8	2012	34.41	22.07	nd	nd	10.07	14.56	8.92	9.28
NY10	2012	43.09	23.46	nd	nd	4.27	17.58	12.47	12.06
NY11	2012	29.08	18.17	nd	nd	7.82	12.16	8.68	10.04
NY12	2012	84.28	42.92	nd	nd	18.89	30.92	25.43	28.77
OR1a	2012	62.42	43.09	nd	nd	14.64	23.44	11.76	11.64
NY13	2012	33.68	18.50	nd	nd	9.05	13.19	19.40	19.30
NY14	2012	61.83	33.50	nd	nd	13.50	24.88	9.04	8.84
NY15	2012	69.20	37.09	nd	nd	15.51	25.52	nd	11.15
NY16	2012	43.99	27.09	nd	nd	11.59	18.88	20.78	23.60
NY17	2012	37.08	23.38	nd	nd	10.83	16.31	nd	nd
NY18	2012	56.41	43.71	nd	nd	18.56	22.65	7.67	9.67
NY19	2012	44.81	22.40	nd	nd	8.19	16.03	19.10	19.95
NY20	2012	31.99	19.52	nd	nd	8.39	11.79	17.78	18.71
NY21	2012	8.82	7.17	nd	nd	2.50	2.18	nd	nd
NY22	2012	18.30	15.90	nd	nd	8.69	8.98	nd	nd
NY23	2012	26.94	12.88	nd	nd	5.26	8.38	22.31	23.59
NY24	2012	24.39	10.39	nd	nd	3.21	6.97	8.28	8.91
NY25	2012	nd	nd	nd	nd	0.61	nd	54.73	49.17

Table 2 – continued

Wine	vintage	Furanoid (+)-trans Linalool oxide	Furanoid (-)-cis Linalool oxide	(-)-(2R,4R)-trans-rose oxide	(+)-(2S,4S)-trans-rose oxide	Furanoid (-)-trans Linalool oxide	Furanoid (+)-cis Linalool oxide	(-)-Linalool	(+)-Linalool
NY26	2012	14.91	11.85	nd	nd	3.00	7.28	120.92	107.73
NY27	2012	145.17	72.81	nd	nd	38.11	51.58	31.73	32.61
NY28	2013	16.06	9.69	nd	nd	5.15	7.40	34.24	30.81
NY29	2013	9.20	6.46	nd	nd	3.86	5.05	60.95	50.42
NY30	2013	46.48	25.87	nd	nd	11.68	17.77	20.23	20.16
NY31	2013	nd	nd	nd	nd	nd	nd	38.72	35.16
NZ1	2009	93.48	60.56	0.66	nd	24.01	57.56	nd	nd
NZ2	2009	73.17	42.87	0.56	nd	18.60	33.25	nd	nd
NZ3	2010	37.55	21.05	0.29	nd	3.09	15.43	6.01	6.63
NZ4	2010	51.05	28.69	nd	nd	5.85	24.36	nd	nd
NZ5	2011	85.32	51.85	nd	nd	22.53	31.59	nd	nd
NZ6	2012	36.22	27.69	nd	nd	9.54	17.74	nd	nd
NZ7	2012	203.49	112.71	nd	nd	45.30	77.68	nd	nd
NZ8	2013	94.35	65.65	nd	nd	22.09	39.22	nd	nd
NZ9	2013	41.09	22.60	nd	nd	12.05	15.59	35.72	36.51
NZ10	2013	20.72	16.52	nd	nd	8.32	9.75	6.27	6.62
NZ11	2013	12.27	10.84	nd	nd	6.00	6.72	7.88	7.83
NZ12	2013	72.05	39.71	nd	nd	15.62	24.16	5.49	6.11
OR1	2008	99.92	61.06	0.57	nd	25.87	42.07	nd	nd
OR2	2009	87.51	53.90	0.41	nd	21.01	38.97	nd	nd
OR3	2010	60.95	51.19	nd	nd	19.27	29.66	nd	nd
OR4	2010	94.77	77.40	1.21	nd	28.77	41.62	nd	nd
OR5	2011	32.23	27.89	nd	nd	nd	14.41	nd	nd
OR6	2011	24.90	18.31	nd	nd	6.87	10.04	nd	nd

Table 2 – continued

Wine	vintage	Furanoid (+)-trans Linalool oxide	Furanoid (-)-cis Linalool oxide	(-)-(2R,4R)-trans-rose oxide	(+)-(2S,4S)-trans-rose oxide	Furanoid (-)-trans Linalool oxide	Furanoid (+)-cis Linalool oxide	(-)-Linalool	(+)-Linalool
OR7	2011	30.53	21.24	0.31	nd	3.94	13.67	nd	nd
OR8	2011	29.63	22.45	0.34	nd	5.47	12.98	nd	nd
OR9	2012	80.15	49.86	nd	nd	21.53	33.01	16.06	15.37
OR10	2012	70.04	42.22	nd	nd	17.58	26.36	10.85	12.94
OR11	2012	45.25	27.37	nd	nd	10.93	18.73	13.83	13.81
OR12	2012	53.72	30.89	nd	nd	12.69	19.82	14.61	15.46
OR13	2012	77.57	42.77	nd	nd	17.76	29.22	11.96	14.19
OR14	2012	69.83	37.58	nd	nd	14.73	24.87	13.98	15.81
OR15	2012	50.12	25.21	nd	nd	10.45	18.76	12.75	14.76
OR16	2012	71.61	40.96	nd	nd	15.13	27.05	9.70	10.57
OR17	2012	106.67	56.23	nd	nd	22.03	41.67	nd	nd
OR19	2012	125.51	70.82	0.46	nd	27.69	5nd	nd	nd
OR20	2012	69.07	39.53	nd	nd	14.76	26.74	7.36	8.69
OR21	2012	49.70	26.90	nd	nd	9.79	19.08	8.43	9.79
OR22	2012	82.08	46.95	nd	nd	18.46	31.28	nd	nd
OR23	2012	51.78	29.99	nd	nd	8.78	31.37	11.26	15.86
OR24	2012	47.54	32.30	nd	nd	12.89	19.20	12.59	14.04
OR25	2013	41.10	23.44	nd	nd	6.63	22.66	19.78	28.04
OR26	2013	73.64	46.90	nd	nd	16.88	25.82	19.93	18.79
OR27	2013	155.44	68.46	nd	nd	29.02	57.26	23.88	20.89
OR28	2013	114.96	79.47	nd	nd	33.33	43.61	11.72	11.52
OR29	2013	42.56	16.69	nd	nd	4.07	13.47	11.54	12.70
OR30	2013	33.28	20.72	nd	nd	8.72	12.03	21.02	19.07
WA1	2010	42.77	23.14	nd	nd	3.51	17.34	nd	nd

Table 2 – continued

Wine	vintage	Furanoid (+)-trans Linalool oxide	Furanoid (-)-cis Linalool oxide	(-)-(2R,4R)-trans-rose oxide	(+)-(2S,4S)-trans-rose oxide	Furanoid (-)-trans Linalool oxide	Furanoid (+)-cis Linalool oxide	(-)-Linalool	(+)-Linalool
WA2	2011	46.70	26.68	nd	nd	nd	16.27	8.08	9.12
WA3	2011	29.71	18.29	nd	nd	9.38	12.13	8.12	8.39
WA4	2011	10.13	11.91	nd	nd	7.58	4.87	24.00	24.03
WA5	2011	20.14	14.61	nd	nd	6.34	5.65	13.86	15.02
WA6	2011	25.19	14.84	nd	nd	8.77	10.34	42.44	40.90
WA7	2011	10.64	7.91	nd	nd	3.09	3.06	10.81	12.52
WA8	2012	30.74	18.02	nd	nd	8.76	12.63	39.65	37.99
WA9	2012	13.22	7.56	nd	nd	3.49	7.39	24.00	23.93
WA10	2012	23.56	14.68	nd	nd	6.88	9.78	18.77	18.38
WA11	2012	28.78	18.48	nd	nd	8.06	11.03	16.48	16.52
WA12	2012	40.59	18.28	nd	nd	8.90	14.86	26.93	29.17
WA13	2012	22.07	11.92	nd	nd	5.27	9.34	23.50	22.75
WA14	2012	49.60	24.91	nd	nd	11.56	18.46	11.00	12.38
WA15	2012	21.72	14.19	nd	nd	nd	12.48	15.06	15.52
WA16	2012	24.36	18.30	nd	nd	8.62	8.67	42.60	41.65
WA17	2012	4.63	3.08	nd	nd	nd	nd	61.75	58.11
WA18	2012	14.16	7.98	nd	nd	3.88	3.50	18.62	19.43
WA19	2012	5.86	7.43	nd	nd	2.78	1.09	42.68	39.60
WA20	2013	41.15	30.98	nd	nd	13.99	17.08	62.49	50.86
WA21	2013	7.71	12.72	nd	nd	4.57	1.53	78.43	71.44