Dynamic Viscosity Levels of Dry Red and White Wines and Determination of Perceived Viscosity Difference Threshold

L. Danner[1*], J. Niimi[1,2], Y. Wang[1], M. Kustos[1], R.A. Muhlack[1], S.E.P. Bastian[1]

[1]The University of Adelaide, Australia, [2]Goethe Universität, Germany

*lukas.danner@adelaide.edu.au

THE UNIVERSITY of ADELAIDE

Background and Aims

Wine mouthfeel is an important aspect of the overall sensory perception and quality of wines. In addition to the wine body, with its often ambiguous definition and understanding (Niimi et al., 2017), viscosity has potential to be a more objective parameter to describe and measure wine mouthfeel properties. However, the relationship between dynamic viscosity and mouthfeel of dry table wines is still not fully understood.

The objectives of this study were to:
i)   determine the difference threshold for perceived viscosity in wine by varying xanthan gum additions to wine,
ii) measure dynamic viscosity of a wide range of Australian commercial dry Shiraz and Chardonnay wines,
iii) investigate the relationship between dynamic viscosity and chemical parameters (i.e. residual sugar, ethanol, and pH) in commercial dry wine samples.

Materials and Methods

Sensory difference threshold testing:

Wine viscosity difference thresholds were determined with an ascending two-alternative forced-choice test (45 experienced tasters). To simulate the viscosity range of commercial dry wines without altering the aroma and flavour of a Hunter Valley, Semillon, xanthan gum was added in 0.02 g/L steps up to 0.12 g/L.

Wine chemical and physical measures:
- **Dynamic viscosity** measured with a falling-ball viscometer (Fungilab Viscoball).
- **Density** and **alcohol content** measured with the Alcolyser Wine ME (Anton Paar, MEP Instruments Pty Ltd.).
- **Residual sugar** was measured enzymatically as total glucose and fructose (Boehringer- Mannheim/R-BioPharm) and a spectrophotometric plate reader (Tecan M200 Infinite).
- **pH** and **titratable acidity** determined with a Mettler Toledo T50 Autotitrator.
- **Tannin concentration** of red wines was determined by the methyl cellulose precipitable-tannin assay and expressed as epicatechin equivalents.

Wine samples:

Commercially available dry (< 4 g/L residual sugar) Australian **Chardonnay** (n = 34, from 5 regions) and **Shiraz** (n = 29, from 2 regions) wines were sourced from South Australian stores or donated by the wineries.

Key Findings

Wine viscosity difference threshold

A viscosity difference threshold of 0.138 mPa·s in wine was determined confirming the value of 0.141 mPa·s found by Nobel of Bursick (1984) using a similar approach.

64.4% = $p < 0.05$

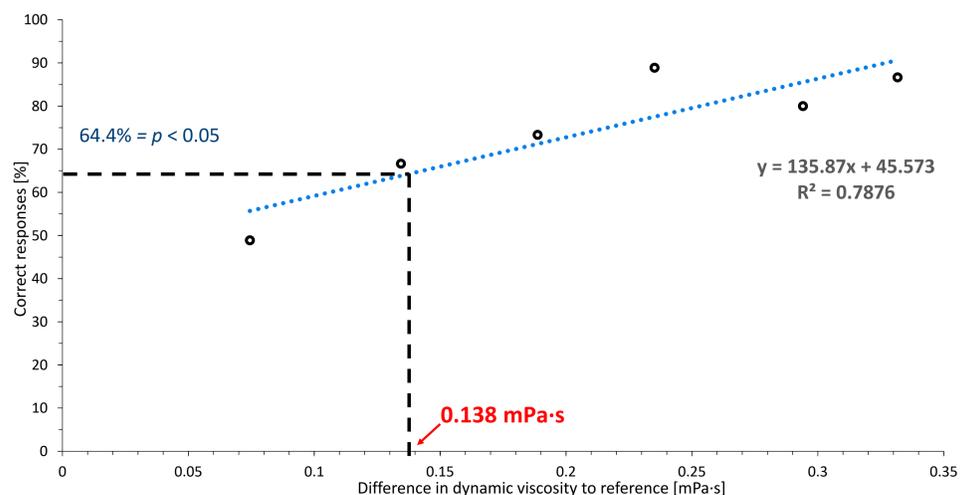$y = 135.87x + 45.573$
$R^2 = 0.7876$

0.138 mPa·s

Figure 1: Correct responses (N = 45) in perceived viscosity differences as a function of difference in dynamic viscosity of wine spiked with Xanthan gum relative to the reference. Broken lines denote the significant difference (p < 0.05) between the reference and sample of interest, with corresponding difference in dynamic viscosity, interpolated with the linear slope. Adapted from Danner et al., 2019.

References:

Danner, L., Niimi, J., Wang, Y., Kustos, M., Muhlack, R. A., & Bastian, S. E. P. (2019). Dynamic Viscosity Levels of Dry Red and White Wines and Determination of Perceived Viscosity Difference Thresholds. Am. J. Enol. Vitic., 70(2), 205–211.

Niimi, J., Danner, L., Li, L., Bossan, H., & Bastian, S. E. P. (2017). Wine consumers' subjective responses to wine mouthfeel and understanding of wine body. Food Res. Int., 99, 115–122

Noble, A. C., & Bursick, G. F. (1984). The Contribution of Glycerol to Perceived Viscosity and Sweetness in White Wine. Am. J. Enol. Vitic., 35(2), 110–112.

Dynamic viscosities of commercial Chardonnay and Shiraz wines

Overall, the dynamic viscosity range was lower and smaller across Chardonnay than the Shiraz wines, with means of 1.475 and 1.611 mPa·s, respectively. The viscosity of Chardonnay wines ranged from 1.448 to 1.529 mPa·s (Δ = 0.081 mPa·s). Dynamic viscosities of Shiraz ranged between 1.488 and 1.695 mPa·s, with more than double the range of Chardonnay (Δ = 0.207 mPa·s).

The total dynamic viscosity range of the 34 analyzed Chardonnay wines was below the difference threshold of viscosity perception, and just above for the 29 Shiraz wines. This indicated that tasters are likely to be able to perceive differences in viscosity between the analysed Shiraz wines but not the set of Chardonnay wines.
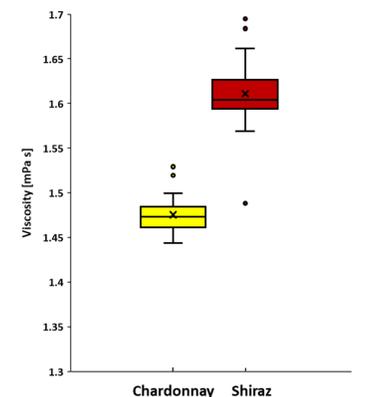

Figure 2: Box and whisker plots of dynamic viscosity for dry Australian commercial Chardonnay (n = 34) and Shiraz (n = 29) wines. Means are denoted with the symbol × in the boxes. Adapted from Danner et al., 2019.

Correlations of dynamic viscosity with basic chemical measures of wine

a) Shiraz
$y = 0.0439x + 0.9707$
$R^2 = 0.2923$

b) Chardonnay
$y = 0.0313x + 1.0591$
$R^2 = 0.7004$

c) Shiraz
$y = -0.1033x + 1.9716$
$R^2 = 0.0715$

d) Chardonnay
$y = -0.055x + 1.6517$
$R^2 = 0.0932$

e) Shiraz
$y = 0.0344x + 1.5842$
$R^2 = 0.0572$

f) Chardonnay
$y = -0.0019x + 1.4784$
$R^2 = 0.0046$

g) Shiraz
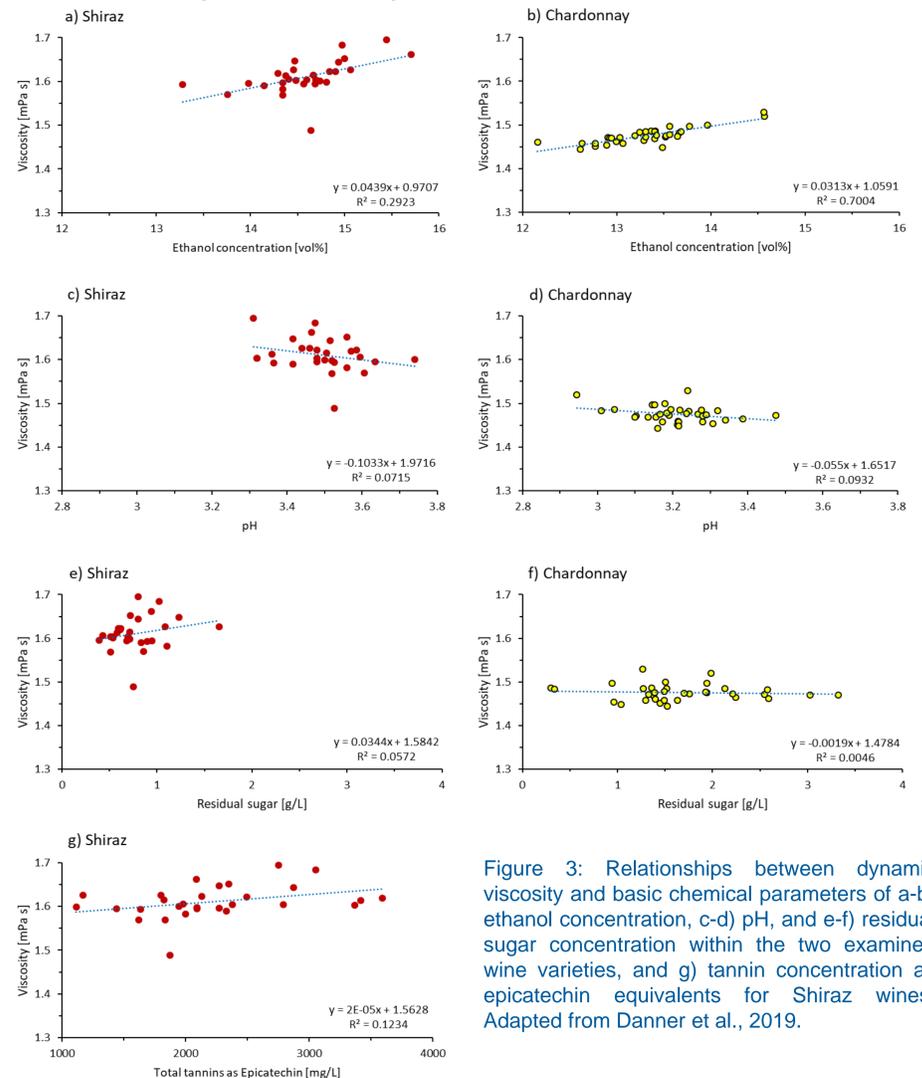$y = 2E\text{-}05x + 1.5628$
$R^2 = 0.1234$

Figure 3: Relationships between dynamic viscosity and basic chemical parameters of a-b) ethanol concentration, c-d) pH, and e-f) residual sugar concentration within the two examined wine varieties, and g) tannin concentration as epicatechin equivalents for Shiraz wines. Adapted from Danner et al., 2019.

Significant correlations between ethanol concentration and dynamic viscosity were observed for Shiraz ($p = 0.002$) and Chardonnay ($p < 0.001$). No significant correlation was observed for pH and residual sugar for either of the varieties. A weak correlation ($p = 0.062$) between tannin concentration and viscosity was found.

Conclusions

a) A viscosity difference threshold value in dry wine of 0.138 mPa·s at 20°C was determined.
b) Dynamic viscosity at 20 °C ranged from:
   - 1.448 mPa·s to 1.529 mPa·s for Chardonnay wines (n = 34)
   - 1.488 mPa·s to 1.695 mPa·s for Shiraz (n = 29)
c) Significant correlations between dynamic viscosity and ethanol concentration, but not for pH and residual sugar were found. This indicates that ethanol may have been the main compositional factor that influenced dynamic viscosity in commercial dry wines. However, further studies are required to investigate other potential factors e.g. polysaccharides and amino acids.