Application of ultrasonic and refractometric measurements in enological samples and related model solutions

Matteo Sesenna[1], Edoardo Longo[1], Alessandro Fornasier[2], Luca Rolle[2], Ulrich Pedri[3], Danila Chiotti[3], Emanuele Boselli[1]

[1]Free University of Bozen-Bolzano, Italy; [2]University of Turin DISAFA, Italy; [3]Institute for Fruit Growing and Viticulture, Laimburg Research Center, Italy

macrowine 2021 Virtual June 23 - 30

Introduction

- The refractive index is a basic optical property of materials and a key tool for the determination of major components in musts, such as sugars
- Ultrasonic based technology is emerging as a well-suited tool for monitoring food processes and quality, and in particular it has been applied in predicting the alcohol content and measuring the ultrasonic velocity in enological products
- The aim of this study is to combine the applications of these two technologies to quantify alcohol and residual sugar in real and model enological samples
- The effects of major wine and must components on the combined application of these analytical tools are investigated

Methods

- Refractometric and sonic Brix values were determined using a **LP10 sensor** (Maselli Misure, Parma, Italy) working at controlled temperature
- The real enological samples were obtained during the 2020 harvest in South Tyrol (Italy)
- The model solutions were prepared at different combinations of different levels of ethanol in water, glucose, tartaric acid, malic acid and gallic acid as major wine components
- For these model solutions, firstly the levels of each component were chosen upon a likelihood criterium, then to reduce the number of analyses to run. A refined randomized selection of these combinations was chosen according to a D-Optimal experimental design with a large enough number of selected experiments to ensure representativeness
- The statistical analysis of the results for the real and model samples has been performed on Origin Pro 2021B (OriginLab, USA), CAT (Leardi, R., Melzi C., Polotti G., Chemometric agile software, Gruppo di chemiometria) and XLStat (Addinsoft, France)

Results

- The statistical analysis of the obtained results allowed to investigate the effects of these major components (ethanol, glucose, tartaric acid, malic acid and gallic acid) on the sugars and alcohol determinations by combined refractometric and acoustic analyses, in real and model enological samples
- The calculated models showed that interactions between different components are necessary to explain the instrumental responses to the different levels of major components
- The effects of the residual sugar and alcohol by volume (ABV) on the determination of Brix and Sonic Brix are discussed in detail

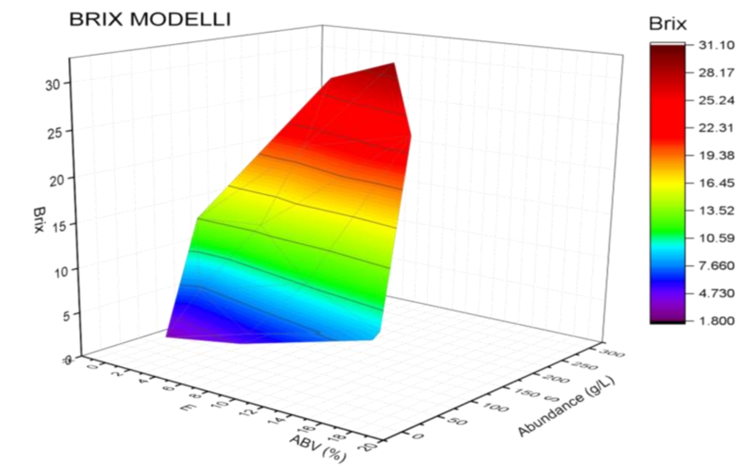


Figure 1. Brix Surface Plot for model solutions (abundance of glucose in g/L)

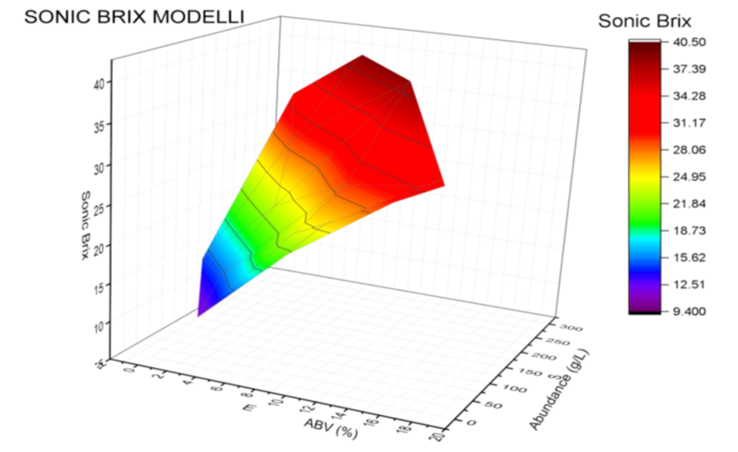
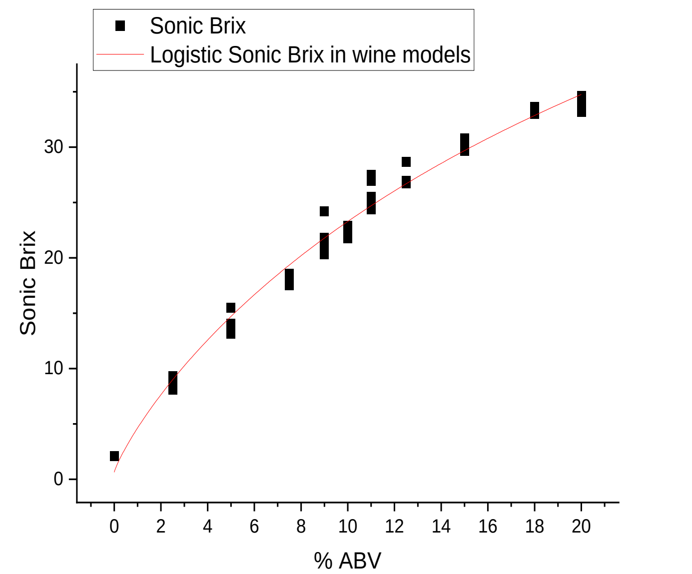


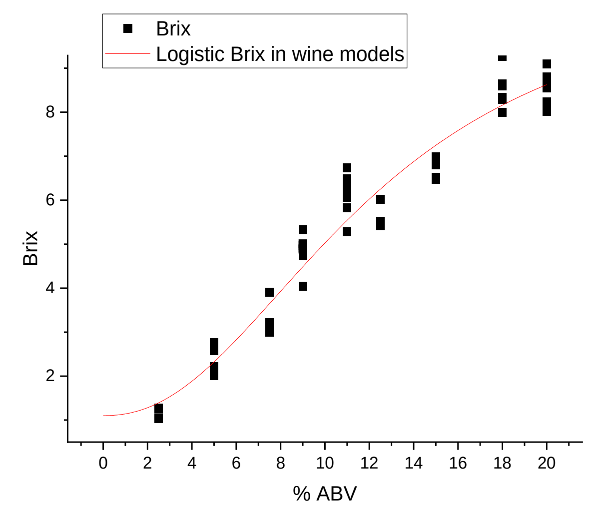
Figure 2. Sonic Brix Surface Plot for model solutions (abundance of glucose, g/L)

- The dependency on ethanol at low sugar concentrations (dry-wine models)of the refractometric and ultasonic parameters were easily modelled by analytical functions (see Figure 3-4)
- Accordingly, the dependency on glucose (as the model sugar used in this study) at low ethanol concentrations (grape must models) of the refractometric and ultrasonic parameters were easily modelled by analytical functions



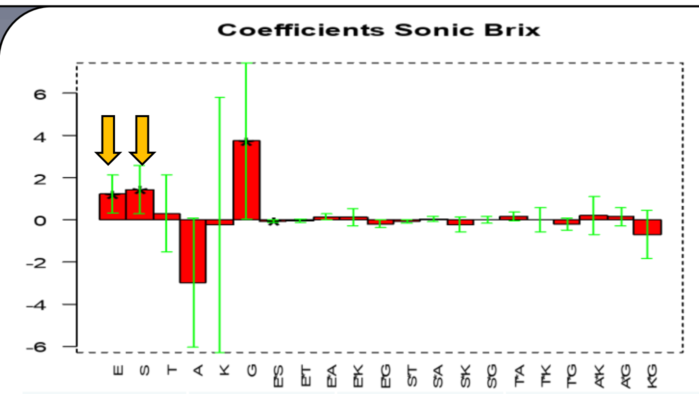
Model	Logistic
Equation	y = A2 + (A1-A2)/(1 + (x/x0)^p)
R^2	0,99
Adj. R^2	0,99
A1	0,63 ± 0,38
A2	91,27 ± 21,80
x0	36,02 ± 17,55
p	0,86 ± 0,08

Figure 3. Sonic Brix Logistic graph constructed at glucose concentration up to 5 g/l in wine models solutions



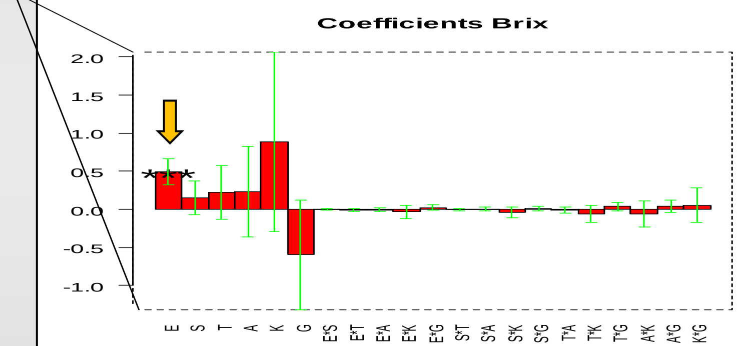
Model	Logistic
Equation	y = A2 + (A1-A2)/(1 + (x/x0)^p)
R^2	0,94
Adj. R^2	0,94
A1	1,10 ± 0,39
A2	11,17 ± 1,57
x0	12,24 ± 1,73
p	2,21 ± 0,48

Figure 4. Brix Logistic Graph constructed at glucose concentration up to 5 g/l in wine model solutions



Coeffcients	Significance of the coefficients	Coeffcients	Significance of the coefficients
b0	0,13	E*G	0.05
E (ethanol)	**0.01 ***	S*T	0.06
S (glucose)	**0.02***	S*A	0.46
T (tartaric acid)	0.69	S*K	0.17
A (malic acid)	0.05	S*G	0.84
K (KOH)	0.92	T*A	0.13
G (gallic acid)	0.04	T*K	0.97
E*S	**0.03***	T*G	0.11
E*T	0.37	A*K	0.61
E*A	0.07	A*G	0.41
E*K	0.48	K*G	0.18

Figure 5. Sonic Brix Coeffcients of wine models solutions (significant coefficients with one, two or three asterisks for p value <0.05, <0.01, <0.001, respectively)



Coeffcients	Significance of the coefficients	Coeffcients	Significance of the coefficients
b0	0,51	E*G	0,15
E(ethanol)	**0 *****	S*T	0,90
S(glucose)	0,14	S*A	0,84
T (tartaric acid)	0,18	S*K	0,24
A (malic acid)	0,38	S*G	0.39
K (KOH)	0,11	T*A	0.62
G (gallic acid)	0,09	T*K	0,21
E*S	0,58	T*G	0,14
E*T	0,30	A*K	0,43
E*A	0,69	A*G	0,25
E*K	0,34	K*G	0,57

Figure 6. Brix Coefficients of wine models solutions (significant coefficients with one, two or three asterisks for p value <0.05, <0.01, <0.001, respectively)

Conclusions

- In must or in dry wine model solution, the application of this combined technique for residual sugar and alcohol determinations could be feasible, provided that the full dependence of these refractometric and acoustic parameters on the major sample components and their interactions is well understood, and the related mathematical models validated over the widest possible range of enological samples
- For (refractometric) brix and sonic brix the factor that was most significant in the model for dry wines was ethanol. In contrast, in the must model the most significant factor was glucose

Bibliography

- Lamberti, N., Ardia, L., Albanese, D., & Di Matteo, M. (2009). An ultrasound technique for monitoring the alcoholic wine fermentation. Ultrasonics, 49(1), 94-97.
- McClements, D. J., & Gunasekaran, S. (1997). Ultrasonic characterization of foods and drinks: Principles, methods, and applications. *Critical Reviews in Food Science & Nutrition*, *37*(1), 1-46
- Leardi, R., Melzi C., Polotti G., Chemometric agile software (CAT), Gruppo di chemiometria, http://gruppochemiometria.it/index.php/software)