Abstract

Bioprocess monitoring of alcoholic wine fermentation using at-line near and mid-infrared spectroscopy

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Introduction

Alcoholic fermentation (AF) is a complex bioprocess that is influenced by several biological and physicochemical factors, of intrinsic and extrinsic nature. Many risks, including those of chemical and biological origin, are associated with this stage in winemaking and the unpredictable onset and duration of fermentation, are well known. In this presentation, the potential of at-line NIR and MIR for monitoring of AF is evaluated.

Materials and Methods

Cabernet Sauvignon and Shiraz grape juice were fermented (12 individual batches each, 25 L) at 23-28^{o}C. NIR spectra (800–2500 nm) and MIR spectra (1996–10 764 nm or 929–5011 cm^{-1}) were recorded at 12 hourly intervals. Small aliquots were also removed at 24-hourly intervals for chemical analysis, to construct PLS calibration models for prediction of important chemical parameters. The evolution of aroma compounds was also monitored by GC-FID analysis. At the observation level, multivariate batch statistical process control charts based on PCA of infrared spectra, were constructed to understand the typical spectral evolution in normal fermentation batches and to predict specific stages of "maturity" of AF, as judged on the completion of alcohol production and sugar consumption. The models obtained at batch level were also used to distinguish between good and problem fermentations that were artificially induced in some batches, by lowering the grape must pH to 2.80 prior to yeast inoculation.

Results and Discussion

The calibration statistics using NIR spectra for prediction of important fermentation parameters were: alcohol (R^2 = 0.95; RMSEP = 1.6% v/v; RPD = 5) glucose plus fructose (R^2 = 0.92; RMSEP = 6.4 g/L; RPD = 10), pH (R^2 = 0.93; RMSEP = 0.05; RPD = 4) and volatile acidity (R^2 = 0.90; RMSEP = 0.08 g/L; RPD = 4). Statistics obtained with MIR spectra were: alcohol (R^2 = 0.99, RMSEP = 0.15% v/v, RPD = 30), glucose plus fructose (R^2 = 0.99; RMSEP = 5.2 g/L; RPD = 13), pH (R^2 = 0.93; RMSEP 0.04; RPD 5) and volatile acidity (R^2 = 0.90, RMSEP = 0.07 g/L, RPD = 3). Multivariate modeling of the NIR spectra provided a graphic presentation of normal fermentation trends and problem fermentations. Specific time-points in the fermentations, for example stage of completion in terms of sugar consumption and evolution of aroma compounds could be identified. These results demonstrated the utility of using NIR and MIR spectra for qualitative monitoring of alcoholic fermentation and the PLS based models for aiding quantitative interpretation of the spectral patterns.

Conclusion

The utility of at-line NIR and MIR spectroscopy to monitor the progress and stage of completion of AF in winemaking and predict important chemical parameters was demonstrated. Abnormal fermentations could also be detected using the qualitative models.

Reference paper as:
H. Nieuwoudt (2012)Bioprocess monitoring of alcoholic and malolactic wine fermentation using on-line near and mid-infrared spectroscopy (abstract), in: Proceedings of the 15th International Conference on Near Infrared Spectroscopy, Edited by M. Manley, C.M. McGoverin, D.B. Thomas and G. Downey, Cape Town, South Africa, p. 411.