

Fast prediction of iso-alpha-acids in beer using UV-Vis spectroscopy and multivariate data analysis for inline process control

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Introduction

Up to now, there are only a few parameters which can be measured inline during beer processing. Recently developed new production technologies like high gravity brewing, late brewing or continuous brewing require the possibility to monitor and control all quality parameters inline to guarantee quality and to save money and time. Optical spectroscopy offers the possibility to qualify and quantify components on a molecular level. Besides ethanol, extract or carbon dioxide, which are already measured inline, the bitterness of beer is another important variable for characterizing the quality of beer. The common method to determine these so-called bittering units (IBU) is to measure the extinction at 275 nm from an iso-octane extract of beer [1]. These bittering units should describe the amount of iso-alpha-acids, although this method also contains all kinds of polyphenols or oxidation products from beta-acids [2] as well. A possible inline measurement of IBU is shown below.

Conclusion and Perspectives

The results show that it is possible to separate the different beer styles from the UV-Vis spectra and to determine the concentration of iso-alpha-acid with an error of ± 2 IBU – a result being comparable to the accuracy of the reference method. Especially UV-Vis spectroscopy is ideally suited for inline and online control of iso-alpha-acid because of its high precision at low costs. For a better calibration model it is necessary to minimize the influence of the different beer styles and to correlate the spectra with data from a more specific method (e.g. HPLC). A wider range of bittering units can also improve the method as a possible direct spectroscopic measurement.



[1] European Brewery Convention: Analytica EBC, Hans Carl Getränke-Fachverlag: Nurnberg, 1998, p. 125

[2] Philpott, J., Taylor, D.M. and Williams, D.R., Critical assessment of factors affecting the accuracy of the IoB Bitterness Method. J. Am. Soc. Brew. Chem., 1997, 55(3), 103–106

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Experimental Setup and Results

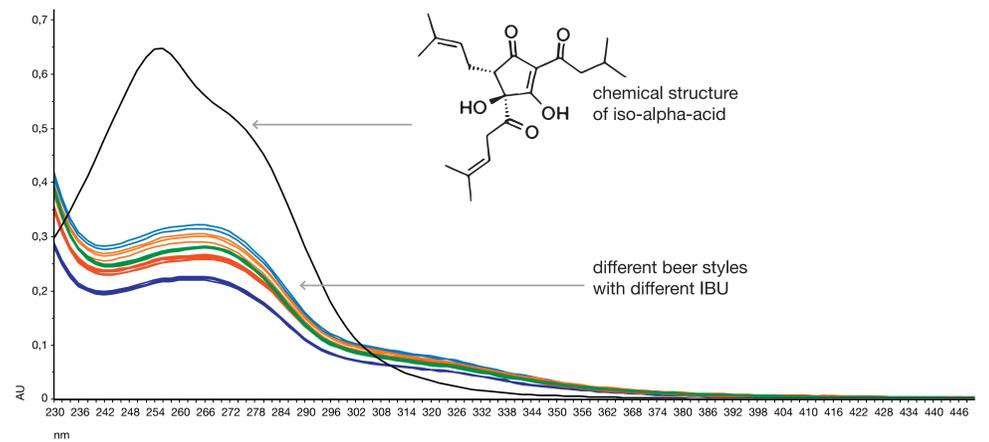


Fig. 1: UV-spectra from different beer styles with different IBUs and chemical structure of iso-alpha-acid

In order to locate and attribute the important wavelength ranges for a selective characterization on a molecular level, iso-alpha-acid extracts are diluted and measured in the UV-region between 230-450 nm (pathlength 10 mm). Different beer styles with varying amounts of iso-alpha-acid are also measured and shown in figure 1.

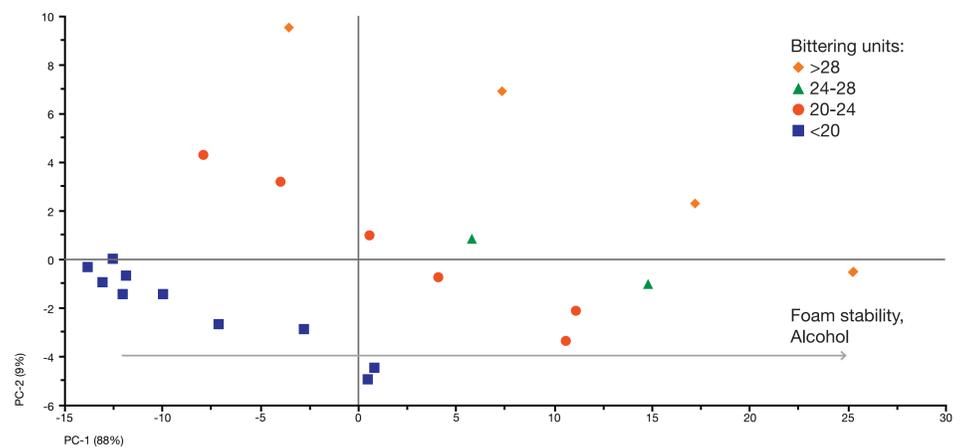


Fig. 2: Principle Component Analysis (PCA), Scores Plot with 4 different bittering categories

The principle component analysis (PCA) of the routine analysis data identifies the alcohol and foam stability as the most important information in the data (PC 1). With the bittering units and the beer colour (PC2) 97 % of the data can be explained.

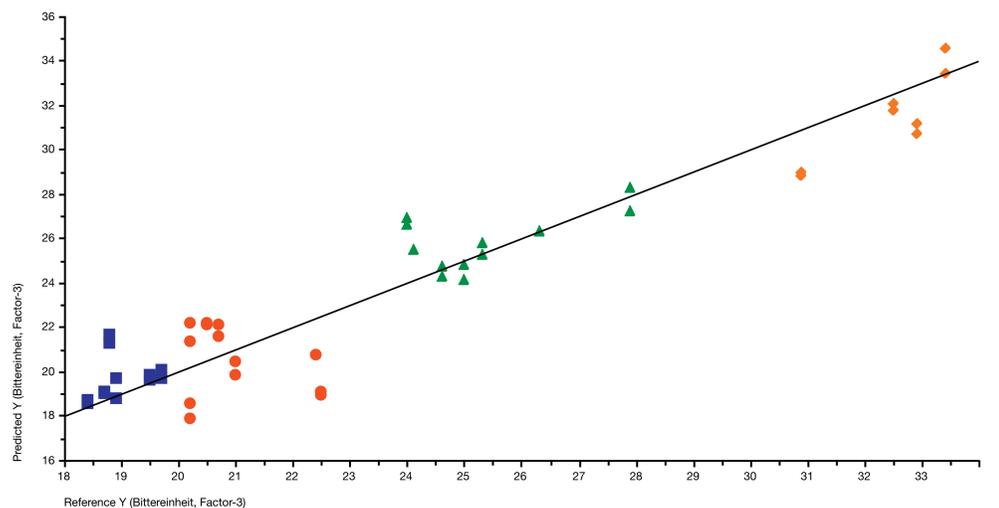


Fig. 3: Predicted vs. Referenz Regression Plot

The spectra are then correlated by means of multivariate partial least square regression (PLS-R) to the international bittering units of the beers. The calibration model is validated using an independent sample set of different beers brewed at different sites. With three factors and a $R^2=85\%$, the root mean square error of validation is ± 2 bittering units.



Fig. 4: Possible inline Analysis by Dausch Technologies

Figure 4 shows a possible inline measuring system by Dausch Technologies already in use in the soft drink industries.