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

AIM: 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 selection of the real enological samples for the study has been made 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, calculated on the R-based application CAT, 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 CAT and XLStat (Addinsoft, France). RESULTS: A statistical analysis of the obtained results allowed to investigate the effects of the major constituents on the Brix and alcohol determinations by combined refractometric and acoustic analyses, in real and model enological samples. The calculated models showed that the effects of interactions between variables/chemical components and non-linear contributions cannot be a priori ruled out in order to accurately explain the instrumental responses to the variations of these major components. As an alternative, the evaluation of separate models for more limited experimental domains (e.g. only musts, only dry wines or musts undergoing fermentation) is also discussed. The effects of the residual sugar and alcohol content on the determination of refractive and sonic Brix are discussed in detail. CONCLUSIONS: In samples collected during fermentations or in wines, 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. Some mathematical models have been proposed and discussed along with validation.

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