Precision viticulture: Assessing variability in grape ripening

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Bio

Daniel Schorn-García, Postdoctoral Researcher in Analytical Chemistry and Food Science at the Department of Analytical Chemistry and Organic Chemistry, Universitat Rovira i Virgili in Tarragona (Catalonia, Spain). His research focuses on the monitoring of grape ripening and alcoholic fermentation process, as well as other analytical approaches in grape and wine analysis.

Pedro Cabanillas, Oenologist of the experimental vineyard and Adjunct Professor at the Faculty of Oenology, Universitat Rovira i Virgili. His efforts are focused on maintaining the vineyard and supporting the research of the faculty in an interdisciplinary ambit, while teaching viticulture, oenology, and wine tasting to undergraduate students.

Barbara Giussani, Associate Professor in Analytical Chemistry and Chemometrics at the Department of Science and High Technology at the University of Insubria in Como (Italy). Her research focuses on developing chemometric and smart analytical methods to address real-world challenges using mainly mid- and near-infrared (MIR and NIR) spectroscopy with portable sensors.

Laura Aceña, Associate Professor in Analytical Chemistry at the Department of Analytical Chemistry and Organic Chemistry at the Universitat Rovira i Virgili. Her research focuses on food analysis by applying different analytical techniques such as gas chromatography (GC), GC-olfactometry (GCO), and infrared spectroscopy.

Olga Busto, Associate Professor in Analytical Chemistry at the Department of Analytical Chemistry and Organic Chemistry, Universitat Rovira i Virgili. Her research focuses on food analysis of specific group of analytes such as biogenic amines by high-performance liquid chromatography (HPLC), and the development of methods used in food fraud through spectroscopic methods.

Ricard Boqué is an Associate Professor at the Department of Analytical Chemistry and Organic Chemistry at the Universitat Rovira i Virgili in Tarragona, where he has been teaching analytical chemistry and chemometrics since 1992. His research focuses on the development and application of new multivariate calibration and classification methods, including the estimation of their uncertainty, mainly in the agri-food field.

Montserrat Mestres, Associate Professor in Analytical Chemistry at the Department of Analytical Chemistry and Organic Chemistry of Universitat Rovira i Virgili. Her research experience focuses on two main areas: the development and validation of food analysis methods, including their aromatic characterisation and food quality control by using rapid analytical techniques, and the application of the Process Analytical Technologies (PAT) approach to agri-food processes.

Further reading

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Precision viticulture

Assessing variability in grape ripening

- One of a winemaker's most difficult decisions is choosing the best time to harvest their grapes.
- Within a single vineyard, the accumulation of sugars, phenolic compounds, acids and other compounds varies among vines, bunches of fruit, and even individual grapes.
- Researchers at Universitat Rovira i Virgili, Tarragona (Spain) have developed a fast and non-destructive methodology to monitor the grape-ripening-process.
- They have also developed a quality-control-tool to help viticulturists determine which grapes are suitable for harvest based on desired characteristics.

The quality of wine depends very much on the quality of the grapes used. To achieve optimal ripeness, regular quality control is required throughout the ripening process. One of a winemaker's most difficult decisions is choosing the best time to harvest their grapes, especially as they are non-climacteric fruits. This means that grapes must remain on the vine to reach full physiological maturity. Once picked, they stop maturing and will not improve.

Sampling grapes

Oenology is the science and study of wine and winemaking. Sugar content and pH of grapes are the most common oenological parameters used to monitor the ripening process. Further information is acquired by identifying their flavour, texture, acidity, and phenolic composition (phenolic compounds, such as anthocyanins or tannins, influence the colour, taste, and feel of the grapes in the mouth).

The variability in grape ripening is due to each grape undergoing its own biochemical processes.

Sampling of fruit in a vineyard is well-established but not straightforward. Studies have shown that even within a single vineyard, the accumulation of sugars, phenolic compounds, etc, varies amongst the grapes. Such disparities are largely due to the differences in the viticultural (winegrowing) practices, eg, soil preparation, trellising, pruning vines, and treatments to fight diseases. Moreover, differences in climate and sunlight can produce different physiological responses in plants, bunches of fruit, and even individual grapes.

To make good wine you need good grapes, but how can grape quality be guaranteed when there are so many variables to consider? This quandary has led to traditional grape growing being replaced by precision viticulture. Precision viticulture involves optimising vineyard performance to maximise grape quality and yield, while minimising environmental impact and risk. It requires knowledge of each vine and its evolution as well as exhaustive sampling (selecting an adequate number of samples to ensure that the variability present in the vineyard is effectively captured) together with swift analysis of the oenological parameters – a process that is expensive both in terms of time and money.

Variability analysis and a socioeconomic factor

There is a clear need for portable and rapid analysis techniques that can be used in vineyards together with appropriate statistical treatments of the data obtained. In Spain, there is also a socioeconomic factor where the pressure on prices in the domestic market means that the price of the grape does not cover the cost of production. Research by Associate Professor Montserrat Mestres from Universitat Rovira i Virgili (URV), Tarragona (Spain), and her colleagues addresses both issues. The team have developed a portable, reliable, and fast control methodology to monitor the grape-ripening-process, allowing each type of grape to be redirected to the most suitable product.

The researchers explain how the variability in grape ripening is due to each grape undergoing its own biochemical processes. Traditional viticulturists averaged the physicochemical values of hundreds of grapes to inform their decisions. Nevertheless, accurate results can only be achieved if the different sources of variability are evaluated, so exhaustive sampling is necessary.

A portable instrument was used to analyse samples in the field.

Both the position of the grapes on vines and within bunches significantly affected their ripeness.

Grape samples were obtained from the experimental vineyard Mas dels Frares, Constantí (Spain) of the URV. The experimental cellar has a record of the evolution of each variety, including the harvest date of each vintage, and maturity controls typically start three weeks before the average harvest date. The researchers selected the 'Muscat of Alexandria' variety because it is used for both wine production and consumption as table grapes. The harvest date (7th September) was considered optimal, and 90 grapes were harvested during the ripening process with batches of 18 grapes collected at five different times during the period from 12th August to 15th September.

Reliable, fast, portable analysis

The team have developed a quick and reliable grape ripening control methodology that can process monitoring of grape ripening on site. First, they assessed the sources of variability that affects grape ripeness in terms of harvest time and relative position (top, centre, and bottom) of the grapes both on the vines and within the bunches using a portable MIR (mid-infrared) spectrometer in the form of an ATR-FTIR instrument. Attenuated total reflection (ATR) is a sampling technique that can be used with infrared spectroscopy to analyse samples without further preparation. Fourier transform infrared spectroscopy (FTIR) uses infrared light to scan samples and examine chemical properties to identify materials.

Prediction models

Then they used ANOVA–simultaneous component analysis (ASCA) to analyse the spectra and gauge the contribution of different factors including grape maturity, position on the plant, as well as position in the bunch. This enabled them to build prediction models of the key variability sources associated with grapes maturity. Results showed that maturity over time was the most significant factor affecting grape characteristics. Both the position of the grapes on vines and within bunches significantly affected their ripeness. Additionally, it is worth noting that, with the same analysis, they were able to predict the main parameters used by viticulturist to monitor grape maturity (sugar and acid levels).

Based on their findings, the researchers have developed a quality control chart to help viticulturists determine which grapes are suitable for harvest. This supports dividing the harvest across different days to optimise the quality of each harvested grape. Producers can use this tool to decide which parts of the vine will be ready to harvest at different times.

Personal response

What initially sparked your interest in oenology and viticulture?

The research group has long been attached to the Faculty of Oenology of Tarragona (Universitat Rovira i Virgili), driving a significant part of its research towards studying the composition and quality of wine and grapes.

This focus stems from the intrinsic connection that exists between these products and our territory. In fact, the Faculty is located in a highly prestigious wine-growing region that includes such recognised Protected Designations of Origin (PDO) as Priorat and Penedes (birthplace of Cava). Moreover, from an analytical chemistry point of view, oenological samples stand out for their captivating complexity and variability.

To put it differently, wines and grapes not only mirror terroir but also offer compelling subjects for analytical chemistry investigation. This dual significance has constantly motivated our research efforts to understand and improve the wine and grape qualities.

What has been the most satisfying aspect of this research?

For a researcher, the most fulfilling aspect of their work is the applicability of their findings in solving real-world problems. In our case, the challenge presented was how to support the primary sector (in this study the viticulture and oenological sector) in enhancing the value of their products. This led us to consider an unconventional approach: instead of solely targeting the optimal grape ripening point for winemaking, we explored alternative ripening stages. These stages could yield juices with specific characteristics or produce flours from grape skins and seeds for elaborating healthy snacks, among other possibilities.

Therefore, through this research, vineyard owners, who are often forced to leave grapes on the vine due to the unprofitability of harvesting, now have the opportunity to harness these grapes at an alternative optimal ripening stage, directing them towards more advantageous purposes. This opens doors to practical and innovative applications, benefiting both the industry and sustainability initiatives.

What advice would you give a young researcher who is interested in a career in analytical chemistry and food science?

Young researchers aiming for a career in Food Science and Analytical Chemistry are entering an incredibly promising field. The current societal push for innovative, nutritious, and sustainable products presents an exciting challenge. This upcoming generation of researchers will play a crucial role in creating transformative food solutions while minimising waste. This demands expertise from food science and analytical chemistry as these are disciplines essential for crafting new, sustainable, and efficiently produced foods, emphasising the necessity of continuous quality control.

In my perspective, this field is not just a career path but a long, enticing, and stimulating journey waiting to be explored. It offers an opportunity to contribute to a healthier and more sustainable world by prioritising innovation and sustainability.

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