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Researchers Use Infrared Technology to Assess Wine Quality Without Opening Bottles

New non-destructive method developed in Verona detects storage damage and cork variability, promising better quality control for the wine industry

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Researchers at the University of Verona are developing a new method to monitor wine quality inside sealed bottles using near-infrared (NIR) spectroscopy. This non-destructive technology allows scientists and industry professionals to assess the condition of wine without opening the bottle, addressing a long-standing challenge in the wine sector: the unpredictable evolution of wine after bottling.

Wine quality can change significantly during storage and transport, influenced by factors such as temperature fluctuations, exposure to light, and the permeability of cork closures. These variables are often unknown to distributors, retailers, and consumers. Traditional laboratory methods for analyzing wine require opening the bottle, which destroys the sample and makes it impossible to check every bottle intended for sale or aging.

The NIR in-bottle spectroscopy technique developed in Verona uses a broad spectrum of infrared light to scan the wine through the glass. The process involves moving the bottle during scanning to minimize interference from the glass itself. The resulting data is analyzed with advanced computational methods that interpret complex spectral patterns rather than focusing on individual chemical parameters like pH or alcohol content. This holistic approach enables detection of subtle changes related to oxidative stress, thermal damage, or photo-oxidation—issues that can compromise wine quality and longevity.

One key application of this technology is identifying differences between bottles within the same batch. Natural corks vary in their permeability to oxygen, which can lead to uneven aging and quality among bottles from a single production run. The NIR method can flag bottles that have experienced higher levels of oxygen exposure or other forms of stress, helping producers and distributors isolate non-conforming units before they reach consumers.

Preliminary results from laboratory tests show that this approach is effective in detecting bottles affected by poor storage conditions or closure variability. Researchers have successfully identified wines that suffered from excessive heat or light exposure during transport, as well as those impacted by inconsistent cork performance. These findings are particularly relevant for wines intended for long-term aging, where even

minor deviations in storage conditions can have significant effects on taste and aroma.

The research team at Verona has been working on this project for about two years, with support from industry partners such as Diam Bouchage and Vinicola Farina. These collaborations provide access to a wide range of samples and practical insights into real-world storage challenges. Ongoing doctoral research focuses on refining the technique’s ability to detect photo-oxidation and other forms of qualitative decay under various stress scenarios.

For distributors and restaurateurs, this technology offers a practical tool for quality control without sacrificing inventory. It enables rapid screening of large numbers of bottles, reducing the risk of selling wines that have deteriorated due to unknown storage issues. The process is described as efficient and cost-effective compared to traditional destructive testing methods.

The adoption of NIR in-bottle spectroscopy could mark a significant shift in how the wine industry manages quality assurance and traceability. By providing detailed information about each bottle’s history and current state, it helps bridge the information gap between producers and end-users. This innovation supports better decision-making for wines destined for aging or premium markets, where consistency and provenance are critical.

While further validation is underway, early data suggest that non-destructive NIR analysis has strong potential to improve batch uniformity, reduce product recalls, and enhance consumer confidence in aged wines. As research continues, industry stakeholders are watching closely to see how this technology might be integrated into standard quality control practices across global wine markets.