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Measurement Uncertainty as a Criterion for Analytical Method Selection in Quality Assurance Systems*

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Abstract

The accurate determination of sulfur dioxide (SO_2) content in wine is critical for compliance with regulatory limits, preservation of sensory quality, and consumer health protection. This study compares two analytical methods – the aeration-oxidation (AO) reference method and a modern spectrophotometric method – for quantifying total SO_2 content in red wines. The primary focus is the evaluation of each method's measurement uncertainty as a decisive factor in method selection for routine quality assurance.

The research design involved method validation across a concentration range of 10–200 mg/L, corresponding to regulatory thresholds. Measurement uncertainty was assessed by identifying and quantifying key sources of variability, including reagent dosing, repeatability, and instrumental performance. Statistical tools such as linear regression, Hartley's Fmax test, and confidence interval analysis were used to evaluate method accuracy and bias.

Findings indicate that while the AO method provides high accuracy, it is susceptible to systematic error due to equipment limitations and is less efficient in routine settings. In contrast, the spectrophotometric method offers superior repeatability and speed, with measurement uncertainty comparable to the reference method. Regression analysis confirmed the statistical equivalence of both methods within the tested range.

The study underscores the role of uncertainty estimation in method selection, advocating for the spectrophotometric approach in routine laboratory operations where speed and automation are priorities. However, the AO method remains essential for official controls and regulatory reporting. These findings contribute to improved analytical reliability in oenological quality control systems.

Keywords: Measurement Uncertainty, Sulfur Dioxide Determination, Analytical Method Validation

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