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Miniature Spectrometers Track Brewing in Real Time

A Chinese study found that portable near-infrared devices can accurately measure wort during mashing, potentially reducing lab testing.

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A new study from China suggests that miniature near-infrared spectrometers can monitor key wort measurements during industrial mashing in real time, a development that could help breweries catch process problems earlier and reduce the need for lab testing.

The research, published May 6 in Discover Chemistry by Springer Nature, tested three portable NIR devices on wort samples collected during commercial brewing at Beijing Yanjing Brewery Co. The instruments were used to estimate original gravity, maltose and free amino nitrogen, or FAN, three measurements that help determine how efficiently mash is converting grain into fermentable material and how the beer will ultimately taste and ferment.

The study found that the best-performing instrument, a Fourier transform NIR system, produced highly accurate models for all three targets. According to the paper, the coefficient of determination exceeded 0.99 for original gravity and maltose and was above 0.90 for FAN when the researchers used multivariate calibration methods. Prediction errors were low enough to suggest that the technique could be used on-site during production rather than only in a laboratory.

Original gravity is one of the main indicators of how much dissolved material is present in wort and helps determine alcohol content and body in finished beer. Maltose is a major fermentable sugar, while FAN is an important nutrient for yeast health and fermentation performance. Brewers typically measure these values with separate laboratory methods that take time and require sample preparation.

The authors said that real-time monitoring could help breweries respond faster to changes in raw materials, temperature or mash timing. If maltose levels are too low, for example, brewers could extend the mash or adjust temperature. If FAN is insufficient, they could alter protein rest conditions or make other process changes before the batch moves forward.

Near-infrared spectroscopy has long been used in food and beverage analysis because it is fast and non-destructive. But applying it to wort during mashing is difficult because wort contains more than 90% water, which creates strong absorption bands that can mask weaker signals from sugars and nitrogen compounds. To address that problem, the researchers used preprocessing methods such as standard normal variate correction and multiplicative scatter correction, along with statistical models including partial least squares regression and support vector regression.

The study compared three compact systems with different optical designs: a Bruker Matrix-F Fourier transform spectrometer, a JDSU MicroNIR linear variable filter device and an Axsun XL410 MEMS-based spectrometer. Each was tested under industrial conditions using wort samples taken during the enzymatic phase of mashing, when saccharification is most active.

The paper said the FT-NIR system delivered the strongest overall performance because of its higher signal-to-noise ratio and broader spectral range. The smaller handheld systems were less powerful but still showed promise for plant-floor use because they were compact and easier to integrate into production lines.

The researchers also noted practical issues that matter in breweries, including vibration, temperature changes and differences between batches of raw materials. They said those factors can affect spectral readings and may require model updates over time if the technology is deployed at scale.

For breweries facing pressure to improve consistency while controlling costs, the appeal of such systems is straightforward: faster decisions, fewer off-spec batches and less reliance on routine lab work. The study said that on-site NIR monitoring could lower analysis costs while giving brewers a clearer view of what is happening inside the mash tun as it happens.