How discrete wet chemical analysis is bringing flexible, cost-effective multiparameter testing to the beverage industry

Deck: Multiparameter beverage analysis with discrete analyzer technology ensures high product quality and throughput, while reducing cost, waste and hands-on sample time. This approach is used with great success in Montana State University's Barley, Malt & Brewing Quality Lab, USA, which performs integrated malt testing with the Thermo Scientific™ Gallery™ discrete analyzer.

Introduction

When producing any type of product, quality and consistency are key—and nowhere is this more true than in the beverage industry. From testing water at the point of entry to assessing batches of end product, screening for potential performance issues to ensure a consistent, high-quality outcome is essential across all stages of production.

Traditional methods of wet chemical analysis test for various parameters using continuous flow technology. Parameters range from those affecting taste and color to those impacting product development and stability, and each plays a crucial role in quality assurance (QA). But such techniques can be labor intensive and time-consuming. Testing for more than one parameter with traditional wet chemical analysis requires multiple techniques, instruments and highly skilled operators, adding time, cost and complexity to the beverage production process.

However, innovative discrete analyzers offer a different approach: one that is automated, streamlined and more cost-effective. The benefits of such technology were discussed in a SelectScience webinar exploring the application of the Thermo Scientific Gallery discrete analyzer at Montana State University's Barley, Malt & Brewing Quality Lab, USA. This summary provides an overview of how and why the laboratory uses the Gallery discrete analyzer for testing, and reveals how it has enabled consistency, compliance and quality, and expanded their analytical capabilities.

The importance of beverage testing

Analysis is essential throughout the entire beverage production process for numerous reasons, the most notable being financial, customer-related and regulatory. Testing is central to QA, minimizes the risk of batch failures, and ensures consistency (both for processes across the production cycle and in the end product). By implementing beverage testing across their workflows, manufacturers can guarantee every batch of their product looks and tastes the same, and satisfies all required regulation in terms of label claims and legal limits. Testing prevents financial and material loss, improves profitability, assures compliance, and protects product authenticity, helping beverage producers and brewers to not only retain their customer base, but expand it.

Tests cover a diverse range of parameters that influence an equally diverse range of product characteristics. The quality and consistency of numerous attributes, from color to mouthfeel to stability, relies upon beverage testing, with different product types being subjected to different tests.

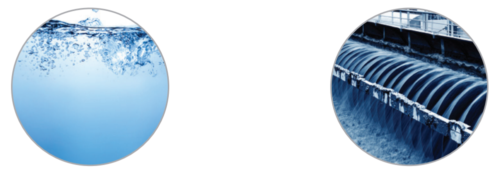
Fruit juice	Wine	Beer
pH, calcium, magnesium, sugars, organic acids, total acidity		
	Ammonia, alpha-amino nitrogen (NOPA), ethanol, free and total SO_2, impurities	
		β-glucan, α-amylase, bitterness

Key parameters in fruit juice, wine and beer testing

From point-of-entry (POE) to waste water

As the entire beverage production process begins and ends with water, testing is necessary not just across raw materials, samples and final products, but for all water that enters and leaves production workflows.

The composition and properties of POE water can affect product taste, color and salinity, and cause corrosion of instrumentation (acidity), scaling and deposition (hardness), and varying energy efficiency. Waste water analysis is necessary to ensure regulatory compliance and facilitate environmental monitoring. It also brings efficiency by ensuring that water has been appropriately treated to be reused within the production process (as cooling or raw water, for example), or for other purposes, such as biogas production (thereby also reducing overall discharge).



POE	Waste water
pH, conductivity, alkalinity, hardness	
Iron, calcium, magnesium	Nutrients (ammonia, nitrite, Total Kjeldahl Nitrogen (TKO), Total Oxidizable Nitrogen (TON), phosphate, total phosphate), organic acids

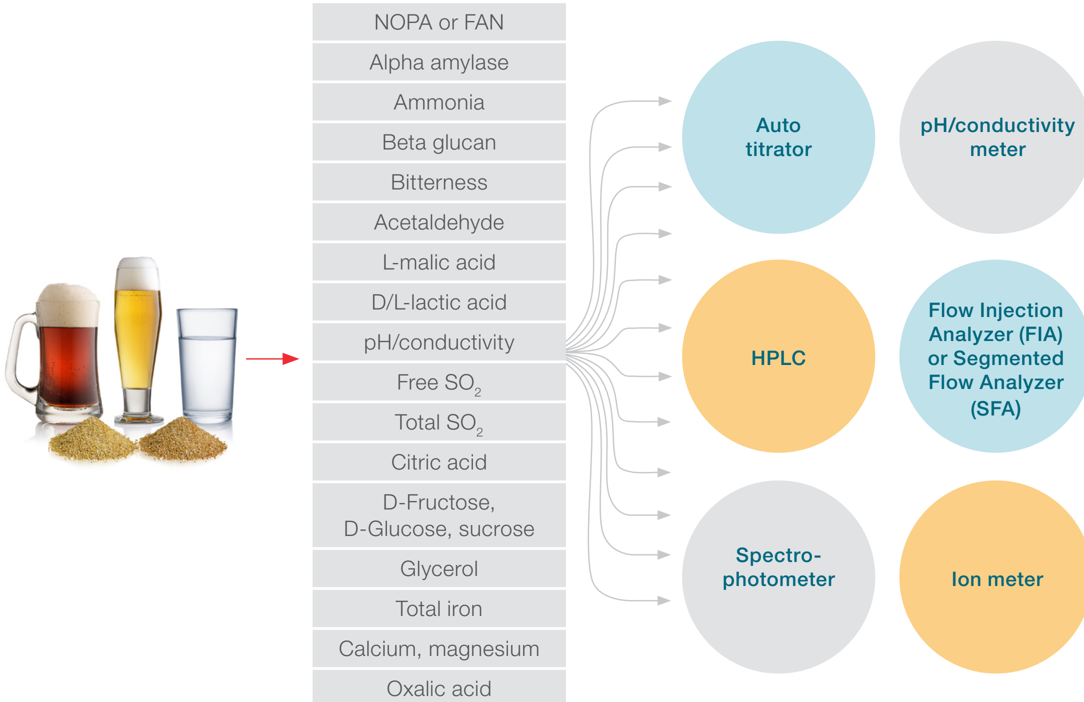
Key parameters in water testing

Traditional methods of wet chemical analysis

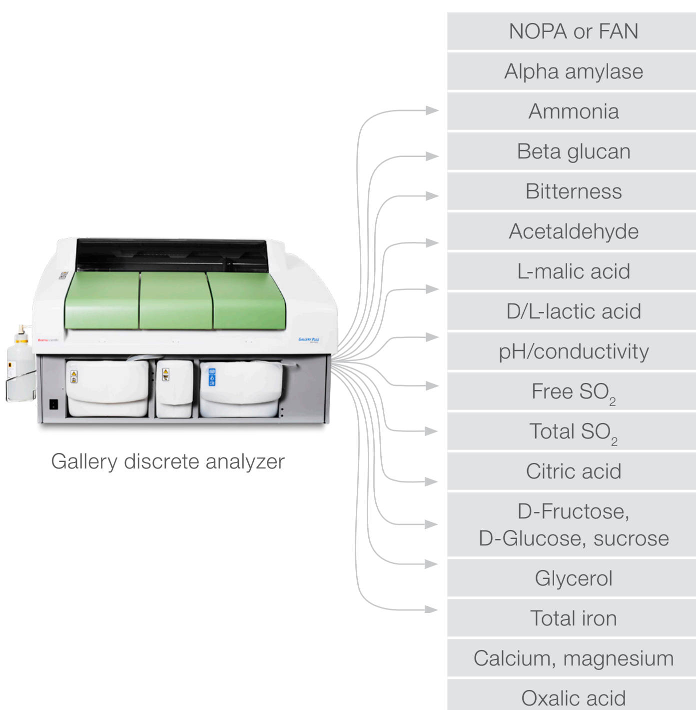
Traditional testing procedures use wet chemical analysis based on continuous flow technology: flow injection and segmented flow analyzers. These rely upon visual detection methods using liquid samples. While some such analyzers offer automated means of analysis, they use large amounts of samples and reagent, generating copious amounts of waste, and are inflexible when it comes to adding tests to a laboratory's analytical capabilities.

Additionally, common wet chemical methods are only applicable to specific individual parameters. Testing for multiple parameters, therefore, requires multiple techniques and instruments, resulting in long hands-on sample and response times, reduced throughput and increased per-analysis costs. What's more, significant investment in ongoing staff training and instrument maintenance is also required.

Why operate multiple analyzers, when you can do all your essential testing with one?



Multiple parameters – multiple instruments



Gallery discrete analyzer

Single instrument – multiple parameters

Consolidated testing via integrated multiparameter analysis

Consolidated multiparameter discrete analysis now offers a solution to these difficulties. A leading example of such a platform is the Gallery discrete analyzer, which consolidates and simultaneously tests for up to 20 parameters — using a single instrument with a single operator. It is a fully integrated walkaway solution: the testing workflow is easy to learn, and can be left unattended, improving throughput, system uptime and staff productivity. While traditional analysis requires multiple wet chemistry methods and, therefore, multiple samples, the Gallery discrete analyzer consumes a maximum of 300 µL of sample per test, can test for up to 20 parameters per sample, and runs up to 200 tests per hour. As a result, the cost per analysis is 10 to 20 times less than traditional wet chemistry methods.

Barley testing with the Gallery discrete analyzer

Established in 2016, the MSU Barley, Malt & Brewing Quality Lab is able to fully malt and test their barley in-house and provides testing services externally, while also performing barley breeding and genetics analysis. In order to meet regulatory requirements, facilitate a successful malting process and brewing conversion, ensure product consistency and minimize potential shelf life issues, the laboratory tests for over a dozen critical parameters in barley and malt analysis: pre-harvest sprout damage, fusarium (DON) infection, enzymatic capacity (α-amylase, diastatic power), protein degradation (soluble protein, free amino nitrogen), cell wall breakdown (β-glucan), color, pH, sugars, and other wort components. Beer is subsequently tested for parameters, including pH, organic acids, bitterness and impurities as shown above.

To complete these numerous complex tests, the laboratory uses the Gallery discrete analyzer. This analyzer has a high correlation to industry standard analyzers, but with reduced set-up time, required sample size and reagent volume. The workflow is robust with good repeatability, low cost of entry, and, being an open system, high flexibility for improvisation—something that the laboratory highlights as a key benefit.

Photo courtesy of Montana State University's Barley, Malt & Brewing Quality Lab, USA

Setup and typical workflow at MSU

MSU utilizes the Gallery discrete analyzer, giving capacity for six racks for reagent and sample storage (each sample rack holds 18 samples, while each reagent rack can hold six reagents). The analyzer is run at a temperature of 37 °C and covers 12 wavelengths ranging from 340 to 880 nm. Typically, 32 samples are run per day.

Typical workflow at MSU

Prepare reagents	10-15 min.*
Load standards	~1 min.
Load reagents	~1 min.
Run calibration	~1 hr. for 4 parameters
Freedom to do sample prep during calibrations	
Daily analysis and reference samples	~1.5 hr.

* Thermo Fisher Scientific offers ready-to-use reagents that speed up the process further, with good stability and traceability.

Applying discrete testing to critical process parameters

The laboratory uses the Gallery discrete analyzer to perform process critical parameter tests, including diastatic power, α-amylase, free amino nitrogen (FAN) and β-glucan.

Diastatic power

- Evaluation of a wort's ability to produce small fermentable sugars
- Before the laboratory purchased the Gallery discrete analyzer, this test was the biggest concern, as the process was delicate and had many disparate parts — but the analyzer brought a robust, streamlined workflow
- Reagents: 1% starch, a-glucosidase, buffered NADP+/ADP, HK/G-6PHDH
- Detection wavelength: 340 nm
- Improvisation: Optimized/standardized reagent mixes and methods, incorporated internal standard dilutions for the daily calibration curve
- Typical measures: Mean of 132 °ASBC, standard deviation of 4.65, range of 121 to 141 °ASBC. Gallery coefficient for DP calibration curve: 0.9977.

α-amylase

- Evaluation of a wort's enzymatic capacity for rapid conversion of starches to sugar
- Reagents: Starch substrate, 0.5% NaCl, iodine
- Detection wavelength: 660 nm

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- Improvisation: Optimized/standardized reagent mixes and methods, expanded and added points to calibration curve, currently working to establish substrate mixture that needs less frequent mixing
- Typical measures: Mean of 66 DU, standard deviation of 3.24, range of 60 to 72 DU. Gallery coefficient for DP calibration curve: 0.9984.

FAN

- Evaluation of FAN levels by NOPA method: FAN offers nutritional value to yeast and ensures fermentation proceeds readily, but too much can negatively impact beer staling and stability
- Reagents: Buffered N-Acetyl-L-Cysteine (NAC), o-Pthaldialdehyde (OPA)
- Detection wavelength: 340 nm
- Improvisation: Stabilized daily calibration via incorporation of consistent sampling
- Typical measures: Mean of 167 mg/L, standard deviation of 3.89, range of 160-174 mg/L. Gallery coefficient for DP calibration curve: 0.9977.

β-glucan

- Evaluation of barley cell wall degradation: low-modification malts have high β-glucan, which can bring process and viscosity issues in the brewhouse
- Reagents: Buffer, calcofluor
- Detection wavelength: 405 nm
- Improvisation: Expansion of daily curve to better fit high variability of breeding material, introduction of manual results acceptance
- Typical measures: Mean of 103 ppm, standard deviation of 12.4, range of 83 to 123 ppm. Gallery coefficient for DP calibration curve: 0.9999.

The benefits of discrete malt characterization

All of MSU's results are highly consistent—something that is supported by the laboratory's best practices for consistency. Worts are pulled for analysis at consistent times (1-hour filtration), and homogenous malt is used for daily quality control. Material is stored consistently to maintain moisture and other characteristics, results are carefully logged and tracked, and the laboratory avoids altering too many variables or practices at one time.

Overall, the laboratory sees flexibility as the biggest benefit of the Gallery discrete analyzer. It allows them to adjust and optimize their existing processing via improvisation, while also bringing in other tests they wish to fit into their system setup [specific wort and barley testing, for example, such as testing for soluble protein and fusarium (DON) infection]. This flexibility also aids their breeding program, as small sample sizes, common for new barleys, can be run on the Galley discrete analyzer, allowing micro and pico malting.

Conclusion

It is imperative that beverage producers use the best analytical tools to ensure their products are of the highest and most consistent quality, and their laboratory is running most effectively. The Gallery discrete analyzer offers capabilities and benefits that are essential across the beverage industry — and, more specifically, for malt and barley testing as part of the brewing and beer production process. The analyzer offers higher throughput with very low reagent and sample consumption, reducing waste and costs. While comparable segmented flow analyzers require purchase of a base model and then additional modules per desired test, and are inflexible to new chemistries and applications, the Thermo Scientific Gallery discrete analyzer is an all-in-one solution. As demonstrated at MSU's Barley, Malt & Brewing Quality Lab, the analyzer's flexibility and versatility enables laboratories to expand their in-house analytical abilities, ensure quality and consistency, and increase profitability and performance.

References

1. SelectScience webinar: https://glc2.workcast.com/clusterSVCFS1/NAS/OnDemand/10275/3042811165320781/Media/10275_20200330235758975_30march2020_selectscience_od_mp4.mp4

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