Filtration and analytical testing in brewing

cytiva

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Introduction

Beer is more popular today than ever, produced around the world by microbreweries, industrial scale breweries, and even home-based hobbyists.

Commercial brewers need to provide a safe product in compliance with national regulations, as well as meet customer expectations for quality, taste and beer characteristics. A large range of analytical methods are used to monitor the brewing process and to achieve consistency in the characteristics of each particular brand.

This e-book introduces the key analytical applications used throughout the brewing process and the types of filter most suited to each application. Applications and filter recommendations are based on scientific analytical methods written by key professional organizations that are associated with regulation of the brewing industry globally.

Analytical testing methods for safety and quality control (QC) used by the brewing industry are published by a number of national and international bodies. The organizations referenced in this e-book are:

- The European Brewery Convention (EBC)
- Mitteleuropäische Brautechnische Analysenkommission (MEBAK™)
- The American Society of Brewing Chemists (ASBC)

Filtration in brewing and beer safety tests

Filtration-based tests are central to any brewer's quality control processes. They help microbreweries make sure their unique-tasting craft beers offer a great drinking experience, and enable macro breweries to produce and supply a safe and consistent product across a global market.

These tests are also essential for meeting guidelines laid down by the various regional industry bodies, such as EBC, MEBAK, and ASBC. However, not all tests apply to all sizes of brewery.

Divided into the categories of safety and quality, beer safety tests aim to ensure the product, be it a locally brewed, limited run craft beer or a globally-recognized brand, is safe for consumption. As long as their products meet these safety standards, this is the extent to which microbreweries tend to perform filtration-dependent analytical tests.

Macro breweries are expected to provide a consistent looking and tasting product everywhere it is sold. As such, they perform additional tests at various stages of the beer brewing process (Fig 1) to help ensure their products provide a consistent experience, and meet additional industry regulations.

As microbreweries scale up production, or are acquired by larger breweries, these additional tests become more relevant for them. Filtration and filtration products have essential roles in both the safety and quality tests, including the collection, preparation, incubation, and analysis of samples.

Find the optimal filter for beer brewing analytical tests with the Whatman filter selector

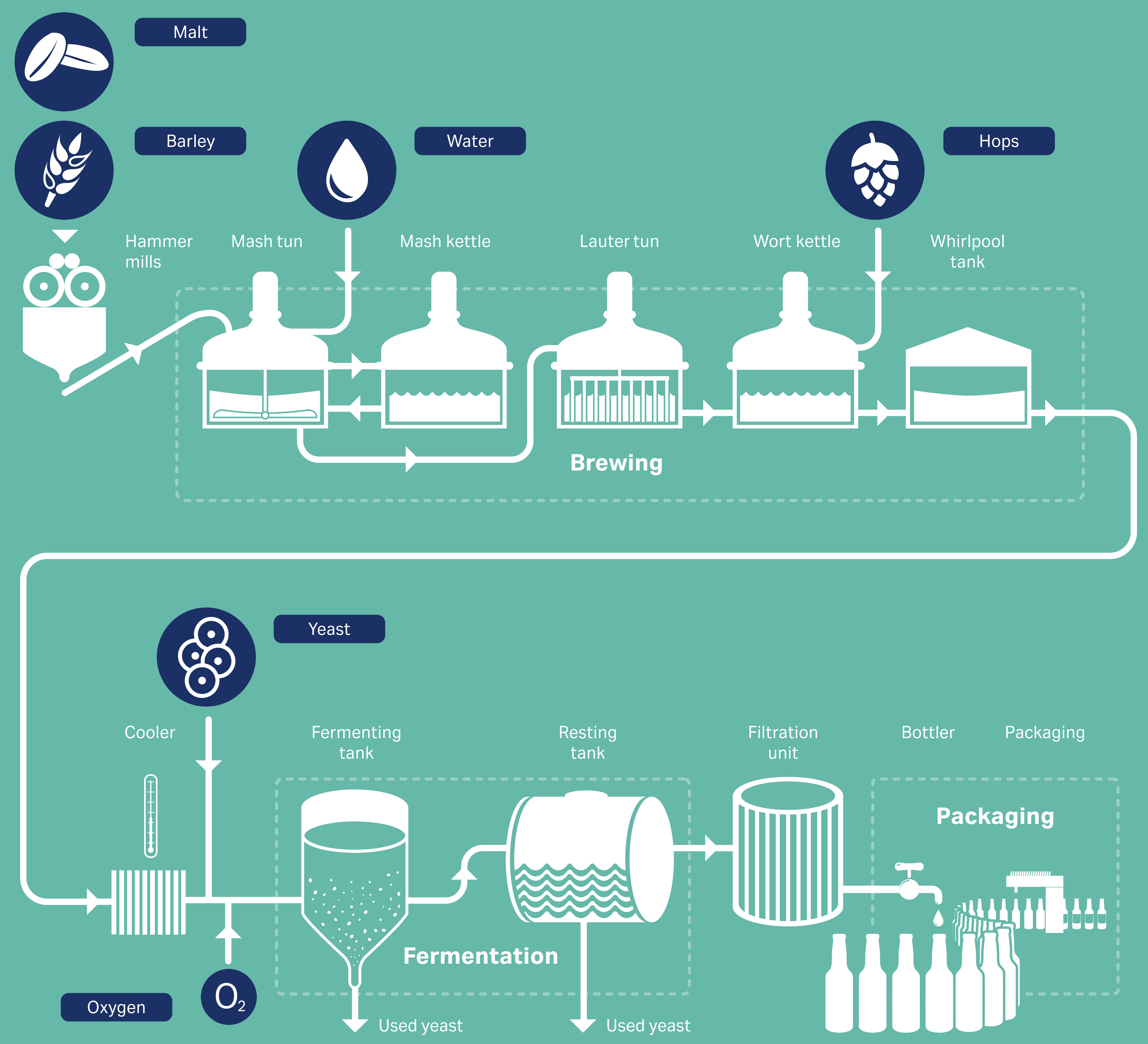

Fig 1. Beer brewing workflow with key steps and ingredients highlighted.

Microbreweries vs macro breweries: a difference in scale

Craft and microbreweries tend to form around the discovery of a unique tasting brew, which the brewers then aim to sell to a small, often local, customer base. Usually they produce less than 15 000 barrels of beer a year.

Macro breweries operate on a different scale. For example, in 2017, Heineken sold more than 8.5 million barrels of beer in the United States alone. It produces beers that are nationally and internationally recognized brands, and often the reason the customer is buying their branded beer is the expectation of consistency.

Microbrewery acquisitions: challenges of a larger market

There is a growing trend of macro breweries acquiring microbreweries. In some cases, the microbrewery might continue operating largely independently and supplying to the same sized market. In other cases. the acquisition can result in the parent company scaling up the craft beer production for a larger market. A microbrewery might also scale itself up to supply a larger market.

In these cases, the inherent variability of a craft beer becomes less desirable from a commercial point of view. As the beer becomes available to a wider market, an expectation of consistent appearance and taste builds. To meet these expectations, the breweries will expand their range of filtration-based quality control tests to include analysis of the ingredients, as well as the product color, taste, and composition.

Performing these tests at various stages, including malt preparation, wort boiling, fermentation, filtration, and bottling makes sure the brewing process is producing a consistent product. Where there are unwanted variations, the production can be brought back on track with adjustments.

Essential beer filtration tests for breweries

All breweries, large and small, must meet a basic standard in their beers, not just from a regulatory standpoint, but also for long-term commercial viability. Consumers might or might not expect a specific beer to look and taste the same everywhere they go, but they do expect the beer to be safe and pleasurable to drink.

Three of the key testing procedures that rely on lab filtration are: general clarification and degassing, alcohol testing, and microbiological tests.

General clarification and degassing of beer samples

Clarification and degassing support accurate color analysis and help protect brewing equipment from clogging and damage by particulates. Passing a beer or wort sample through filter paper removes particulates, such as yeast, as well as gases, such as CO_2, that could distort color and other measurements.

This is a critical step in the preparation of wort and beer, and in making sure downstream tests are as accurate as possible. For example, the CO_2 produced during the fermentation process dissolves into the beer or wort and so can lead to inaccuracies in the total acid determination test.

The recommended method to address this challenge is to simply let a sample flow through an appropriate cellulose filter, such as Whatman Grade 2V fluted filter paper for ASBC method Beer-1B.

Alternative methods of clarification and degassing include:

- Membrane vacuum filtration using cellulose nitrate membrane circles.
- Use of filtration devices for high particulate samples, such as the Whatman GD/X.

Alcohol content tests to meet regulations and taxation laws

Required for all levels of brewing, alcohol tests determine the strength of a beer as well as the fermentation rate. Having this information available is essential for complying with regulations and, in some countries, alcohol taxation laws.

These taxation laws are an interesting challenge for brewers as rules vary from country to country, sometimes with a different rate of tax applied to different percentages of alcohol by volume (ABV). To avoid unintentionally producing a product that might be taxed at a higher rate, brewers have the option to monitor alcohol percentage throughout the brewing process, adjusting processes as necessary to meet a target ABV. There are several options for alcohol tests, including near infrared spectroscopy and gas chromatography.

Filtration plays a key part in these tests. In Beer-4C, one of the methods recommended by the ASBC for measuring alcohol content, any turbidity might distort the perceived density of the beer. This would result in a higher apparent ABV percentage than desired, potentially leading to an unnecessary adjustment to reduce it.

Centrifuging the sample, or simply passing it through a fluted filter paper negates this risk.

Microbiological tests for beer safety

The hops used in the production of beer have antimicrobial properties, however, some species of bacteria can still grow and spoil the flavor and appearance. The ASBC provides several methods for assessing microbiological spoilage, including Microbiological-1D, 2B, 2C, and 5.

In all these methods, beer or wort samples can be collected at different stages of the brewing process and vacuum membrane filtered to retain any microbes. The samples can then be added to a growth plate and placed in anaerobic conditions to assess the level of contamination.

As the key brewery microorganisms, *lactobacillus* and *pediococcus*, grow as white- and cream-colored colonies, black membrane filters with white gridlines, such as Whatman ME (mixed cellulose ester) membranes, provide good contrast for assessment of other, non-brewery, microbial species.

Filtration tests for batch-to-batch brewing consistency

Color determination test for beer quality control

The color of a branded beer is part of the beer's identity. If the color varies, consumers might question the quality and provenance of the beer or lose faith in the brand.

A color determination test might be performed at different stages of the brewing process. Methods, such as MEBAK 2.12.1, require clarification by membrane vacuum filtration or gravimetrically with glass fiber filters. This clarifies the sample, enabling the analyst to make a truer assessment of color.

Perform efficient and effective clarification of large sample volumes gravimetrically with Whatman 934-AH™ Glass Microfiber filters

Tests for factors influencing taste

There are several sources of influence on taste in the beer brewing process, including:

- water composition
- acidity
- build-up of sulfur compounds

Beer is mostly water: a 5% ABV beer typically contains 93% water. Differences in ions, dissolved minerals compounds, and trace metals composing the water used in production can have a substantial influence on the final taste of the beer. So, analyzing water composition becomes, not a regulatory need, but a commercial one to maintain consistency between brewery sites in different geographic locations.

Ion chromatography methods for analyzing water composition include ASBC Beer-43 and MEBAK 2.22.1. These methods require clarification through nylon membranes and prefiltering of the wort and beer samples. Given the sensitivity of ion chromatography, accurate analysis requires that prefiltering devices have low levels of anion leaching to avoid influencing the data.

Prefilter clarified ion chromatography samples with Whatman Anotop™ IC syringe filters

Another key component in the taste of beer is bitterness, measured in International Bitterness Units (IBU), and determined by the concentration of α-acids, β-acids, and isomerized versions of these acids in hops. The α-acids—humulone and cohumulone—come from hops and are isomerized during the boiling process to produce iso- β-acids, which are responsible for the bitterness in beer.

Like water composition tests, bitterness tests are essential for the brewer to obtain and maintain the desired taste of the beer between batches and breweries. These tests help identify the optimum quantity of hops, boiling time, and additives for each batch.

High-performance liquid chromatography (HPLC) is the preferred method of analyzing α-acids. This method benefits from a clean, particulate-free mobile phase to both maximize accuracy of analysis and minimize risk of damage to the chromatography column.

However, unlike clarification steps in other methods where a simple paper filter is sufficient, there are several options for membrane material and filter device, depended on the properties of the sample. There are some general rules for filter choice:

- **Polar (hydrophilic) solvent:** Use a hydrophilic membrane filter device, such as a Whatman Puradisc syringe filter with nylon membrane.
- **Non-polar (hydrophobic) solvent:** Use a hydrophobic membrane filter device, such as a Whatman Puradisc filter with polytetrafluoroethylene (PTFE) membrane.
- **High-particulate sample:** Use a filter device containing an appropriate membrane and glass fiber prefilter, such as Whatman GD/X devices.
- **Difficult to handle samples (e.g. hot wort):** Use preassembled syringeless filters with an appropriate membrane and prefilter stack, such as a Whatman Autovial™.

Lastly, sulfur compounds, such as sulfur dioxide and dimethyl sulfide (DMS) can build up throughout the brewing process, acting as antioxidants, but also resulting in off-flavors. Sulphur dioxide is a by-product of yeast, produced when under stress, and detected by UV/Vis spectroscopy, while DMS is produced as a result of heating wort, and detected by head space gas chromatography.

Tests for both sulfur compounds, such as ASBC Malt-11 and Beer-23B, require degassing and clarification of the sample with an appropriate cellulose filter paper, such as Whatman Grade 2V fluted filter paper.

Beer quality control tests

Any slip in quality can be very costly for popular national and international beer brands. To maintain standards, macro breweries monitor several quality indicators, including:

- barley germination
- carbohydrate levels
- organic and inorganic nitrogen
- protein levels

As one of the main constituents of beer and its preparation being the first step in the brewing process, barley has a substantial impact on the quality of the final product.

Together with water, barley forms the malt. Given that mid-sized and macro breweries might source barley from many different suppliers throughout their network of breweries, testing it to make sure it meets the desired standard is essential for the sites to produce a consistent product.

Germinative energy tests can tell the brewer about the barley's growth environment and whether it has been stored properly since harvest. These tests measure the ability of the barley to germinate. Following the ASBC Barley-3 method, the tests involve placing dry barley kernels onto moistened cellulose filter paper and measuring how they respond to optimal growth conditions over several days.

The fermentation step, which is further along the brewing process, is another point for quality control.

Carbohydrate fermentation has a strong bearing on the final beer quality. Before the sugars and carbohydrates can be analyzed by a conventional carbohydrate test by HPLC, as specified by ASBC methods Sugars and Syrups-18 and Wort-22, the sample must be degassed, clarified, and pre-filtered with appropriate cellulose filter papers and membrane filters.

Efficient yeast metabolism during fermentation requires appropriate levels of nitrogen and protein, and so those levels are central to the quality of a beer. Nitrogen and protein levels also influence the shelf life of the final beer product, the feel of the beer in the mouth, and the foam stability.

Kjeldahl analysis can measure nitrogen in both organic substances, such as proteins, and inorganic compounds, such as ammonia and ammonium. The method requires specialty filters and weighing boats with low nitrogen content to avoid any influence on the results.

Use Whatman GD/X syringe filters to prefilter and degass highly particulated samples prior to analysis

Brewery waste management

One factor that is not necessarily considered for quality control, but is equally essential for macro breweries to test, is wastewater, or effluent.

Craft breweries use an average of three pints of water for every pint of beer produced. For macro breweries, this can increase up to seven pints for every pint of beer produced.

The regulations regarding wastewater management vary from country to country, but are largely based around those from the European Committee for Standardization (CEN) or United States Environmental Protection Agency (EPA). Local authorities might require breweries to treat their wastewater or pay fees to cover the extra costs involved in managing the wastewater at local water treatment plants.

The wastewater from breweries can contain high levels of suspended solids, which can be damaging to local ecosystems. These suspended solids usually consist of the remains of yeast, hops, grains, and sugars. Given the volume of wastewater they produce, mid-sized and macro breweries have a responsibility to monitor suspended solids.

The total solid (TS) content of wastewater is measured by the mass loss of total suspended solids (TSS) using methods based on CEN EN 872 and EPA 2540 D standards. Filtration plays a key part in these methods, relying on glass fiber filters that offer fine particle retention with good flow rate and capacity.

Whatman Grade™ RTU and Whatman Grade 934-AH RTU glass fiber filters are each designed to meet the CEN and EPA standards respectively while saving time in otherwise quite involved preparation steps for wastewater analysis.

Expanding responsibilities for testing with brewery size

Craft beer manufacturers embrace their unique and variable product while they are still microbreweries. This also means they only have a responsibility to make sure their products are safe for consumption, and need not concern themselves with maintaining consistent color and taste between batches.

As these microbreweries scale up production, or are acquired by mid-sized and macro breweries, they gain additional responsibilities for testing their products. Their larger market will have an expectation of quality and consistency in appearance and taste.

An argument could be made that, if a craft beer comes under such control it is no longer a craft beer. However, the growing trend is towards expansion, and so, producing a consistent product across multiple breweries to meet the consumer expectations means an expanded set of analytical tests, all of which involve filtration to a greater or lesser degree.

We produce high-quality filters for brewing applications. For more information or to discuss any custom filtration needs, please contact our Scientific Support or your local representative.

Find the optimal filter for beer brewing analytical tests with the Whatman filter selector

Streamlining beer brewing quality control with glass fiber filtration

Beer is a billion-dollar industry. With millions of beers sold each year, maintaining quality and consistency, as well as maximizing efficiency in the brewing process is essential for breweries to remain competitive.

Analysts continuously perform quality control (QC) tests throughout the production process to assess the various attributes of their beer to make sure they maintain the signature taste, smell, and color. But conducting these tests can create bottlenecks in production.

Some of these bottlenecks relate to filtration. In this chapter, we discuss using glass fiber filters as an alternative to cellulose paper filters to save time in QC.

Importance of filtration in brewing

Filtration is not just part of the protocol, but an essential part of the brewing process, both for producing a pleasing final product and for accurate QC testing.

Organizations like the EBC, MEBAK, and ASBC include various preparative filtration steps in their standards and guidelines for high-performance liquid chromatography (HPLC), spectrophotometry, and liquid chromatography mass spectrometry (LC-MS).

One of the most common filtration steps is degassing and removal of particulates using cellulose filter paper. Without this step, particulates such as wort and yeast from the brewing process can clog and damage your HPLC columns. Dissolved gases, usually carbon dioxide, can affect the results of your analyses.

Let's take a look at two quality tests where paper filters are commonly used: alcohol and carbohydrate tests.

Fig 2. Glass fiber filter paper resting on top of filter funnel as specified in ASBC method Wort-9.

Table 1. Comparing properties of cellulose and glass fiber filters

Grade	2V	GF/C
Material	Cellulose, fluted	Borosilicate glass
Typical particle retention in liquid[1]	8 µm	1.2 µm
Typical water flow rate[2]	38 ml/min	105 ml/min

[1]At 98% efficiency. [2]For 9 cm diameter.

Filtration in alcohol tests

Determining the alcohol content of a beer is essential in maintaining a consistent product and complying with regulations. You might use near infrared spectroscopy or gas chromatography to measure alcohol content. In either case, you would usually pass the sample through a cellulose filter paper to remove any turbidity that could affect the results.

Filtration in carbohydrate tests

Carbohydrate levels are another measure of quality and consistency in beer. In this case, high-performance liquid chromatography (HPLC) is the analytical method, but like alcohol tests, you would usually use a cellulose filter paper for degassing and clarification.

Cellulose versus glass fiber filters in brewing QC

Cellulose filter paper is very versatile. It is the first option for degassing and general clarification in the brewing process, providing a consistent level of filtration, and is specified in numerous methods. If you are running a large-scale brewery, chances are that you have used the same type of cellulose filter paper for many years.

But cellulose filter paper can create a bottleneck related to its flow rate. Glass fiber filters (Fig 2), by comparison, have much higher flow rates, and similar—or even better—particle retention, which could save precious minutes in every QC test.

If we compare a representative filter grade of each type, these differences are readily apparent (Table 1).

In this specific comparison, the grade GF/C glass fiber filter has almost three-fold greater flow rate than the grade 2V fluted cellulose filter paper. So, consider whether you could replace cellulose filter paper with glass fiber filters in some or all your sample clarification steps and save time in your QC processes.

You might already have some glass fiber filters at hand, as glass fiber is well suited for wort filtration, specified in the ASBC method, Wort-9, and used in suspended solids content tests of brewery wastewater.

Try our Whatman Filter Selector to find the right filter for your application fast. Or contact the Support Team to discuss your options for improving filtration efficiency.

Find out more about the range of glass fiber filters Cytiva has to offer

Analysis of Whatman filter papers for use in the brewing industry

Quality control (QC) methods used by the brewing industry often involve a filtration step for sample preparation. In this study, three grades of Whatman filter paper (Grades 2V, 597½, 2555½) were evaluated in analyses representing different steps in the brewing process. These tests, from ASBC methods, were 1) removal of turbidity from wort, 2) removal of CO_2 from finished beer, and 3) removal of yeast cells after fermentation. The data presented here demonstrate that all three filter grades are suitable for use in the filtration steps that these methods require.

Introduction

Growing competitiveness in the global market for beer has led brewers and standard-setting agencies for regional varietals to increase focus on product consistency for characteristics such as color, alcoholic strength, flavor, and clarity.

The EBC, MEBAK, ASBC, and other organizations publish analytical methods to guide beer quality testing. Many of these methods require filtration to prepare the sample for testing. Some methods rely on the traditional concept of filtration, wherein the filter's sole purpose is to remove particulate matter from a liquid sample prior to analysis of the clarified liquid (i.e., the filtrate). Other methods require testing of the retained solids (i.e., the retentate).

Data presented here show how Whatman filters of three grades performed in supporting three ASBC methods of importance to the overall QC process. Tests carried out were 1) removal of turbidity from wort (Malt-4), 2) removal of CO_2 from finished beer for quality control purposes (Beer-1,D), and 3) removal of yeast cells after fermentation (Beer-8).

Wort filtration

The quality of a wort batch is dependent on the quality of the malt used to produce it. Measurement of wort filtration speed and turbidity allows a brewer to qualify whether the malt used to produce it is leading to a desirable end product and to quantify a tolerance range for quality control of end product consistency. A slower filtration speed reflects a lower wort solubility. Measuring the filtration speed also helps the brewer understand the malt's contribution to fermentable extract, pH, color, viscosity, and nitrogen content (1). A wort sample with low turbidity is required to support later photometric testing. Gravity filtration using an appropriate filter paper supports all of these objectives.

CO_2 removal prior to further testing

During fermentation, CO_2 is produced and dissolves into the solution. When a QC lab prepares a sample of this solution for analysis, this dissolved CO_2 may lead to inaccurate results in tests such as total acid determination. Therefore, the CO_2 content needs to be minimized prior to testing. One method for achieving this is to pass the beer sample through an appropriate paper filter using gravity filtration.

Removal of yeast cells after fermentation

Measuring the total acidity of the final brewed product requires that the remaining yeast cells are removed. This simple separation of particulate matter from liquid sample can be achieved through gravity filtration.

Methods

In the study presented here Whatman Grades 2V, 597½, and 2555½ from Cytiva were evaluated for their suitability in the three tests described below. All filters were 320 mm in diameter and prepleated with 16 pleats (Fig 3).

All tests were performed according to the ASBC methods presented in Table 2. All testing was performed by the Biotechnology School at Jiangnan University, No 1800 Lihu Avenue, Wuxi, Jiangsu, 214122, China.

Fig 3. A prepleated filter paper sitting in a filter funnel.

Table 2. Study design

Whatman filter	Product code	Lot number	Tests (ASBC Method)
Grade 2V	1202-320	G8605164	Wort filtration (Malt-4) CO_2 removal (Beer-1,D) Yeast cell removal (Beer-8)
Grade 597½	10311853	G7471143	
Grade 2555½	10313953	G5137158	

Removal of turbidity from wort

Two batches of malt were prepared to support testing of the filtration step for method ASBC Malt-4. The malt was prefiltered prior to further testing in order to isolate the wort. Spent grain was removed by prefiltering the malt using a coarse filter bag. The wort in the filtrate was adjusted to a turbidity level of 10 prior to measuring the base turbidity. A 150 ml sample of wort was filtered using gravity through Whatman filter paper Grade 2V, 597½, or 2555½. The turbidity pre- and post-filtration was measured and the percent reduction calculated. This process was repeated for a total of three samples. The filtration times were also recorded.

CO_2 removal from bottled beer

The amount of CO_2 in beer is expressed as mg/ml and is derived from the following formula:

$$\frac{C \times (V-V_0) \times 44}{10} \times \frac{V_1+1}{V_1}$$

Where:

C = concentration (M) of HCl standard

V_0 = volume of HCl (ml) required to adjust pH in a water blank to 3.9

V_1 = sample volume (ml)

V = volume of HCl (ml) required to adjust pH of the sample to 3.9

Per ASBC method Beer-1,D a 4 mL sample of beer chilled to 4°C was filtered using gravity through Whatman Grade 2V, 597½, or 2555½ and transferred to a conical flask. NaOH (1 mL of a 10 M stock) was added to the beer and mixed thoroughly. A 10 mL sample of this mixture was transferred to a fresh beaker and 20 mL of distilled water added. The mixture was then titrated against 0.5 M HCl, with the volume required to reduce the pH to 3.9 recorded. The measurement was repeated with 50 mL of unfiltered beer and then with 50 mL of water (as a blank control).

The amount of CO_2 in unfiltered and filtered beer samples was measured, and the amount and percentage of CO_2 removed was calculated. This process was repeated for a total of three samples.

Removal of yeast cells after fermentation

A typical fermentation broth containing yeast cells suspended in solution was prepared. In order to test such a broth for acidity per ASBC method Beer-8 such a broth would first have yeast cell content removed. The initial number of suspended yeast cells was estimated using a cell counting chamber. Aliquots of 150 mL of this suspension were then filtered by gravity through one of the three filter paper grades. The filtrate was subjected to serial dilution. The resulting samples were plated on YPD agar plates to determine the number of viable yeast cells not retained by the filter. The difference between the two counts was used to determine the efficiency of filtration. This process was repeated for a total of three samples.

Results and discussion

Removal of turbidity from wort

The results for the two prefiltered wort batches are provided in Table 3.

Table 3. Turbidity reduction for wort batches. Results are the average of triplicate measurements

Whatman filter grade	Initial turbidity		Turbidity after filtration		Turbidity reduction (%)	
	Batch 1	Batch 2	Batch 1	Batch 2	Batch 1	Batch 2
2V	10.6	30.1	6.54	6.39	38.3	78.8
597½			8.02	7.25	24.3	75.9
2555½			7.24	8.96	31.7	70.2

Although Grade 2V was superior for turbidity removal, filtration time was much longer than with the other two papers (up to 413 s for a 120 mL sample compared to 83 s and 52 s for Grades 597½ and 2555½, respectively). The 597½ grade paper showed better performance characteristics with higher turbidity starting material, and Grade 2555½ performed better when initial turbidity was low. Filter selection ultimately depends on the time allotted to perform the test and the required level of sample clarity. Table 3 and the filtration times should allow for an informed choice with respect to these parameters.

CO_2 removal from bottled beer

Results for CO_2 removal are given in Table 4. The Grade 2V paper showed the highest efficiency in removing CO_2 from the beer, indicating its particular suitability for this analysis.

Table 4. CO_2 removal from bottled beer by Whatman paper type. Results are the average of triplicate measurements

Filter grade	CO_2 (mg/mL)		CO_2 removed (mg/mL)	% removal
	Unfiltered	Filtered		
2V	4.75	1.06	3.69	77.68
597½		1.94	2.81	59.16
2555½		2.07	2.68	56.42

Removal of yeast cells after fermentation

Table 5 provides results for yeast cell removal from fermentation broth. All three papers performed well in the test, removing greater than 99.5% of suspended yeast cells from the broth. Whatman Grade 2V filter paper achieved 99.99% removal.

Table 5. Yeast cell removal from fermented beer. Results are the average of triplicate measurements

Filter grade	Yeast cells (number/mL)		% removal
	Before filtration	After filtration	
2V	2×10^7	1.9×10^3	99.991
597½		4.3×10^4	99.783
2555½		2.5×10^4	99.874

Conclusions

Cytiva produces a wide range of Whatman filter papers suitable for use in the beer industry. A sample of this range, Whatman Grades 2V, 597½, and 2555½, were tested in support of three representative quality control procedures from ASBC. All three grades of paper performed well in removing turbidity, CO_2, and yeast cells. Whatman Grade 2V in particular stands out as providing the highest rate of turbidity reduction and CO_2 and yeast cell removal from samples. However, use of Grade 2V comes at a cost of a longer time to filter. The data presented here will be useful to brewers deciding what filtration papers to use given their resource, time, and quality constraints.

Reference

1. Kühbeck *et al.* Influence of Lauter turbidity on wort composition, fermentation performance and beer quality – a review. *J Inst. Brew.* **112**, 215–221 (2006).

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