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Yeast Cell Counts and Viability in Brewing: Finding a Method You Can Count On

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Brewers worldwide rely on accurate yeast cell counts and viability determinations to achieve consistent, high-quality, tasty fermentations. To ensure the perfect pint every time, precise measurements are crucial, as inaccurate estimates can lead to unwanted variations in beer flavour and production. Determining the correct amount of live yeast needed to start fermentation, known as the 'yeast pitch', is vital. Research from Dr Matthew T. Cottrell revealed the main sources of variability in these measurements, aiming to empower brewers with more reliable data and a predictable brew.

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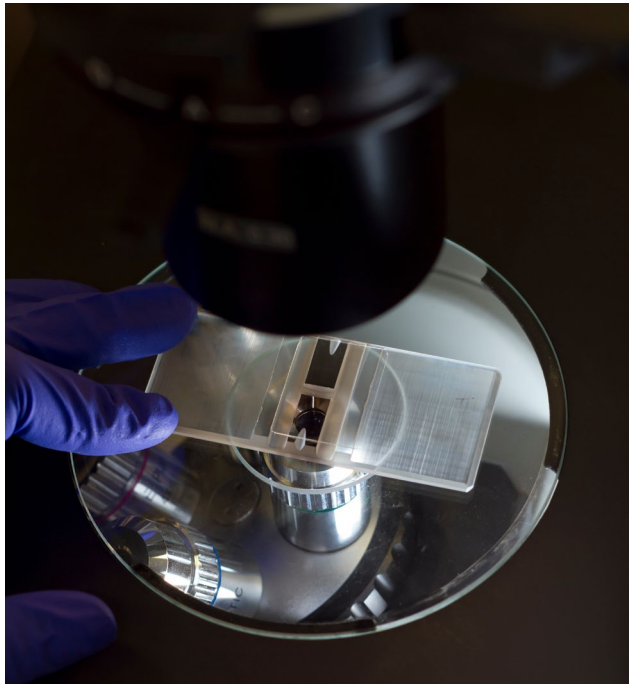
Consistency is Key

Beer is one of the oldest and most widely consumed beverages in human history. While early brewing may have been an art, modern brewing is absolutely a science, demanding precision, control, and reproducibility at every stage.

Current brewing practice includes strict yeast management. Yeast converts the sweet, sugary wort (produced from malted grains and water) into beer. Yeast is a living organism with natural variability, so knowing the total number of yeast cells available to a brewer and the proportion of live cells (viability) is key. Only viable cells are active in fermentation, influencing sugar consumption and the production of desirable and undesirable flavour compounds. Therefore, achieving the optimal 'pitch rate' (initial concentration of viable yeast) is fundamental for achieving the desired quality and consistency in the final product.

An inaccurate pitch rate can have significant consequences. Pitching the wrong amount of yeast can produce unwanted alcohols and 'off-flavour' compounds —such as diacetyl and acetaldehyde, which give sickly sweet and astringent sharp flavours, respectively. Given these direct impacts on beer quality, obtaining accurate and precise estimates of yeast cell count and viability from the yeast source is not just desirable, but essential.



Putting Yeast Counts to the Test

To determine the amount of stored yeast to pitch, brewers commonly use the direct manual cell count method, using a microscope and a haemocytometer (specialised counting slide) to count cell numbers within a defined volume. Viability is assessed by selectively staining dead cells, allowing for simultaneous counting of live and dead cells. Recognised methods and guidelines are available from the American Society of Brewing Chemists (ASBC) and the European Brewery Convention.

However, every measurement —including a yeast cell count— is an estimate of the "true" or parametric value, which nobody can ever know. All that is available is an estimate based on observations (counts) and a measure of the variability of those counts. Dr Cottrell systematically identified the sources of variability in yeast cell counts and viability determinations obtained through microscopy. The research utilised three distinct methodologies to help brewers better understand the reliability of microscope counts, and to enable targeted improvements of counting processes.

The first approach was computer-simulated cell counting. The simulation tested various sample sizes, from as few as 5 to as many as 800 cells per simulated microscope image, and explored different yeast viability percentages.

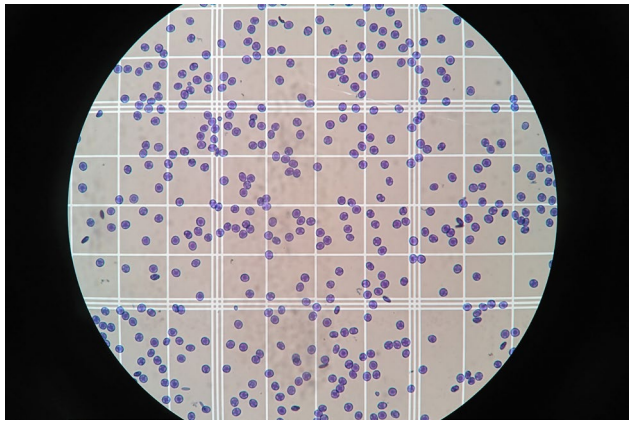
For the second method, samples from active fermentations and post-fermentation slurries which included 3 brewing yeast strains were prepared through precise dilution, and then counted following the American Society of Brewing Chemists (ASBC) method Yeast-4 protocol. This protocol describes how to dilute the sample, how to load the haemocytometer counting slide, and provides guidance for both how many cells to count and how many cells should be present in each of the 10 fields of view counted. The formula for calculating the final yeast count from the microscopic counts of 10 fields of view is given, but the ASBC method does not indicate how to assess the reliability of the estimate, it merely indicates what is the typical variability.

Thirdly, semi-automated cell counting by image analysis was used; this involved capturing high-resolution images of the prepared yeast samples, using a microscope fitted with a digital camera. Yeast cells were identified using a cutting-edge deep neural network algorithm. The speed of this automated process was notable, with 10 images being processed in approximately 25 seconds.

Finally, the semi-automated cell counting that avoids any added variability among human microscopists doing the counting was used to quantify variation at three distinct levels: fermentation sampling, sample dilutions, and different fields of view. This enabled the calculation of a 'coefficient of variation' (CV), which identified which of these sources contributed most significantly to the overall variability.

Uncovering Hidden Variables

Often reinforcing established brewing practices while also providing new, data-driven recommendations, Dr Cottrell's results offered crucial insights: the variability in both cell count estimates and viability determinations substantially decreased as the 'sample size' (the average number of cells counted per field) increased. Importantly, when viability was low, the variability in its determination was higher. This indicates that the consistency of cell counting is separate from



the consistency of viability measurement, especially at lower viabilities. Nevertheless, a comparison between semi-automated image analysis and traditional manual microscopy showed a general agreement between the two methods.

The most significant finding regarding sources of variation was that the variability observed among different fields of view was the largest contributor to the overall variability in cell count estimates. Hence, the biggest challenge to precision lies in the uneven distribution of cells within the sample across the haemocytometer, as well as the consistency of counting across different microscopic views.

Actionable Insights for Brewers' Accuracy

These findings offer practical, actionable guidance for brewers. The key takeaway is to focus on minimising the variability among fields of view, as this is the predominant source of error in both cell counts and viability determinations. While there is support for the ASBC method, Dr Cottrell provides a more refined recommendation. The study pinpointed an 'optimal' counting effort: counting fields of view containing between 25 to 30 cells. By averaging cell counts from 10 such fields of view, brewers can achieve results with approximately 15% CV, offering a good balance of precision and practicality.

The research also highlighted a crucial aspect often overlooked: the reliability of viability determinations, especially for yeast with lower viability. Simulations revealed that pitching yeast with low viability carries an added risk of unpredictable fermentation performance because the estimate of viability itself can be highly variable and uncertain when viability and the number of live cells per field of view are low. Thus, the impact of low viability on the precision of its determination is greater than its impact by virtue of low viability yeast containing a large proportion of dead cells.

Precision Pitching: A Path to the Perfect Pint?

For brewers achieving the desired yeast pitch, which involves multiplying the cell count by the viability, the total uncertainty is the sum of the relative errors (CVs) from both the cell count and viability determinations. Therefore, directly addressing and controlling the field-to-field variability is the most effective way to improve the overall precision of the calculated amount of yeast to pitch. **Efforts focused on repeatedly sampling the yeast source or preparing numerous sample dilutions will be less impactful, as these contribute less to the total variability**.

This study provides actionable, statistically-backed guidance for brewers. Dr Cottrell showed that simply understanding and actively managing the predominant source of variability enables even breweries with modest laboratory facilities to obtain the highest accuracy and reliability of yeast cell count and viability determinations. High precision in yeast management is fundamental to producing fermentations that consistently yield the highest quality beer, turning the art of brewing into an even more refined science.

Article written by Joseph Earley, PhD

MEET THE RESEARCHER

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Dr Matthew T. Cottrell obtained his Bachelor of Arts in Biology at Columbia University in 1986. He completed his Master of Science and Doctor of Philosophy in Marine Environmental Science at Stony Brook University and University of Texas at Austin in 1989 and 1995, respectively. He was a Research Scientist in the College of Marine Science at the University of Delaware until 2016. Dr Cottrell published extensively on the role of microbes in carbon cycling in the ocean, including probing metabolism and phylogeny of microbial community structure and functional relationships, as revealed by single-cell microscopy.

Dr Cottrell received basic science research funding from US federal agencies supporting Oceanography. In 2017, he left academia and the diversity and wilds of marine microbes for more uniform, domesticated brewing yeasts. He obtained an International Diploma in Brewing Technology from the World Brewing Academy, Siebel Institute of Technology, Chicago, IL, and Doemens Academy, Munich, Germany. He then became Quality Manager and Microbiologist at several craft breweries, working with beer until 2025. His devotion to the complexities of microbes continues now, as he peruses the diverse populations of wild yeasts found on grapes, as part of his current role in winemaking.

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Podcasts:

Master Brewers Association of the Americas Podcast

Creep control, Master Brewers Podcast with John Bryce, February 17, 2025

IoT Autoclave, Master Brewers Podcast with John Bryce, October 7, 2024

Cannabaceae Creep, Master Brewers podcast with John Bryce, September 12, 2022

https://www.masterbrewerspodcast.com/guests/matt-cottrell

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FURTHER READING

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