Characterizing Beer stability with the Turbiscan

- Haziness, foam and process optimization -

FOOD & BEVERAGES

Introduction

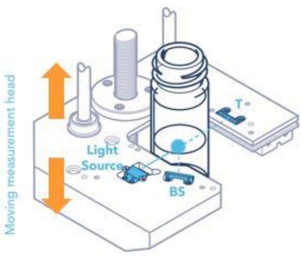
Beer, one of the oldest beverages produced by humans, appeared as early as 5,000 years ago. It is a complex beverage, containing a diverse mixture of carbohydrates, proteins, and aroma compounds. Unlike other manufactured beverages that can be easily fine-tuned by adding/removing ingredients, the natural fermentation process does not lend itself to simple tuning to achieve precise ingredient concentrations. Instead, raw ingredients and processing parameters (i.e. time, temperature) must be carefully adjusted to achieve the desired stability and sensory profile. Unfortunately, the Turbiscan didn't come along until 1994 to help brewers fine tune the stability of their beers and easily estimate shelf life and other quality parameters (yeast sedimentation, haze stability, flocculation, clarity, foam…). The Turbiscan can be used to quantitatively predict sedimentation of yeast and proteins, haze stability, flocculation, clarity and foam stability, all of which are key parameters for many beer types

KEY BENEFITS

- QUANTIFIED
- NO DILUTION
- SENSITIVE

Reminder on the technique

Turbiscan® technology, based on Static Multiple Light Scattering, consists on sending a light source (880nm) on a sample and acquiring backscattered (BS) and transmitted (T) signal over the whole sample height.
By repeating this measurement over time with adapted frequency, the instrument enables to monitor physical stability. The signal is directly linked to the particle concentration (φ) and size (d) by the Mie theory knowing refractive index of continuous (n_f) and dispersed phase (n_p):



$$BS = f(\varphi, d, n_p, n_f)$$

The Turbiscan® and Turbiscan® Stability Index (TSI) are 'must-have' tools for formulators for fast and quantitative formulation screening, rapid product development, and quantitative measurements of stability. Turbiscan technology has been used for decades by formulators for stability measurements and is now recognized as a standard technique for direct stability analysis.

Methods

The Turbiscan can be used to quantitatively predict sedimentation of yeast and proteins, haze stability, flocculation, clarity and foam stability, all of which are key parameters for many beer types. In this note, we will highlight the utiility of the Turbiscan for analyzing beers at all stages of the brewing process for raw ingredient analysis, optimization of processing parameters, and rapid shelf life determination.

Stability analysis of a "hazy" IPA

Hazy IPAs have gained significant popularity in recent years and represent an emerging trend for craft and large breweries. These beers are characterized by their hazy appearance that has been described as similar to that of orange juice. Indeed, the taste profile is commonly quite fruity.
These types of IPAs are especially prone to sedimentation due to their high turbidity (proteins, yeast…) and for optimal consumer experience, the haze should be stable in a variety of storage media (cans, bottles, or kegs) at given temperature. The early stages of this destabilization phenomenon can be detected using the Turbiscan (**Figure 1**).

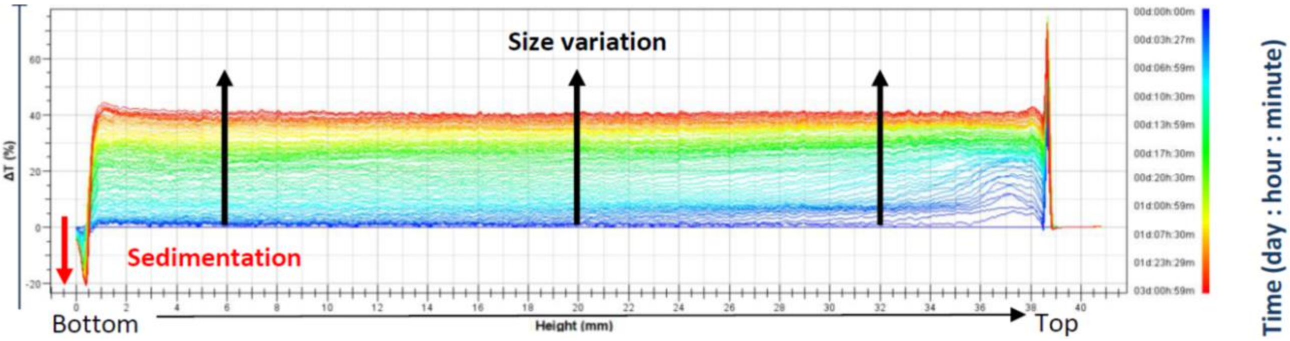


Figure1: Transmission data of an IPA beer (sample A) - 3 days

From the Turbiscan data obtained (**Figure 1**) over 3 days, multiple destabilization phenomena can be detected. At the bottom of the sample vial (left side of the scan) there is a sharp decrease in transmission, indicating sediment formation. A nearly global increase in %T is also observed, indicating particle size variation - flocculation. Analysis using Turbiscan software (Turbisoft) can show the flocculation kinetics of various hazy IPAs (**Figure 2**) allowing to compare different profiles and evaluate the kinetics.

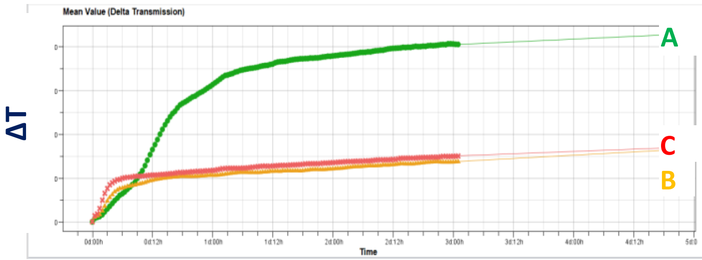


Figure 2. Flocculation kinetics obtained from the Δ%T readings in the middle of the hazy IPA samples.

Samples **A**, **B**, and **C** were of the same beer, but samples came from different batches. From this data, it is clear that the stability of the batch obtained on day **A** was significantly lower than other batches (days **B** and **C**). The Turbiscan helped the brewery to rapidly identify a “bad” batch in less than 24 hours, triggering further investigations into the root cause of the destabilization. In addition to monitoring changes over time to predict beer stability, initial clarity/opacity can be rapidly determined using the Turbiscan (**Table 1**).

As different beers will vary in their clarity, criteria can be established for acceptable initial raw transmission value (at t=0) as a method for assessing initial quality.

Table 1. Raw transmission values at t=0

Batch	%T at t=0	%T at t=3 days
A	40.98	75.57
B	40.98	51.78
C	47.83	59.18

This type of data allows brewers to assess batch stability in a fraction of the time compared to a subjective visual test. With changing consumer tastes, it is important to have the flexibility to modify ingredients and develop new brews while ensuring stability and performance are maintained.

Monitoring quality parameters during the brewing process - Wort clarification

Process parameters must be carefully adjusted and maintained to achieve the desired properties. By determining the optimum time and temperature for each step in the process, energy and time needed can be reduced. The Turbiscan can be used to assess quality parameters even at early stages of the brewing process. One example of this is the analysis of wort clarity and the influence of processing temperature.

Wort is the mother liquor that can be thought of as the “beer starter” and is typically prepared from hot water added to mashed grains. The Turbiscan can be used to monitor the clarification of the wort and determine clarification kinetics at various temperatures.

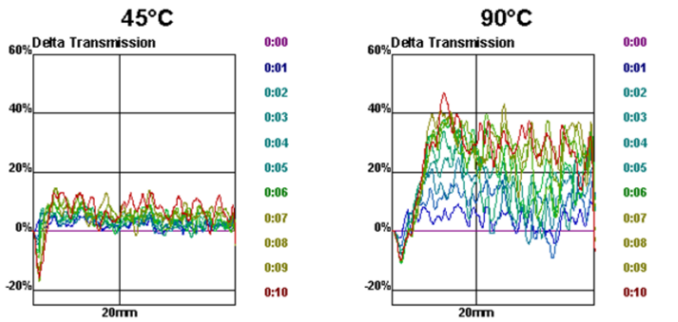


Figure 3. Wort clarification profile analyzed in the middle of the sample for 10 min.

A short 10-minute test allows to identify the differences between the sample behaviors. By plotting the change in transmission over time Turbiscan can help analyze clarification kinetics at different temperatures.

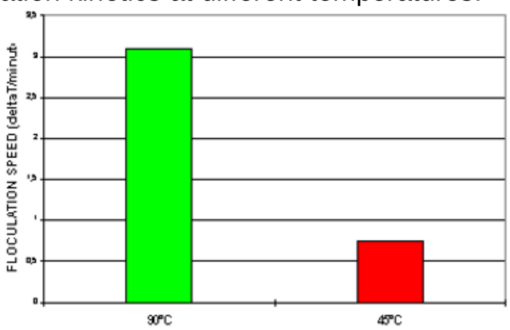


Figure 4. Flocculation rate in Δ%T/min at 90°C and 45 °C.

By rapidly determining the rates of clarification in small test batches, the conditions can be optimized for mass production that cannot be easily monitored.

Beer Foam Properties[1]

Beer foam, also known as beer head, is formed from the naturally produced carbon dioxide during fermentation. Beer foam can significantly affect the sensory experience and imparts a creamy quality with a sense of fullness. Certain hydrophobic proteins are known to increase foam stability, providing a longer softening effect on the palate. Conversely, ethanol can inhibit foam formation. Several types of beers were studied in regards to foam formation over time.

Table 2. Select characteristics of the tested beers

Beer	A	B	C	D	E	F
Container	Can	Can	Bottle	Bottle	Can	Bottle
Alcohol (vol%)	5.7	6.0	4.1	7.0	2.0	6.0

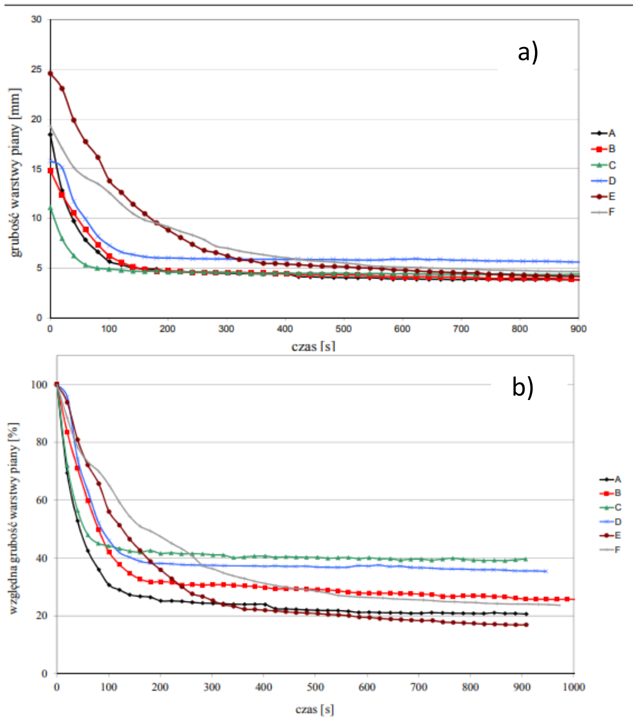


Figure 5. Absolute thickness (mm) of the foam layer for each beer (a). Relative thickness of the foam layers (b) over time.

Unsurprisingly, the beer with the lowest alcohol content (E) gave the most foam that was quite stable, only decreasing to 20% of the original volume after 400 s. At the same time, beer F showed good foam stability for its moderate alcohol content. In addition when compared to Beer B which contained the same amount of alcohol but had lower foam stability than beer F it can be seen that the use of a different container can have an impact on final foam quantities.

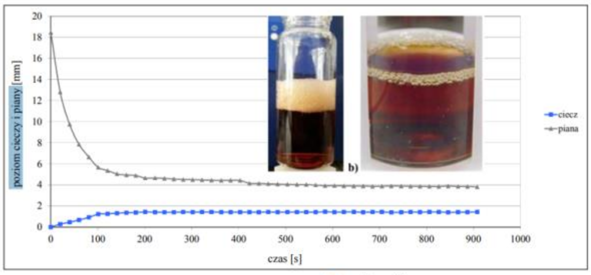


Figure 6. Detailed foam drainage kinetics of Beer A and pictures of the beer in a Turbiscan vial after 300 and 900 seconds of analysis (inset, left and right).

Diving deeper into the Turbiscan data, the drainage kinetics of the foam can be plotted alongside the growth of the liquid layer. Because the Turbiscan measures the backscattering and transmission simultaneously, information on both the foam (backscattering) and beer (transmission) can be obtained from a single scan or series of scans without the need to switch reading modes. In this manner, the Turbiscan can be used to obtained detailed kinetics of foam stability and allow the brewer to adjust the beer to obtain the desired characteristics.

Conclusions

This brief note has demonstrated the capability of the Turbiscan to characterize beers and optimize brewing parameters. The results provide accurate, quantitative data for beer stability analysis and removes the guesswork associated with visual stability observations. This high-resolution analysis can accelerate the stability analysis timeframe from many days or weeks to a couple hours for rapid shelf-life determination. This helps move projects to completion at a much faster rate than traditional methods. The Turbiscan has proven to provide fast and accurate results that can be applied to all types of beers including traditional varieties and emerging trends such as hazy IPAs.

[1] Kowalik, K., B. et al. *Postępy Techniki Przetwórstwa Spożywczego* (2018).