INTERPRETING MALT CERTIFICATES OF ANALYSIS

A. SCOPE:

Understanding malt analysis is key to producing beer of consistent quality. Malt and barley are natural ingredients subject to batch-to-batch and seasonal variations. Malt analysis gives brewers the opportunity to optimise their process to achieve consistency and efficiency.

This document is intended to be a high-level practical introduction to interpreting malt analyses, and its relationship with brewing performance and beer quality. It will not explore the malting process or how these parameters are controlled by maltsters.

Malt requirements in the brewery

The basic attributes of brewing malt should meet the following requirements:

- Desired extract yield
- Appropriate brewhouse cycles times and wort separation rates (this will be specific to your equipment)
- Desired colour, clarity, foam, flavour, aroma and stability
- Free from contamination and safe for use in beer production.
- Appropriate proteolytic and cytolytic modification to allow access to starch granules in mashing

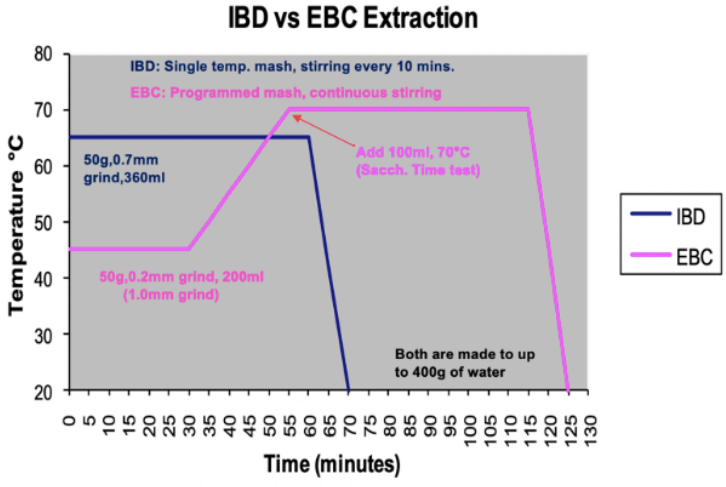
Certificates of analysis and Specifications

Maltsters typically provide a specification for a given type of malt (for example "lager malt" or "Munich malt"). Separately, they will provide on request certificates of analysis (CoAs) for individual lots of malt. Brewers can use these CoAs to anticipate process changes required to achieve consistent brewing results, and to verify compliance with malt specifications.

Malt analyses fall into three primary categories: physical tests of the malt kernel and resulting grist, biochemical tests of the malt, and wort tests from wort extracted from standardised laboratory "congress mashes".

The Congress Mash

Standard laboratory based mashing regimes are used for wort analysis – there are several such methods used internationally, each of which can yield very different results for the same analyte. The IoB and EBC methods are pictured below to highlight the main differences.



Congress mashes do not represent typical brewing conditions and should not be considered direct indications of brewing performance.

Some main differences between the congress mash and typical brewery mashes are listed below:

	EBC CONGRESS MASH	TYPICAL BREWERY CONDITIONS
Low temp (proteolytic and cytolytic) rests	20mins @ 45˚C, ramping to 70˚C	Varies, but increasingly unused.
Saccharification temperature	70˚C	Varies, but typically around 65˚C
Liquor:Grist	8:1	3-5:1
Milling	Very fine (0.2mm disc mill)	Contingent on mill and brewhouse, but typically much coarser

Typical malt analyses and their significance

ANALYTE	SIGNIFICANCE IN BREWING
Barley variety	Different barley varieties exhibit different malting characteristics, and variety will influence extract, protein, β-glucan, enzyme levels and grain size. Some brewers contend barley variety is important in finished beer flavour.
Crop Year	Changes in crop year can bring malting challenges, with dormancy and water sensitivity of barley affecting malting performance differently throughout the season. Being aware of the crop year of your malt can help pre-empt potentially large between-season changes.
Size/homogeneity/Screenings	Important in determining mill adjustments to yield consistent grist.
Friability	The 'crushability' or 'mealiness' of the malt and serves as an indication of the level of modification. Can be used in conjunction with β-glucan numbers to give an indication of cytolytic modification and any potential mashing and wort separation issues. **Typical values <90%**
Moisture	Used in extract yield calculations and affects the storability of the malt. Brewers want to avoid 'paying for water' in high moisture malt sold by the tonne however should be cognisant of increased breakage, enzyme instability and higher colours in very-low moisture malt. **Typical values <4-6%**
Extract	The measure gives the maximum value for extract yield potential and is used to calculate the quantity of malt required per brew and for calculating process yield. Expressed as either 'as is' i.e. correcting for moisture or 'dry basis' and as either fine grind or coarse grind (which better approximates brewing conditions). Extract is inversely related to protein content. **Typical values <79% FGDB**
Coarse/fine difference	An indication of modification – the lower the coarse/fine difference, the more highly modified the malt. High error, and a small difference between big numbers means this analyte is of questionable value if used in isolation.

ANALYTE	SIGNIFICANCE IN BREWING
Colour	Colour is produced from the interaction of reducing sugars and amino acids. The colour of congress wort is used to adjust the colour of the finished beer. Wort colour will darken during wort boiling. Note: The EBC congress worts are typically around 8°P, so must be adjusted for other wort strengths. **Typical values EBC: Lager <3.5, Pale <4.0 and Ale 3.0 to 7**
Total protein (or Nitrogen)	Protein is inversely proportional to extract, so brewers tend to favour lower protein malt, however protein-derived amino acids (FAN) are essential to yeast health. Protein is also related to foam stability and haze and is dependent on barley variety. Divide protein by 6.25 to convert to Nitrogen **Typical values depend on malt type, but generally 9-12%**
Soluble protein (or Nitrogen)	Key indicator of proteolysis during malting, and the level of modification.
Kolbach index or soluble:total protein ratio	This is the amount of total and soluble protein and is an indicator of degree of modification, and highlights to the brewer batch-to batch differences which may affect mashing, wort separation, foam and fermentation characteristics. Note there is no 'ideal' s/t, and it is somewhat contingent of barley variety. **Typical values 38-45%**
Free Amino Nitrogen (FAN)	FAN is a measure of how much protein has been degraded to amino acid level. Required by the yeast for normal metabolic processes – yeast require a balance of carbon and nitrogen. Excessively high values can cause issues with beer stability and colour development. **Typical value: >120**
β-glucan	Used by brewers to anticipate issues in wort separation filtration from the formation of β-glucan gels. Β-glucan can also be used as an indication of cytolytic modification – how much of the cellular structure of the barley endosperm has been degraded during the malting process to unlock access to the starch granules inside. **Typical value: <150ppm**
DMS-P or SMM	The precursor to DMS (which has a flavour perception threshold of only 35ppb). DMS-P is partially converted to DMS and removed in malt kilning – the residual DMS-P can give the brewer an indication of the boiling regime required to achieve sufficient DMS reduction.
AAL	Apparent attenuation limit – can be used to help guide mashing program decisions between batches of malt but does not well correlate to real-world brewing performance due to the nature of congress mash. **Typical value: 75-82%**
Diastatic Power (DP)	This is the combination of starch degrading enzymes, alpha-amylase, beta-amylase, limit dextrinase and alpha-glucosidase. This attribute has an impact of fermentability and can be manipulated by adjusting the mash temperature. **Typical value: >120WK**
LOX	Lipoxygenase. Responsible for catalysing lipid oxidation and the creation of precursors which contribute to beer stailing. Can be inhibited by low pH (<5.3) and higher temperature mashing (>64°C). **<15 U is good, < 7 U even better**

Accuracy and inter laboratory error in malt analysis

When assessing compliance with malting specifications, it is important to note many of the methods for measuring the above analytes have high standard deviations and interlaboratory error – details on these errors are published by the EBC and ASBC.

Inverse relationships in malt analyses

It is worth noting that many malt properties have directly linked relationships driven by the malting process – be aware of these when setting malt specifications, for example; Moisture and DP, Moisture and colour, FAN and low soluble protein, high DP and low total protein.

Food Safety Issues

As with other brewing raw materials it is important to ensure food safety – typical food safety

- NDMA – a likely carcinogen in high levels which maltsters monitor in their process.
- DON and mycotoxins – toxins arising from fusarium and other fungal infestation of barley and malt
- Foreign contaminants – stones and metal contaminants pose low food safety risk and are typically removed at wort separation, but can cause plant damage
- Residues – Rules covering pesticide and herbicide residues in barley are governed by the department of agriculture and several government and industry bodies. It is important to consider residues when procuring malt from overseas or new suppliers.

Calculating process yield

An example below shows how to use malt extract to calculate extract yield through the brewing process

kg malt: 300
malt extract (coarse grind, as-is): 78%
1800l cold wort @ 12°P, 1.048SG
Extract in malt = 300kg x 78% = 234kg
Extract in wort = 1800l x 12%°P x 1.048sg = 226kg
Extract in wort / extract in malt = 96.5% yield

Beyond CoAs

Malt CoAs describe the malt leaving the malting – it is important brewers changes that could occur in storage and through the supply chain