Malt Analysis and Specialty Malts

An analysis sheet should accompany every shipment of malt delivered to the brewery from the maltster. This is a sheet detailing how the particular “lot” of malt performed in various standard laboratory tests. This has long been a controversial issue because often laboratory measurements are unrelated to the actual performance of the malt in the brewhouse. Brewers can request a whole range of tests on their malt and define specific specifications from the maltster but must be aware of how the numbers are related. For example demanding low moisture and low color when the only way to provide low moisture is through extend kilning which darkens the color. It is incumbent on brewers to understand the numbers on the specification sheet and how they are related to each other even if they simply take delivery of whatever the maltster has available. Maltsters too need a range of specifications as a target for manufacture and strive to make malt that falls within the ranges.

Malt Analysis
Much of the analysis of malt concerns the “degree of modification” and many of the analysis we will look at are considered "indices of modification" which taken together, may tell how well modified a malt sample is. We will first examine the physical analysis and move onto the chemical analysis of malt.

Standards
There are several standards used in the analysis of malt (in fact in all beer related analysis). Each of the standards is associated with a particular country (or continent in the case of Europe). The following is a list of the standards commonly relied upon:

- **ASBC** American Society of Brewing Chemists. Similar to the EBC methods. Use a weight/weight basis for calculation.
- **IoB** Institute of Brewing. British system which uses a weight/volume basis for calculation.
- **EBC** European Brewing Convention. Focus more on lager malts, and use a weight/weight basis for calculation.

In the case of malt analysis, the procedures are typically carried out by maltsters, and not brewers.

Physical Data
The following is a list of some of the more common physical analysis that are conducted:

- Plumpness
- Acrospire Growth
- Friability
- Moisture Content
- Color
- Wort Viscosity

Plumpness
Plumpness is really a measure of evenness of sizing, and is often referred to as assortment. By putting the malt onto sieves with various sizes, the malt can be graded by the amount remaining on each sieve. This is important to the brewer for determining the mill gap setting. The combination of material on both the 7/64" and 6/64" will mill very adequately. Some of the material on the 5/64" screen may not mill as much as desired.
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The “thrus” (material that passes through the 5/64" screen) are predominately broken pieces of malt and hull. Uniformity would be another description of this analysis, and it is critical to the brewer that there is not too much flour (which could hinder wort separation) or too many thin grains, which would be malted unevenly or poorly modified barley.

**Acrospire Growth**

The growth of the acrospire is a direct measure of the amount of modification that has taken place in the malt. Acrospire growth may be misleading since embryo growth and endosperm modification don't necessarily go hand in hand. To determine the acrospire growth, the malted barley is inspected to determine the length of the acrospire in comparison to the length of the grain.

Average results for well modified malt:

<table>
<thead>
<tr>
<th>%</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>2%</td>
<td>Overgrown</td>
</tr>
<tr>
<td>85 %</td>
<td>3/4 +</td>
</tr>
<tr>
<td>13%</td>
<td>1/2 +</td>
</tr>
<tr>
<td>0%</td>
<td>1/4+</td>
</tr>
</tbody>
</table>

**Friability**

Friability is a measure of how easily the dried malt can be broken. Although there are standards for this method, the most general usage of the term refers to the percentage of broken kernels in a sample. For standard analysis, this method uses a “friabilimeter” to measure how easily broken the malt kernels are. Higher friability indicates better modification (since barley is harder than malt). Theoretically, the higher the friability, the better, but too high a friability will result in the starch being exposed before milling, leading to the problems associated with moisture content (see below).

**Moisture Content**

Moisture content is simply the amount of moisture in the dried malted barley. This is important since brewers don't want to pay for water in the malt, and a high moisture content will affect extract. The moisture content must also be know to calculate the dry basis for extracts.

i.e. 100 lb. malt at 5% moisture = 95 lb. malt dry basis, while 100 lb. malt at 10% moisture would only yield 90 lb. malt dry basis, and hence less extract on an “as is” basis. The moisture content will vary from 2-6% depending on the malt type. High moisture can result in insect infestation, mold growth, difficulty hitting target mash temperatures and poor milling qualities leading to increased astringency and lower extract yields.

**Color**

Color is not so much the color of the malt, but the color of a wort made from the malt. Color is an arbitrary measurement will not predict the final color of the beer made from the malt, but does give an indication of the depth of color of a particular lot of malt. This is very important to the brewer wishing to control the color of the finished beer. Extract of the malt is made (see Hot Water Extract, below), and color is compared to standards.
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Color can be measured in several ways, either with comparator wheels or spectrophotometer analysis. Note that since gravity of the extract used is around 8°P, this will affect the actual color when making stronger worts (this topic is discussed further in Brewhouse Calculations). Color also tells the brewer something about flavor. Specialty malt flavor can only be achieved if kilning has taken place aggressively enough to produce some color. Distillers malt, which is kilned more gently, may have DP numbers as high as 200, but it's less flavorful and may have a color as low as 1. A number of independent variables are involved in color and flavor development in malt. Aroma and flavor are difficult to measure, but their intensity is related to the coloration produced during kilning.

Note there are several standards for color, including °L (Degrees Lovibond, American), SRM (Standard Reference Method, UK), and EBC (European Brewing Convention, Europe).

Wort Viscosity
Wort viscosity is a comparison of the flow rate of the wort compared to water and compensated for specific gravity. It is an indicator of the β glucan content, and more importantly, the overall efficiency that may be attained in lautering. 1.5 cp (centipoise) is a normal value for viscosity, and extremely high viscosities indicate that there may be a problem lautering the wort made from this malt. Viscosity is another measurement that tells the brewer something about general modification. There will be differences between varieties and growing areas, but higher viscosity numbers may indicate less than ideal modification. Wheat has higher viscosity numbers than barley, everything else being equal.

Chemical Analysis
Although many of the chemical analysis involve little or no “chemistry” per se, they all measure some chemical component(s) in the malt. The chemical analysis of importance to brewers include the following:

- Hot Wort Extract (HWE)
- Cold Wort Extract (CWE)
- Total Soluble Nitrogen (TSN)
- Total Nitrogen (TN)
- Soluble/Total Nitrogen Ratio (S/T)
- Coarse Fine Difference (C-F)
- Free Amino Nitrogen (FAN)
- Diastatic Power (DP)
- Dextrinizing Units (DU)
- Wort β-Glucans
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Hot Wort Extract
HWE is the measure of the theoretical maximum extractable materials in the malt. It is defined as the percent of malts (either as is or dry basis) that dissolves in water under conditions that permit enzyme actions relevant to practical brewing. The conditions of this analysis are not necessarily similar to conditions in the brewhouse. Therefore, these should be considered the maximum extract available from the malt, and brewers can determine the brewhouse yield by running trials and comparing to maltsters' HWE and determining the brewhouse efficiency (usually 85-90% in Micros, 92% common in commercial breweries). Because HWE is a gravity measurement, it reports everything that goes into solution from the malt. In addition to carbohydrates, HWE includes soluble protein and minerals that are part of the malt. The extract percentage varies depending on the variety and class of barley the maltster starts with, and also with the degree of modification. The highest number will be fine grind dry basis. In other words, the amount of extract available from the fine grind analysis corrected for water. This will be 80 - 81.5% for well modified, quality two row malting types, and 78 - 79.5% for well modified six row varieties.

The procedure for determining the HWE is as follows:
The mashing process is one hour and 55 minutes in length, and follows a set temperature regime and water to malt ratio. Fifty grams of ground malt are mashed in 200 ml. of distilled water at a temperature of 45°C. This temperature is held for 30 min. Then the mash temperature is raised 1°C/min. until it reaches 70°C. At this point 100 ml of 70°C water is added, and the mash is held at this temperature for one hour. For comparison purposes, lab worts are only 8.6 to 8.8 ° Plato, with 2-row being higher than six row, as you would expect from their relative extract levels.
The Hot Water Extract can be carried out using either fine or coarse ground malt, and both of these results will be used to determine the Coarse-Fine Difference (see below). The coarse grind is somewhat similar to the grind found in normal brewhouse milling, while the fine grind almost reduces the malt to powder. The fine grind will give the highest theoretical extract yield from the malt.

Cold Water Extract
CWE measures the preformed (prior to mashing) soluble materials. Since this material must have become soluble during the malting process, it gives the brewer an indication of the degree of modification.

<18% = undermodified
18-22% = Well modified
>22% = Over modified

Note that CWE alone cannot be used to determine the overall modification, but along with other analysis, it can give a strong indication to the level of modification.
Total Soluble Protein
TSP does not actually measure the soluble protein, but rather soluble nitrogen. An approximation of the protein can be made by multiplying the soluble nitrogen by a factor of 6.25, the average length of a polypeptide chain in malt. The soluble protein is expressed as a percent, dry basis. Again the moisture content is removed as a variable to allow for easy comparison. The soluble protein is the amount of protein found in the wort made from the malt. The brewer needs soluble protein to provide the nutritional building blocks for yeast growth. However very high levels of soluble protein can lead to haze problems in the beer. Although this method only measures protein, based on nitrogen content, the TSP really assures a brewer that the malt provides adequate amounts of other key yeast nutritional components.

Total Protein
Total protein is the same as the soluble protein, but takes into account all of the protein (actually nitrogen) in the malt, not just protein in solution. This measure is important for determining the S/T ratio (see below).

S/T Ratio (Kolbach)
The relation between total malt protein and soluble wort protein is referred to as the S/T ratio or Kolbach Index, and is simply the amount of protein in solution in the laboratory wort divided by the total protein of the whole malt (multiplied by 100). The S/T ratio is another of several indicators of modification. This is because as malting progresses, proteins which may not be soluble in water, are broken down into soluble polypeptides and amino acids. For American 2 row varieties numbers between 41 and 46 indicate good modification. Higher numbers would indicate over-modification, while a Kolbach index below 40 would indicate an undermodified malt (for two row American pale malts). Note that there is a great deal of variability in this number, and variety, malting conditions and total protein content play a role in this measurement. As such, this ratio, taken alone, will not give an accurate picture of the level of modification.

Coarse-Fine Difference
C-F difference is difference between the fine and coarse grind HWE on a dry basis. The smaller the difference between coarse and fine extracts, the better the modification of the malt. This indicates how easily the contents of the malt can be extracted. This measure is especially important when times and temperatures of mash are restricted or the mash must be runoff through a deep bed (larger particles necessary). Unfortunately, C-F difference is a measure of a small difference with a relatively large margin of error. For North American varieties, a normal C-F difference would be around 1.8. A high C-F difference could indicate undermodification, while a lower number may indicate over-modification.
Free Amino Nitrogen
Free Amino Nitrogen (FAN), also referred to as α amino nitrogen is a measure of the amount of simple amino acids in solution. The amount of free nitrogen ends on amino acids, polypeptide chains and proteins. 100-300 mg/100g (soluble nitrogen) is common, but when brewing an all malt brew, lower is better. Because these are the first nutrients for the growing yeast cells, the FAN can affect fermentation performance and flavor generation as well. Because the side pathways to amino acid degradation and formation are both important to flavor generation, both high and low FAN’s can result in more intense flavor profiles. During cool mashing the FAN of a mash will increase as the polypeptides are broken down into amino acids.

Diastatic Power
Diastatic Power or DP, is often reported in °Lintner (ASBC). To the brewer Diastatic Power describes the enzyme potential of the malt. The DP is determined in the laboratory by the amount of starch in a known solution that is digested in a specific amount of time after the sample malt is added. The more enzyme potential of the malt, the more starch digested. DP relates to the total of α and β amylase. α amylase is measured separately by the activity on a special starch solution (DU, see below). These numbers give the brewer a comparison of the ability of a particular malt to reduce carbohydrate to fermentable sugars during the mashing process. The higher the number the faster the potential of this degradation. The rate of starch degradation is also controlled by temperature and mash thickness. Current North American barleys, when malted adequately, have plenty of enzyme potential for all malt brews. Some six row malts have high enough DP to not only degrade the malt starch, but also additional starch provided by adjuncts, up to 40 or 50 % in some brewing operations. When moist enough to be active, these enzymes are heat sensitive. That is one reason that the maltster must allow the green malt to dry below 15% in the kilning process before applying higher heat levels (160° F; 70°C). The higher heat levels used earlier in the kilning process while the malt is at higher moisture levels creates the color and flavor for specialty malts, but some enzymes are sacrificed in the process.

Dextrinizing Units
DU primarily measures the α amylase activity of the malt. North American malts typically have more than enough α amylase. About 40 DU is normal.

β Glucans
Not commonly found on maltsters analysis sheets, this β-glucans should be as low as possible, in the range of 3-3.5%. β-glucans are not desirable since the create problems with solid/liquid separation (both in the lauter, and later during filtration) and can cause haze. Some of the β-glucans present in malt can be broken down during mashing, particularly during the “protein rest” portion of a temperature profile mash.
Specialty Malts
Specialty malts are defined as any malts other than pale malts. They are used to give both flavor and color components to the beer. Some specialty malts are used for extract, but more often they impart body and foam retention in the form of dextrin.

There are many different types of specialty malt products, but they all basically fall into three different classes:

• Light Malts
• Caramel Malts
• Roasted Malts

Each of these classes contains many types of malts, each with its own unique flavor profile. But the malts within each class share the same methods of production. We will examine each class in turn, giving examples of malts falling into each category.

Light Malts
Light malts are made from slightly overmodified pale malt, and in many cases the “thins” are used. The main difference between light malts and pale malt is that time and temperature profile of the kilning. Light malts are cured at high temperatures (90-110°C) to give more color and flavor components. This also tends to result in a lower enzymatic capability.

Munich Malt
Munich Malt is a highly kilned malt that imparts a pronounced grainy flavor (concentrated malt flavor) and a deep golden color. It is very useful in heavily hopped beer to balance between color, hops and malt flavor. It is sometimes used instead of standard malt in very dark beers. Although the amylase enzymes are less than a standard malt, there are sufficient enzymes to allow trouble-free brewing. Common usage is from 10 - 15% in heavily hopped Ambers and up to 80% in Dark beers. Used in production of dark lagers. Munich malt gives a color increase towards golden to orange hues.

Vienna Malt
Can be used as the basic malt in a brew, as it has good Diastatic Power (DP), and good extract as well. Color is typically 3-4°L, and it will give a deeper golden/red color than standard pale malt. Increases general malty character of the beer, it is often used for dark lagers. Vienna malt is a highly kilned malt with a color and flavor profile about midway between the standard brewers and a Munich Malt. It is used primarily in light ambers for a gold to orange color and to slightly enhance the grainy flavor.

Smoked Malt
These malts are produced by kilning with a fire from various woods, or in some cases peat. The Rauchbiers of Germany use malt smoke with beechwood to produce their beers in Bamberg. Many other woods can be used to smoke malt all giving different, and often pronounced, flavor profiles. Peated malt gives an iodine flavor, and this malt is traditionally used for producing Scotch whisky, not Scotch Ale.

Caramel Malts
The second class of specialty malts is caramel malts, which require not only a different process but also different equipment in their manufacture.

Caramel malts are produced by taking fully modified green malt (un-kilned) with the correct amount of moisture (42-45%) which is then heated to start conversion and
liquefaction of the starches. This is referred to as “stewing” and this is very similar to the mashing process. Starches converted to sugar, and proteins are hydrolyzed to free α amino nitrogen. Once the conversion is complete, the malt is dried with normal kilning procedures and then roasted to the desired color. This entire portion of the process is carried out in a roasting drum, a specialized piece of equipment for roasting malt. Roasting drums are basically a modified version of a coffee roaster, which allow heat to be applied directly to the malt with hot air, or indirectly by heating the drum to produce a stewing effect.

CaraPils® Dextrin Malt
These are a modified crystal malt, with lower color, sweet with little caramel flavor and less roasted flavors than crystal or caramel. They give the following characteristics in beer:
• Add mouthfeel, in the form of dextrins
• Increase foam stability
• Aid in physical stability of beer (they act as an antioxidant)
Popular in the production of lagers, especially low alcohol lagers. These impart a light color, with lots of limit dextrins. Can also balance the body and flavor of darker beers and ales. CaraPils® is a very hard crystalline kernel with a glassy endosperm. The malt is used to add body (mouthfeel) and to improve foam stability and shelf-life without imparting flavor or color. The kernels look dark grey but actually contribute less soluble color than a standard brewers malt. The quantity used normally ranges from 1 - 7% depending on the desired amount of non-fermentables (residual extract).

Crystal
This specialty malt is often called simply caramel malt, and most maltsters have several different gradings of this malt, all rated by color. Crystal is the only malt where a full biochemical conversion takes place outside of the mash tun. Roasting carried out in three stages:
1) Surface moisture is dried off (5 min @ 50°C)
2) Stewing of the malt where the starches are converted to sugars (40 min @ 60-75°C)
3) Drying and coloring period (1.75-2 hrs @ 135°C)
Imparts fermentable extract and dextrins, and a caramel to roasted burnt sugar character. Many of these characters arise from the caramelization of the sugars produced during the stewing stage. Crystal malt is used in all amber, bock, Octoberfest, porter and stout beer types as well as ales for its coloring value and sweet flavor. Additionally, crystal provides body (mouthfeel), improves foam stability and shelf-life. Crystal Malt is characterized by "glassy" centers. Usage rates range from 2 - 50% depending on the type and style of beer desired.

Roasted Malt
The third category of specialty malts are the roasted malts. These malts are produced using a roasting drum, but unlike caramel malts, the raw material used is finished pale malt.
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Black Malt
High color malt, traditionally used in porter, but popular in all dark beers. Gives some harsh astringent flavors, but less than roasted barley. Black malt is a highly roasted barley malt used as a coloring agent. Special production equipment and processes enable achievement of a bland flavor profile (relatively speaking), permitting it's use in lower gravity beers. It is useful in providing color to "lite" - type beers as well as the porters and stouts.

Chocolate Malt
Similar to black malt, but roasted for less time at a lower temperature, giving less color, and less astringent/bitter characters. Chocolate malt is often used to impart a red color to beer. It yields a distinct dark chocolate flavor; a flavor that enhances the characteristics of porter.

Amber Malt
A lightly roasted version of chocolate malt, with a dry, baked flavor. Often described as “earthy”.

Roasted Barley
Unmalted barley is roasted with direct heat for over two hours developing a dark color to produce roasted barley. Primarily associated with stouts, this barley can give an astringent flavor. Black barley is a roasted barley that gives color values similar to black malt; however, it is not interchangeable with Black malt. Black barley provides a sharp, almost acrid, flavor characteristic of stout. It contributes a dryness to stouts and porters.