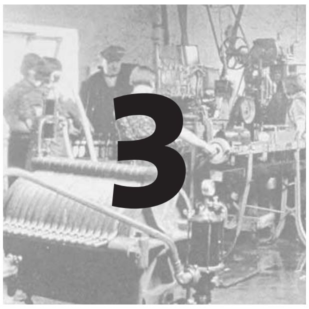


3 Ingredients Used in Brewing Beer

Brewing ale requires the brewer to use art, craft and science along with a balance of natural and fermentable ingredients and skilled processes. On the Fowler's Fellowship Programme you will join in their selection and share in these processes.

3.1 Malting Barley [or 'Making Malt from Barley']

Brewing starts with barley which is normally simply referred to by brewers as the 'malt'. And since the starches found with barley cannot be directly fermented they must be converted into a fermentable form, by malting them. To do this the grains of barley are soaked in water and allowed to germinate. Then they are heated and 'turned' regularly, either in the traditional floor maltings that still give picturesque landscapes or in huge rotating drums. This is called 'drying the malt'.

When germination has unlocked the rich natural sugars in the barley, the grains are heated in a kiln to ensure that they are dried to the correct moisture content (5%) to prevent deterioration due to mould and fungal growth etc and then roasted to the desired colour. The degree of heat used affects the type of malt that will be produced, and its flavour. Accordingly the brewer must give it careful attention. High heat produces dark roasted malts, lesser heats lighter coloured malts. During the malting process, the hard kernels of the grain are converted into a friable, biscuit like material that can be readily crushed and wetted with water as the brewing process moves on.

Malt does not just allow us to produce alcohol. It also eventually gives the colour and the body of flavour of the beer we create. Brewers also use additional ingredients such as fermentable starches and sugars [of which more below]. These additional ingredients will normally be used to improve the appearance of the head, assist fermentation or act as preservatives.

Malted barley, or malt, contains two major components. They are vital to the brewer and must be present in a proper ratio to one another other and within certain parameters for the malt to be good for brewing. The first of these is starch.

Starch is a complex carbohydrate which is converted into simpler forms during malting, then converted to a range of sugars during mashing, and ultimately converted to alcohol and body during fermentation. Without this starch there would be no beer, and the more of it there is the greater is the efficiency or productivity of the malt i.e. the greater will be the fermentable extract achieved from the malt.

Protein is the second of the vital components of the malted barley. Protein is not a single substance but a group of complex nitrogenous substances. During malting high-level proteins and other nitrogenous substances contained in the outer layer of the grain are converted into simpler proteins, soluble proteins, amino-acids, peptides, and enzymes. All of these can be regarded as nitrogenous components.

Malt with too much protein will cause a hazy beer. A protein haze is both tasteless and harmless, but it will certainly spoil the appearance of the beer. A protein haze manifests itself in two basic forms – permanent haze and chill haze.

Permanent haze is always present and caused by semi-soluble proteins that come out of solution but remain in suspension. Chill haze is a similarly derived haze that manifests itself when the beer is chilled but which usually disappears when the beer is warmed up again. This occurs because the solubility of some proteins in the malt decrease with temperature. The effect of chill haze can be quite dramatic. Beers can change from golden clarity to dark, murky, opacity with a temperature change of as little as 4°C below room temperature.

Differing types of malt can of course be created. Some of the most frequently encountered are as follows:

- **Pale Malt** – this is used for almost all British beers. It is a high quality, low nitrogen, malted barley, lightly kilned during drying to provide a light colour. There are several well known varieties e.g. Maris Otter [the most expensive] Pipkin, Halcyon and Golden Promise' Good quality Scottish pale malt as used with the traditional single-temperature infusion mash should be low in nitrogen at approximately 1.55%.
- **Pilsner Malt** – this is usually referred to simply as lager malt and is the palest malt currently available and is used to make the pale-coloured Pilsner-type lagers.
- **Mild Ale Malt** – this is a cheaper grade of malt made from barley that has a higher nitrogen content than is considered acceptable for ordinary British pale malt. Typical nitrogen levels will be in the range 1.6 to 1.65%. The higher nitrogen content has the benefit of giving mild ale malt a higher diastatic activity than pale malt but at the expense of extract.
- **Scotch Whisky Malt** – the best quality whisky malts are kilned over peat thereby gaining a rich smoky flavour for the beverage. In earlier times, when the majority of malts were smoked, it is highly likely that the malt used for Scots and Irish ales would also have been smoked over plentiful local peat, whereas English malts would have been smoked over hardwoods. Those burnt at a higher temperature produced darker malts. The original Guinness malt was certainly smoked over peat.
- Other malted cereals are available viz – wheat, rye, oats, spelt and in Africa, sorghum and millet and (if you ask the right people nicely), peas and beans (as in the nursery rhyme, oats and beans and barley grow).

3.2 Malt to Wort ... and Beyond

Malts need to be crushed or cracked before use in the 'mash tun'. The stock of malt must be carefully stored in dry conditions at fairly stable temperatures. Crushed malt absorbs moisture from the air quite readily becoming what is known as 'slack'. This can cause the malt to lose its efficiency and give rise to the danger of 'throwing' a haze later. In Fowler's Microbrewery, the malt is purchased ready crushed. For reasons of convenience (room), equipment cost and legislation (cost of complying with HM factory, inspectors requirements as regards installing ventilation and explosion damping equipment required for milling) malt dust will explode under certain conditions).

In Fowler's microbrewery the malt is crushed into a grist and then mixed with hot water. A thick porridge like liquid is left in the mash tun for several hours while the sugars in the malt dissolve. When the liquid has absorbed as much sugar as possible, it is run off through the drilled base of the vessel. The resultant liquid is now called 'wort'. The wort is boiled with hops in the copper for at least an hour. After boiling, the hopped wort is separated from the boiled hops. The wort is then cooled and run into fermentation tanks where yeast is added.

3.3 Other Ingredients Used

- **Grits** – the basis of a grit is de-germed grain. Most of the unwanted nitrogenous matter and oil is contained in the outer layer of grains called the germ. Grits are made by a two stage milling process which first removes the outer layer of the grain and then mills the remaining endosperm or kernel into smaller pieces. Removing the outer layer gives a product that is mostly starch containing less then 0.1% nitrogen and less than 1% oil. Oil if left in the grain will interfere with the head formation and retention properties of any beer.
- **Flakes and Torrified Cereals –** flakes are cereals are made from de-germed grain like grits, but they have also followed a secondary processing stage. Flakes are made by a wet heat process. The miller allows the de-germed grain to absorb water and swell, either by steaming or soaking, and then passes it through heated rollers. Torrified grains are made by a dry heat process which rapidly heats de-germed grain, either by microwaves or red hot sand, causing the endosperm to explode. In both processes the

heat treatment significantly gelatinises the starch, rendering it open to attack by the mash enzymes without further treatment. Both products have low nitrogen and oil content.

❖ **Sugars –** many brewers use copper sugars, often sucrose. The invert sugar used by brewers is made from partially refined cane syrup and therefore does impart some flavour. It is also usually caramelised which again imparts flavour and also colours the beer. Brewers have traditionally used invert sugar because they find that ordinary sugar gives a tang to the finished beer and causes disproportionate hangovers.

3.4 Hops

The varieties and relative quantities of hops employed determine some of the predominant characteristics of any given beer. They provide its bitterness but they also supply its aroma and flavour in varying degrees, and they can be used at several different stages of the brewing process to vary the impact of these characteristics. The hop characteristic of a beer is also the most difficult aspect to emulate and provides the most variable aspect of beer production. This is because hops are the ingredient with the most notoriously inconsistent quality in all beer making. Not only are different varieties of hop distinctly different in character but hop flavour mellows with age, and the same variety of hop grown in a different soil or climatic region will be subtly different.

❖ **Bittering Hops** – Bittering hops are those which are put into the copper at the beginning of the boil to impart the necessary bitterness to the beer. Hops put in at this stage also supply components that act as preservatives and thereby improve the shelf-life. Alpha acid is the primary bittering ingredient of a hop. Hops which are rich in alpha acid are the most economical to use although any variety of hop can be used for bittering. However, high alpha-acid hops, the most bitter varieties, usually have a harsh flavour and aroma, whereas low-alpha hops generally have the best aroma. It is important not to confuse hop flavour with bitterness because they are not the same thing.

  High-alpha hops are usually hybrids bred especially for high yields in the hop garden. The high yields make them cheaper to buy and their alpha-acid make them economical to use as a bittering hop in the copper, it is for the reason of increased alpha acid production per acre (hectare) that many Briish hop farms have disappeared (reduced acreage required for a given alpha acid yield). The most common bittering hop used in Scotland is Target, but its flavour and aroma are regarded as unpleasant by many brewers so it is often used in conjunction with other varieties.

❖ **Aroma Hopping –** The aroma elements of hops are volatile and will disappear with the evaporated steam thus, it is common practice for brewers to restore lost flavour and aroma by adding hops during the last fifteen or twenty minutes of the boil. This is known as late hopping and a quantity of high quality aroma hops equivalent to some 20–25% of the main batch, is usually introduced. Late hops do not contribute much bitterness to the brew because their short boiling period. However, the short boiling period does permit some hop flavour to be extracted and allows some of the harsher more volatile flavour and aroma components such as higher hydrocarbons, to be driven off with steam. Too long a boil, however, and some of the more desirable components may also be driven off.

❖ **Hop steeping –** Another method of imparting additional aroma to a beer is to steep a quantity of hops in a hot wort when the boil is complete and leave it to stand for a period. This is used as an alternative to dry hopping. The procedure is similar to late hopping inasmuch as a quantity of the finest aroma hops is added to the boiler either just before or just after the heat is turned off. The infusion is then left to stand for about half an hour before the boiler is turned out.

❖ **Dry Hopping –** Dry hopping is an old-established method of imparting additional hop aroma to a beer and is the term used to describe the practice of adding a few dry hop cones to the cask during filling. They are sometimes referred to in commercial brewing as “bung-hole hops”. During maturation essential oils from the hops diffuse into the beer adding the desired aroma. Dry hopping does not increase the bitterness. Many suppliers now print the measured alpha acid of their hops on the packaging, but the typical average alpha acid content of the most common varieties of hops are given below:

Average alpha-acid of common hop varieties

	Variety %	*Alpha Acid Application*
Bramling Cross	6.0	Aroma Hop
British Columbian	7.0	General-purpose hop
Bullion	7.9	General-purpose hop
Cascade (USA)	6.0	General-purpose hop
Challenger	7.7	General-purpose hop
Goldings	5.3	Aroma hop
Fuggles	4.5	Aroma hop
Hallertau	7.5	Aroma hop
Mount Hood (USA)	5.5	Aroma hop
Northdown (seeded)	8.0	General-purpose hop
Northdown (seedless)	10.3	General-purpose hop
Northern Brewer	7.6	General-purpose hop
Omega	9.7	High-bittering copper hop
Progress	6.2	Aroma hop
Saaz (Zatec)	5.5	Aroma hop
Styrian Goldings	7.0	Aroma hop
Target	11.2	High-bittering copper hop
Tettnang	5.0	Aroma hop
Whitbread Golding	6.3	Aroma hop
Willamette (USA)	5.5	Aroma hop
Yoeman	10.6	High-bittering copper hop
Zenith	9.0	High-bittering copper hop

❖ **European Bittering Units [EBUs]** – European Bittering Units [EBUs] or International Bittering Units, are a world standard method of assessing the bitterness of beers. The bitterness of a beer is computed as:

$$\text{EBU} = \frac{\text{Weight of hops x alpha acid x utilisation}}{\text{Volume brewed x 10}}$$

To find the weight of hops required in order to produce a given bitterness in a given volume of beer the formula can be re-written thus:

$$\text{Weight of Hops} = \frac{\text{EBU x 10 x Volume brewed}}{\text{Alpha acid x utilisation}}$$

Where Volume is in litres, Weight is in grams, Alpha acid in hops is % and Hop utilisation is also %.

- **Hop Utilisation** – The hop utilisation figure in the equation corresponds to the efficiency of the boil and is dependent upon (i) the vigour of the boil; (ii) the length of the boil; (iii) the specific gravity of the wort; and (iv) the equipment used. The utilisation achieved will be in the range of 20-35% under ideal conditions with the hops boiling freely vigorously in the wort or one and a half hours. Because of the variation in methods and technique between brewers, and the variations in quality of the hops available, we have assumed that a typical hop extraction efficiency experienced by brewers will be at a lower end of this range, namely 20%.

$$\text{Weight of Hops} = \frac{\text{EBU x volume brewed}}{\text{alpha acid x 2}}$$

Therefore to achieve 25 units of bitterness in 27 litres of beer using Golden hops at an alpha acid content of 5.3%

$$\text{Weight of Hops} = \frac{25 \text{ x } 27}{5.3 \text{ X } 2} = 64 \text{ grams}$$

This assumes a good 1.5 hour vigorous boil. EBUs apply only to the bittering hops i.e. the hops that are put into the copper at the beginning of the boil. Late hops do not contribute much bitterness to the wort due to the shorter dwell time in the copper. They only restore aroma which has been lost during the boil.

- **Forms of Hops** – Hops are available as whole leaf, plug and pellet forms. Whole hops are the traditional form and the most appropriate for our real ale purposes. These come as hop cones, or flowers, in their natural state.

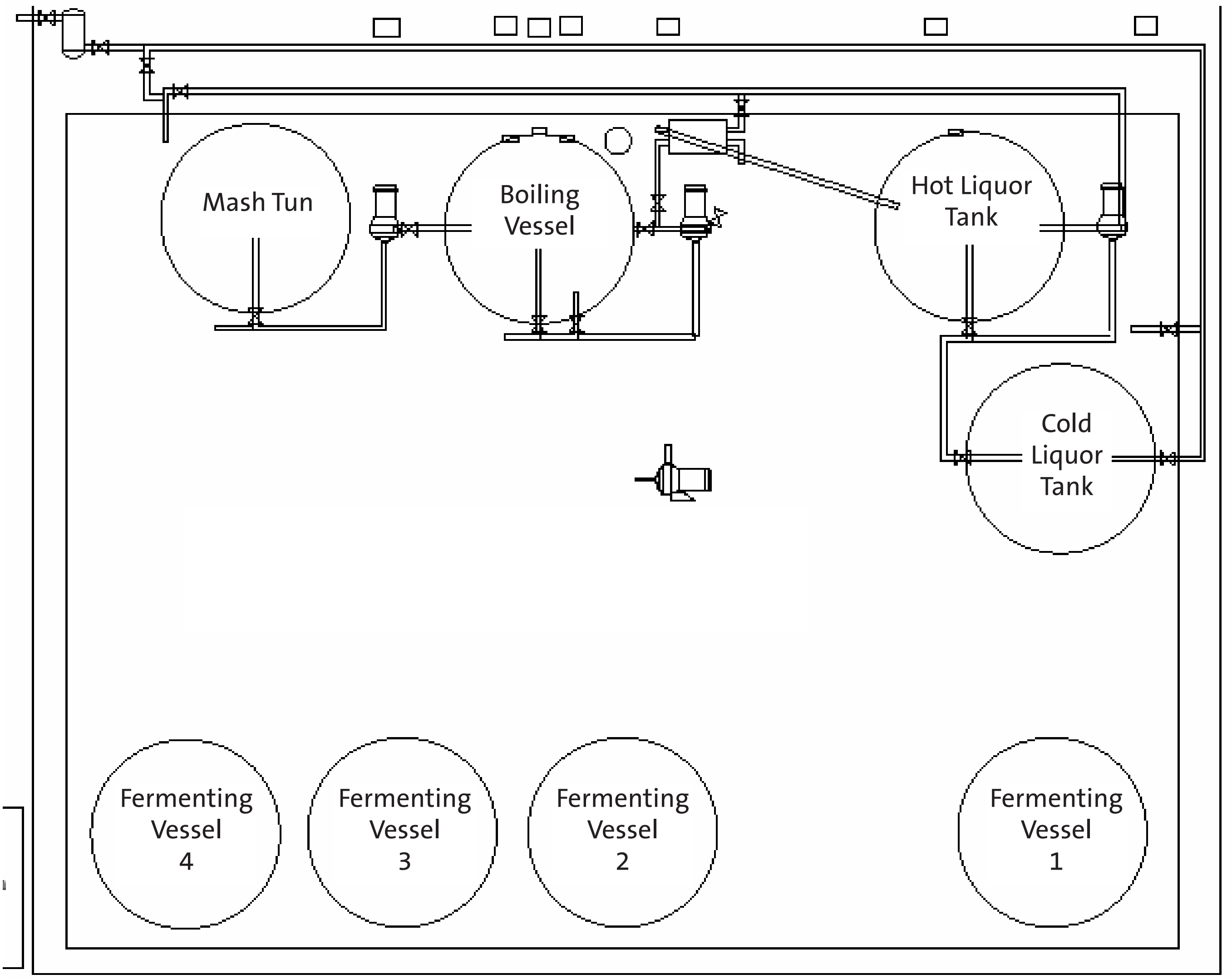
3.5 The Yeast

Yeast is one of the most important ingredients used in the making of beer. The quality, flavour and aroma of a beer are all affected by the type of yeast used. It is a microscopic fungus which feeds off the fermentable sugars producing alcohol and carbon dioxide as waste products. Yeast cells divide and grow rapidly in this warm sugary liquid.

There are various differing sugars in the wort. Simple sugars such as fructose and glucose are present but there are also more complex sugars such as sucrose and maltose. Sucrose is regular domestic sugar and maltose the sugar derived from our malt. Yeast is quite happy to ferment maltose, fructose, glucose and sucrose and these ferment into alcohol disappearing completely from the wort.

Within a few hours a scum appears on the top of the wort which rapidly builds into a great foamy yellow-brown crust although fermentation is taking place throughout the liquid. When fermentation has finished the resultant “green beer” is run into conditioning tanks for several days. There are also some higher sugars that brewer’s yeast is unable to attack [or only very slowly] and they remain in the green beer. They provide body, mouthfeel, maltiness and some residual sweetness.

- **‘Top Working’ Yeasts** – are usually referred to as ‘ale’ yeasts and are characterised by the forming of the thick foamy head during fermentation. They work at relatively high temperatures of 16–20°C and tend to produce fruity ester and flavour compounds that add to the character of the beer.
- **‘Bottom Working’ Yeasts** – are known as ‘lager’ yeasts where most of the yeast settles at the bottom of the vessel during fermentation. The other distinctive characteristic of lager yeast is that it will work at much lower temperatures than its top-working counterpart and produces blander flavours.
- **Liquid Yeasts** – at The Prestoungrange Gothenburg we shall normally be using liquid yeast. It performs true to type, is virtually bacteria free and available in a far wider range of types and strains than is possible with the more conventional yeast.



Liquor and process pipe layout

4 Brewing Fowler's Ales

4.1 Operating the Mash Tun

PREHEATING THE MASH TUN

- ❖ Connect the liquor hose from the liquor mixer and allow it to hang into the mash tun.
- ❖ Ensure that the hose is not kinked.
- ❖ Open and close the relevant valves in the route HLT to water mixer but leave the hot liquor valve to the water mixer shut meantime.
- ❖ Start the liquor pump.
- ❖ Open the hot liquor valve to the water mixer and allow hot water to flow into the mash tun until the plates are covered.

MASHING

- ❖ Despite the water having the chlorine removed by an inline active carbon filter, add to the mash tun the correct quantity of water treatment necessary to produce the required chemical composition of the water relative to the style and volume of beer being brewed.
- ❖ Open the relevant valves from the CLT and HLT to the water mixer but not the cold and hot liquor valves at the water mixer.
- ❖ Open the hot liquor valve at the mixer.
- ❖ Start the HLT pump.
- ❖ Get the bags of milled malt ready to pour into the mash tun and start pouring. An assistant with a mixing paddle is a good idea.
- ❖ Adjust the flow of hot liquor to give thick but fully hydrated mash.
- ❖ Adjust the liquor temperature by gently opening the cold liquor valve.
- ❖ Readjust the hot and cold liquor flow rates to produce a thick fully hydrated mash at the desired temperature.
- ❖ The mash water – grist ratio should be 2.4-2.7:1 ie 2.4/2.7 litres water: 1 kilo grist.
- ❖ Stand the mash undisturbed for one and a half hours for saccharification to take place.

WORT RUN OFF

- ❖ The MASH TUN plates are designed to allow the run off of wort up to 600 litres per hour trying to run faster than this may buckle the plates.
- ❖ Start running off slowly and increase as the run off proceeds.
- ❖ Check the clarity of the wort and run until the SG drops to 1001.5 (test with the refractometer) or the wort becomes unduely cloudy. Check for complete saccharification with iodine indicator (dense blue-black if starch present).