Getting a head

First impressions count. Most consumers drink with their eyes and appearance is often more important than taste.

When ordering a pint the consumer will judge the beer by:

- **Clarity**
- **Colour**
- **Foam**

Beer is a supersaturated solution of gas. In the case of lager this is carbon dioxide, but in the case of ales may be a mixture of carbon dioxide and nitrogen gas. When the beer is poured out (either from a bottle or draught) the gas bubbles break out from solution and rise to the top of the glass. This effect is called "tracing" and many beer glasses have roughened bases inside the glass, which act as nucleation sites, to encourage tracing.

The foam in beer is generally considered to be the head on the top of the glass. There are also other important visual effects from the foam adhering to the side of the glass called "Cling" or "Lacing". This effect is particularly noticeable in beers, which form larger heads and have better foam performance.

In mainland Europe most draught beers can be served with large heads without attracting the wrath of Weights and Measures. Unfortunately in the UK the pint glass is a legal unit of dispense and unless over-measure glasses are used, this limits the amount of head permitted on a glass of draught beer.

Technical Summary 7

By Tim O'Rourke

The seventh in this series of technical summaries for the Institute & Guild's AME candidates.

When considering beer foam it is necessary to look at two complementary conditions in order to ensure a satisfactory foam performance:

- The head formation, which is the ability of beer to form a head when poured.
- The head retention, which is the ability of beer to retain a head once it has formed, after dispense.

It is necessary to have adequate head formation in order to ensure sufficient foam remains during the consumption of the beer.

In some markets bottle beer is drunk directly from the bottle and head has no impact on the quality perceptions of these beers.

The structure of beer foam

The formation and breakdown of beer foam occurs in four stages:

- bubble formation
- drainage
- coalescence
- disproportionation.

Bubble formation occurs where bubbles are formed from a supersaturated beer at nucleation sites in the glass. Gentle pouring and low beer surface tension encourage the formation of smaller bubbles, which produce more stable "creamy" type foam.

After bubble formation drainage of beer from the foam by gravity starts to occur and the bubbles start to shrink and collapse. The rate of drainage can be reduced by factors such as small bubble size, the amount of hydrophobic interactions, reduced surface tension, and increased liquid viscosity.

Other components, such as lipids from food or brewing materials, dirty glasses and some cleaning fluids disrupt the bubble film causing the foam to collapse.

The final stage in foam collapse is due to disproportionation when the gas from smaller bubbles, which is under higher pressure, diffuses into the larger bubbles, which is under lower pressure, creating

FIGURE 1: EFFECT OF HYDROPHOBIC PROTEINS IN REDUCING SURFACE TENSION

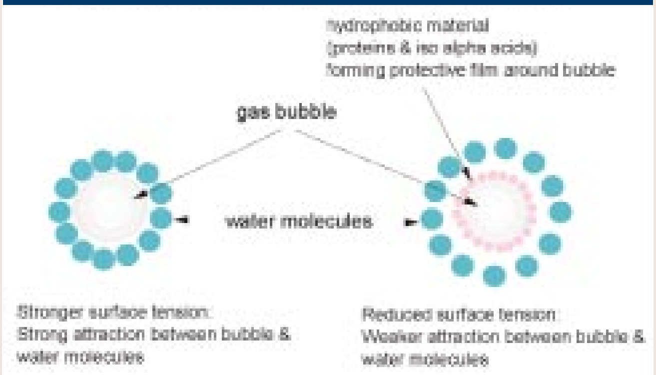

Photo 1: Normal Beer Foam in a lager beer from CO2 the bubbles are larger and more open.

Photo 2: A tight crisp foam on an ale which has both nitrogen gas and CO_2 producing a much creamier head.

Photo 3: Foam sticking to the glass after the beer has been drink is called Cling or Lacing.

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larger “bladdery” bubbles, which collapse more quickly.

Nitrogen is less soluble in beer than carbon dioxide and hence the bubble size is smaller. This means that disproportionation is slower for beers with mixed gas giving the “creamier” appearance and better foam stability.

Factors which improve foam performance

Anything which encouragers the formation of gas bubbles and gas breakout improves the stability of the gas bubbles and will consequently improve the presentation and foam stability of the beer.

The presence of dissolved gas

Bubbles have to be created in order to form a head. This requires a minimum level of dissolved carbon dioxide or mixed gas (mixed carbon dioxide and nitrogen). Typical values are:

- **Lager beers** – between 5 and 6 g/l carbon dioxide
- **Ales** – (usually but not always lower) at between 2.5 and 5 g/l. The carbon dioxide content is often supplemented by 15 to 20 ppm nitrogen gas for mixed gas dispense.

Bubble formation will also be influenced by external factors such as temperature. The solubility of carbon dioxide in particular increases with a decrease in temperature, and hence beers dispensed at low temperatures (for example very cold lager dispense) will produce less foam unless the carbonation level is increased proportionately.

Foam stabilization by reducing surface tension

The main factor which reduces the surface tension in the foam and stabilizes the bubbles is hydrophobic (water hating) protein or polypeptides. These hydrophobic proteins come from the raw materials principally the malt (see figure 1).

Only a small proportion of the malt derived protein is responsible for foam stabilization. The balance of the protein is used as yeast nutrients (amino nitrogen) or can cause colloidal instability (chill and permanent haze). Considerable research has been carried out to identify the exact fraction of protein responsible for improving foam stability.

Foam-positive proteins can be divided into two fractions based on molecular weight:

- high molecular weight (HMW, 35–50 kDa) fraction containing mainly protein Z 23
- low molecular weight (LMW) fraction containing LTP1 (lipid transfer protein 1) and a mixture of hordein and glutelin fragments.

These proteins form a ring around each bubble reducing the relative surface tension and stabilising the foam.

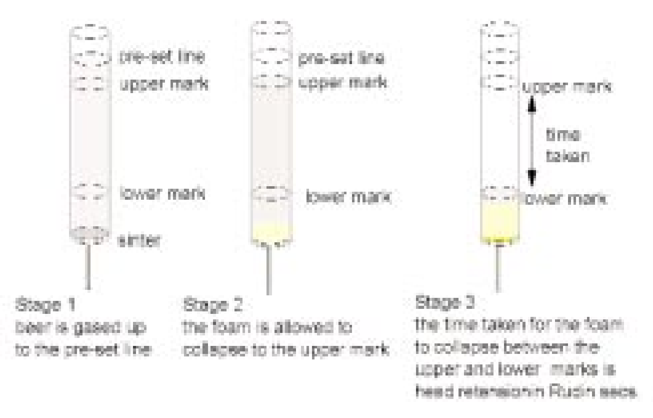
Factors which increase the amount of these proteins in the packaged beer and will subsequently improve the head retention :

- Grist with malt made from high nitrogen barley and all malt grist will contribute increased nitrogen to the wort.
- Poorly modified malts have less protein breakdown resulting in worts with higher protein content.
- It is necessary to avoid excessive wort boiling or excess use of kettle finings which increase the amount of protein removed as hot and cold break.
- Every time the beer foams it uses up some of the precious foam stabilising proteins, which are left behind as a crust on the vessel walls. Avoiding beer fobbing during boiling and all subsequent transfers reduces the loss of foam proteins and ensures more continue into the packaged beer.
- Protein compounds can also be lost during processing through maturation and tight filtration. Care in these areas will improve foam potential.
- Foam proteins are susceptible to breakdown by proteolytic enzymes, which can come from the yeast particularly if the yeast has been stressed (old yeast or poor yeast handling) and these along with any other proteases added can seriously reduce the foam potential of the beer.
- It is reported that there is a greater loss of foam potential in a beer brewed at high gravity when compared to the similar product brewed at sales gravity. It has been shown that foam potential proteins are lost more readily from higher gravity worts. Currently there is no simple explanation for this observation.

In addition to the hydrophobic proteins, iso-alpha acids from the hops also exhibit hydrophobicity and hence make an important contribution to foam stability. The hops are thought to help bridge between the bubbles adding additional support.

Some brewers use reduced hop compounds to improve foam stability.

DETERMINATION OF HEAD RETENTION BY THE RUDIN METHOD



Reduced hop compounds such as tetra-iso-alpha acids are made from hydrogenating the double bonds in iso-alpha-acid.

As well as giving the hop compound protecting against break down under ultra violet light it also makes the molecule more hydrophobic, thus increasing its foam stability when compared to standard iso-alpha acid.

Factors which produce poorer foam performance

It follows that anything (including grist composition), which has an effect on reducing the level of proteins and iso-alpha acid, will tend to produce beers with poorer foam performance.

However, the foam potential can also be reduced by the process conditions, for example excess foaming during transfers, which will reduce both protein and hop compounds and through the effects of protease enzymes, which will breakdown the foam proteins.

Lipids, grease and detergent are detrimental to foam performance. Lipids can form a wall around the bubbles preventing the stabilising action of hydrophobic proteins and iso-alpha acids, thus increasing the surface tension causing the foam bubbles to collapse.

The fatty compounds can be picked up during the brewing and dispense process, with one of the most common areas being poor quality glass washing.

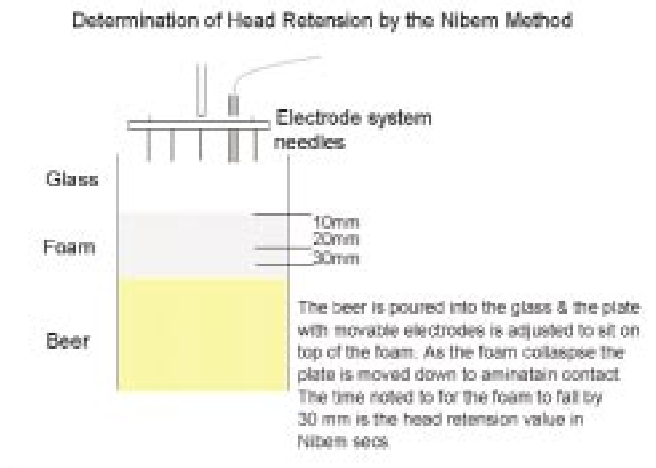
Beer contains a lipid binding protein, which comes from the raw materials and has the ability to reduce lipid induced foam collapse.

However, many brewers chose to add propylene alginate glycol (PGA) as a process aid, which binds to bubble walls and protects them from penetration by lipids.

The measurement of foam stability

There are two principle methods used for evaluating head performance:

DETERMINATION OF HEAD RETENTION BY THE NIBEM METHOD



Determination of Head Retention by Rudin

Principle: it measures the length of time it takes for the foam from gassed up beer to collapse between two set points in a narrow tube.

Method: Degassed beer is placed in a narrow tube and CO_2 is introduced into the bottom of the tube. The beer is gassed up to form a foam head until a pre-set line is reached. The speed with which the foam collapses between two marked points is measured.

Standard: A satisfactory head is one that lasts for longer than 90 seconds by Rudin method. This method is better at measuring the foam potential of the beer rather than the actual performance of the beer in trade since it introduces its own level of carbonation.

Advantages

- It measures beer *intrinsic* ability to foam – i.e. foam potential.

- It eliminates the variations due to carbonation and as a dispense gas because CO_2 used to produce foam.

Disadvantages

- The narrow glass tube has large surface area to volume ratio and is not representative of the performance of the foam in a beer glass.Since additional CO_2 is added it does not truly reflect the actual performance of the beer in trade.

Determination of Head Retention by Nibem

Principle: it measures the time taken for the surface of foam to collapse by 10mm, 20mm and 30mm using conductivity.

Method: A standard pour is used to pour the beer into a glass. A movable plate containing three electrodes is lowered so that it just rests on the surface of the beer foam. As the foam collapses the signal received by the electrodes reduces. The plate moves down to maintain contact with the foam. The more rapidly the needles move down to maintain contact, the less stable the foam.

Standard: A satisfactory head is one that lasts more than 260 – 280 seconds by Nibem. Since no additional gas is added this method will give an indication of the performance of the beer foam in trade.

Advantages

- measurement gives a better indication of probable foam performance under real dispense conditions.

Disadvantages

- can be difficult to get reproducible results.

- susceptible to drafts and temperature.

Although these are the most common analytical methods used for measuring foam performance there are a myriad of other methods proposed and used to measure both foam collapse and assess lacing on the glass.

Many of the methods rely on visual assessments of the foam for both head retention and cling.

More sophisticated systems use computer and video camera technology or infrared analysis to automate the visual observations and to reduce the subjectivity of the methods.

Summary of the key factors affecting foam stability

Anything which encourages the formation of gas bubbles and gas breakout and improves the stability of the gas bubbles will improve the presentation and foam stability of the beer.

The following factors are important when producing the best foam on a beer:

- The beer should have sufficient levels of dissolved carbon dioxide or gaseous nitrogen to produce a good foam head

- The dispense temperature should be sufficiently warm to allow normal gas breakout.

- Small bubbles are required for the best head retention.
- Good quality malt with total soluble Nitrogen of between 0.5 – 0.75% ensures sufficient amounts of hydrophobic proteins are present in final beer. An all malt grist with low malt modification with the addition of wheat or barley will increase the level of hydrophobic proteins.

- Higher bitterness will increase the iso-alpha acid concentration, which helps foam stability. Better results are achieved if part of the iso-alpha acid is replaced with a reduced version such as tetra-iso-alpha acid to between 3.5 - 5 ppm).

- Care is required in the brewhouse to avid excessive breakdown of proteins during mashing or loss as hot and cold break. This requires the use of appropriate temperature and pH conditions for mash to allow survival of sufficient amounts of hydrophobic proteins.

- Care must be taken to avoid fobbing as this will result in the loss of both hydrophobic proteins and iso-alpha acids.

- Yeast handling and removal of tank bottoms is a priority to prevent yeast stress and the leaking of protease enzymes, which can damage foam.

- Better foam stability is obtained with beers brewed at sales gravity over those brewed at high gravity. Higher alcohol products (those with more than 7 or 8% alcohol by volume) tend to have poorer foam performance.

- Addition of propylene glycol alginate to combat the negative effects of fatty compounds.

- Good foaming beers can easily be ruined in trade. Good line cleaning and well rinsed glasses with approved glass rinse chemicals are required to avoid the risk of grease or detergent getting into beer. ■

Further Reading

1. Moll *Beers and Coolers*.
2. Hough, Briggs and Stephen *Malting and Brewing Science*.
3. Evan Evans et al Institute of Brewing Asia Pacific 26th Convention, *Beer Foam: Not Just Froth and Bubble.*