TAVERN HERO

Mike Heydenrych of the Department of Chemical Engineering has developed a research microbrewery, as part of a greater thrust by the University of Pretoria's Department of Chemical Engineering into the field of biochemical engineering.

→ *Professor Mike Heydenrych*

The brewing process

Malting
Barley is soaked in water for about two days, and then allowed to germinate in the presence of air, until the acrospires grow to about the same size as the barley seed. This green malt is then dried, and the brittle root tips are removed from the barley seed. The temperature of drying affects the colour that the malt will impart to the beer, but higher temperatures can destroy the enzymes that are necessary for the brewing process.

Brewing
Brewing is usually done as a batch process. The grist is prepared mainly from crushed barley malt, but it can contain various amounts of roasted malt or other adjuncts such as wheat, oats or maize. Water is heated to an appropriate temperature, and the mineral and pH profile of the water may be adjusted to suit the style of beer to be brewed.

The grist and water are then mixed in a mash tun (cask), where some incredible chemistry takes place. Enzymes that were released from the malting process convert the starch in the malt to fermentable sugars. Some enzymes also break down proteins to form amino acids – an important nutrient for the yeast. Brewers manipulate the time that the malt spends at various temperatures to tailor the character of the beer. Mash temperatures in the range 50-60^{o}C will degrade proteins, to provide the yeast with nutrients, but too much protein breakdown can result in a beer with a poor head retention.

Saccharification enzymes operate in the broad range from 60 - 72^{o}C. At the lower temperatures in this range, the beta-amylase enzymes are the most active. These produce primarily monosaccharide sugars, which are easily fermented by yeast. This will result in a dry beer, because few unfermented sugars will remain. At the higher end of the temperature range, alpha-amylase enzymes predominate. These enzymes break starch molecules at branch points, breaking the starches into oligosaccharides – sugars that starches find difficult to ferment. The resulting beer will be relatively sweet and cloying – suitable for styles brewed in the colder climates such as Scotland.

The sugary water, now laden with malt sugars, is called wort (pronounced wert). Wort is separated from the barley husks by draining the wort, and simultaneously rinsing the husks with water. This process occurs in a lauter tun. Many brewers combine the functions of mashing and lautering in a single vessel, as was done in the University microbrewery.

The clear wort is transferred to a kettle, where it will be boiled, and hops will be added to impart bitterness to the beer. The aim of the boil is to:

- Remove undesirable volatile flavours by stripping them out with the steam;
- Isomerise the hops to impart bitterness to the beer;
- Force proteins out of solution, and to agglomerate these proteins as "hot break";
- Add caramel-like flavours to the beer by exposing the beer to a high temperature for an extended period (Maillard reactions).

At the end of the boil, the hot break and hops (trub, pronounced "troob") settles into a pile, and the clear wort is drawn off, cooled through a heat exchanger, and collected in the fermenter.

Fermentation
Yeast is added to the cooled wort, where it starts its job of converting the sugars to alcohol and carbon dioxide. The best beer is produced by yeast that is unstressed – stressed yeast tends to produce off flavours. The brewer should be aware of the factors that contribute to healthy yeast. In particular, the yeast cells should be exposed to oxygen before, or at the start of fermentation, in order to build up their reserves and to multiply. The wort should also contain sufficient nutrients and be kept at a suitable temperature. Finally, the brewer must ensure that enough yeast has been pitched to complete the fermentation without the yeast cells depleting their reserves.

When fermentation is completed, and only the unfermentable sugars remain, the yeast separates from the beer, leaving a relatively clear beer that can be racked or drained off.

Maturation
Beer needs a period of maturation to smooth out its flavour profile. Maturation is a "mopping up" process of the by-products that the yeast may have formed during fermentation, particularly the removal of a buttery or butterscotch flavour called diacetyl. During this period, a well-made beer will clear totally, although most brewers filter the clear beer as a final polishing step.

Carbonation and packaging
Beer is carbonated by dissolving carbon dioxide gas into the clear beer, and it is then packaged for final distribution, typically in cans, bottles or stainless steel kegs (draft beer). Bottles and cans of the large producers are also pasteurised to give the beer a consistent shelf life.

The University Microbrewery:
The University microbrewery obtains malted barley from SA Maltsters in Alrode, but students can learn to do the other steps described here. This covers most of the main disciplines that are taught in Chemical Engineering: heat transfer (e.g. cooling down hot wort for the fermenter), mass transfer (stripping of volatiles in the kettle) and momentum transfer (pumping and lautering). Microbiology students can gain experience in yeast management – trying to maintain a happy population of yeast cells. Brewing provides a useful training ground for the general skills of students, but also provides specific training for students who wish to make a career out of brewing.

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