

MYCOLOGY ANSWERS

How are beer and lager produced and how do the fermentation processes differ?

SUSAN ISAAC

*Department of Genetics & Microbiology, Life Sciences Building,
University of Liverpool, L69 3BX*

Yeasts have been used to make alcoholic beverages since ancient times and the results have been enjoyed through the ages. Complicated apparatus is not essential, as many home-brew experts will testify, but these days fermentation technology is a carefully controlled and well researched science, giving rise to a reliable and uniform product. Beers, ales, porters, stouts and lagers are all produced by the fermentation of malted barley.

The starch of barley grain is not directly suitable for fermentation and must first be modified. The grains are sprouted in warm conditions and after a couple of days the germinating seeds produce amylolytic enzymes that enable pectolytic enzymes to convert much of the starch to sugars. The sprouts are heated carefully to 80°C, to kill them without destroying the activity of the enzymes. This malt is then mixed with other starch, from rice, wheat or maize, and this grist is "mashed", by cooking and steeping with hot water. The liquid which is then drawn off is a sweet wort which is used for fermentation. The actual process of mashing, in terms of temperature, time of heating and rest periods, are different for beer and lager, and all affect the flavours that enter the fermentation. The wort is boiled up with hops to add bitter flavours (from the acids and oils in the hops) to the ferment and is then sterilized and added to the fermentation vessel. Some antimicrobial compounds are also extracted from the hops and help to limit spoilage by contaminating organisms, such as wild yeasts and bacteria.

Carefully selected strains of yeast are inoculated (pitched) into the wort where they grow and multiply using up the sugars and other nutrient materials and releasing alcohol and carbon dioxide gas as waste products. Eventually, the yeast cells stick together (flocculation) forming masses of cells which either float or sink. This marks the end of alcohol production (attenuation) and also greatly

aids the removal of the yeasts from the finished fermentation. A surface scum of yeast cells may be skimmed off or the ferment may be drained away from settled cells. These days filters may also be used to clarify the resulting liquid.

Yeast cells actually have the ability to stick together from an early stage in their growth but flocculation seems to be prevented, at least in part, by the presence of sugars such as maltose, sucrose and glucose which occur in the wort. Towards the end of fermentation these sugars become depleted and levels of nitrogen also diminish. The yeast cells then stick together, probably by virtue of lectins (proteins which bind to specific sugars) present on the outside of the cell walls. These surface lectins attach to receptors on the walls of neighbouring yeast cells and flocculation results. Sometimes a "stuck" (or hung) fermentation may occur if flocculation happens before all the sugars have been converted to alcohol.

Beers and ales are brewed using top-fermenting strains of *Saccharomyces cerevisiae*. These yeasts remain suspended in the wort with a tendency to be lifted to the surface by bubbles of CO₂ generated in the ferment, forming a thick crust of foam. Ale fermentation is carried out at 16-23°C and is usually complete in 5-7 days. It is then clarified and stored (conditioned) at 7-10°C for a few weeks while the flavour develops.

Lager is produced using bottom-fermenting strains of *Saccharomyces carlsbergensis* which sink to the bottom of the vessel. Fermentation is usually carried out at a lower temperature (5-12°C) and is not complete until 8-14 days. Clarified lager is stored for much longer (several months) and at a lower temperature (0-3°C) for flavour development.

An example of traditional microbial biotechnology in which the principles have not changed for many, many years. A glorious array of products can now be readily obtained.



The thick yeasty foam formed on top-fermenting ale. Courtesy of Dr Malcolm Stratford (a) and Bass Breweries (b).