CHEMICAL & Engineering News

Science & Technology

April 3, 2006
Volume 84, Number 14
p. 39

WHAT'S THAT STUFF?

Beer

Brewing beer from cereals relies on a variety of biological, chemical, and physical processes

Michael Freemantle

Photo By Linda Wang

In C&EN circles, "pubs" means publications. But where I was brought up, in Southampton, England, "pubs" meant one thing and one thing only: public houses. In those days, pubs were places where people—mainly men—quaffed beer or other alcoholic drinks, socialized, and played games such as darts, dominoes, cribbage, and shove-halfpenny. Every village and neighborhood seemed to have at least one pub. Nowadays, most pubs in England offer "pub

grub" in addition to a range of drinks. Many have become restaurants, the best being so-called gastropubs. Even so, there's still a strong association in British culture between pubs and beer.

I must confess: I did not enjoy my first pint of beer. It had a bitter flavor and I could not understand its appeal. However, as the years passed, and with some encouragement from friends, I sampled many of the numerous varieties of beer that are brewed in England. I gradually acquired a taste for "bitter," a type of ale that is served at a relatively warm temperature compared with lagers and is still immensely popular in the country.

Beer, of course, is not just for Britons. People throughout the world have been producing and enjoying beer for thousands of years. The Egyptians brewed beer some 5,000 years ago, according to Graham G. Stewart, director of the International Centre for Brewing & Distilling at Heriot-Watt University, Edinburgh, Scotland. There's also evidence that brewing was practiced in Mesopotamia—an ancient region of the Middle East that is now Iraq—around 6000 B.C. "The key process that occurs during brewing is the fermentation by yeast of an aqueous solution of sugars and amino acids extracted from cereals to produce an aqueous solution of ethanol and other components," Stewart says. The extracted sugar solution, known as wort, is a nutrient medium for yeast cells. "During the fermentation process, the yeast cell population increases by feeding on the sugars and amino acids," he explains.

At the same time, the yeast excretes ethanol, carbon dioxide, and, in smaller amounts, other fermentation products.

Highly soluble, fermentable sugars such as maltose, sucrose, glucose, and fructose are rarely encountered in a free form in nature, notes Ian S. Hornsey, founder of the Nethergate Brewery in Suffolk, England, in his book "A History of Beer and Brewing" (Cambridge, U.K.: Royal Society of Chemistry, 2003). One of the obvious reasons is that much of the animal kingdom, including people, would be frequently inebriated if such sugars were widely available.

"Over the millennia, starch, the main relatively insoluble, polymeric

food-storage compound of green plants, has provided the starting material for alcoholic fermentations in many parts of the world," Hornsey adds.

Five distinct processes, he says, are involved in beer production: malting of cereal (usually barley), mashing, boiling, cooling, and fermenting. Malting is a degradative process by which starch and proteins in grain cells break down into simpler compounds. It involves three stages: steeping in water, germination, and finally, kilning.

Germination of grain requires both water and oxygen and is triggered by the release of plant growth hormones from the grain. Cell-wall polysaccharides, generally known as gums, and cell proteins are broken down by enzymes that are either present in the grain or synthesized during the germination stage. The gums and proteins are used by embryonic grain cells as food. The germinatior stage is brought to a halt by heating the grain to drive off most of the water and stop its metabolic processes.

Malted cereal is the principal starting material for the actual brewing process. The malt is taken to the brewery, where it is milled and mashed; that is, soaked in hot water. During mashing, the starchy polysaccharides break down to give maltose and other fermentable sugars.

The liquid portion of the mash, the wort, is separated from the spent grains, and hops are added to introduce bitterness and aroma. The wort is then boiled to sterilize it, to concentrate the liquor, and to extract flavors from the hops.

Fermentation is started by adding yeast to the wort after it has been cooled. Lagers are traditionally fermented by yeasts that collect at the bottom of the fermenter. Ales, on the other hand, are usually produced by top-fermenting yeasts.

After fermentation, the yeast is separated and reused in subsequent fermentations. Many raw "green" beers, particularly lagers and North American ales, are then stored or aged in tanks for several weeks at low temperatures. The process allows the flavor to mature and haze-forming proteins to precipitate.

The conventional method for producing clarified "bright" beers employs a filter aid. Filtration removes insoluble proteins, yeast, filter aid, and other suspended matter. Some beers, such as traditional British ales, are not filtered at all. The beer is finally carbonated and packed into kegs, bottles, or cans.

The quality of beer relies on a number of characteristics, including color, smell, the foam that forms the head on beer when it is poured into a glass, and particularly its taste. A typical ale or lager may contain more than 800 compounds that are capable of affecting flavor. They include esters such as ethyl acetate, short-chain fatty acids, various alcohols, aldehydes, and sulfur compounds.

A typical beer is 4-5% alcohol by volume. Low-alcohol beers normally contain 0.5-1.5% alcohol, whereas light beers contain 1.6-2.5% alcohol. The reduction in alcohol content is achieved by limiting the fermentation process or by removing alcohol from normally fermented beer of conventional strength by techniques such as distillation or evaporation.

People drink beer for a variety of reasons: to quench their thirst, to enjoy the flavor, to relax, and to socialize. For my part, I think I'll open a bottle of beer to reward myself for finishing this column.

Chemical & Engineering News
ISSN 0009-2347