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FACT SHEET

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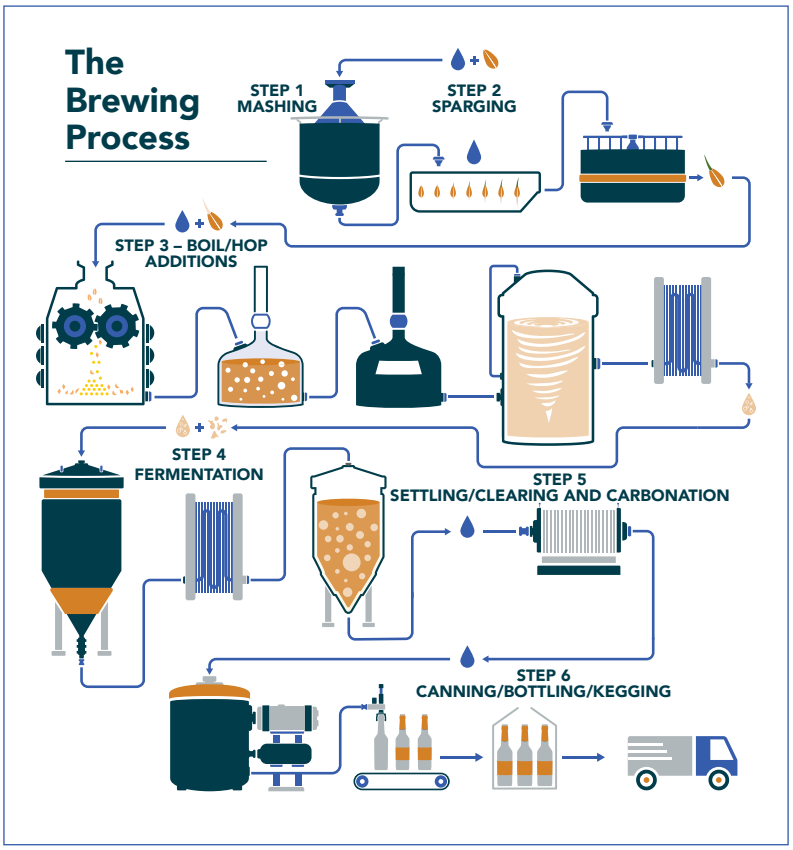
THE SCIENCE OF BREWING

Brewing beer is a science! When you are drinking a nice cold pint, that final beer has gone through a complex chemistry and food science journey. This fact sheet will describe what is occurring during the brewing process and some important considerations to keep in mind as you create your next brew.



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Step 1 - Mashing

Mashing is a crucial step that allows you to convert the starches present in the malted grain into fermentable sugars. This process of turning starches into small chain sugar molecules such as glucose and maltose is called *saccharification*. The enzymes α-amylase and β-amylase break the bonds present in the starches to create fermentable sugars. For the enzymes to function, the temperature range is extremely important. Maintaining the temperature of your mash between 65°C-68°C is ideal. Time is also needed for saccharification to occur, with the standard mashing step taking one hour.

Step 2 - Sparging

Once the mashing process is complete, you need to "rinse" the grains to make sure you get every last bit of fermentable sugar off them. Additional water is used in this step to rinse the grains as the wort is transferred to the kettle. Again, the temperature is important in this step. Water is usually in the 70°C-80°C range to ensure the converted sugars are removed from the grains.

Step 3 – Boil/Hop Additions

During this stage, the temperature of the wort is increased to allow boiling. Then the hop additions or any other special ingredients to impart unique flavours are added to the brew. The hop additions depend on the type of hops and the type of brew desired. Hops contain alpha acids, which impart flavour and bittering. When hops are boiled, the alpha acids are transformed into iso-alpha acids, which are bitter. So, the more alpha acids present and the longer you boil, the more bitter the brew. Hops that are added towards the end of a boil do not impart much bittering because they are not boiled for a long time but contribute strong flavour and aroma characteristics.

Step 4 – Fermentation

Here is where they say the "magic happens." Yeasts convert the sweet wort you have created into beer. They use the fermentable sugars in the wort and, through a metabolic process, create alcohol (fermentation) and carbon dioxide (respiration).

Factors that affect the yeast's performance:

Temperature: there is an optimal temperature that yeast has for fermentation to occur. The general range is 21°C-24°C to achieve the best results and flavour profiles. If temperatures are too cool, the yeast will enter a dormant state, and metabolism will not occur. If temperatures are above the optimal range, then flavour off-notes can occur because the yeast will change their metabolic process. This change can cause fruity notes (esters), which are not always desirable dependent on beer style.

Oxygen: Yeasts require oxygen to complete the fermentation. They use it to build cell-membrane components that are essential to their replication, which occurs during fermentation. It is important for replication to occur during fermentation because yeast will expire over time, and more activity is needed to continue the process to obtain the target alcohol level.

Fermentable sugars: these sugars are the food for the yeast. If there are no sugars, then fermentation will not occur. It's important to have enough sugars to obtain target alcohol values. This is why the mash process is very important.

Step 5 - Settling/Clearing and Carbonation

Once the yeasts have reached the end of their fermentation cycle, they begin to expire and settle to the bottom of the beer leaving a layer of sediment. At this point, breweries accelerated this process by transferring the beer to a brite tank. This tank usually has a glycol jacket, which allows very cold temperatures to be reached. This cools the beer quickly and causes the yeast to expire faster and fall out of the beer. This process is called cold crashing and results in a beer that is clearer and has a less yeasty taste profile.

Yeast creates some carbonation during the fermentation process but not enough for a carbonated brew. Carbonation comes next. To dissolve more carbon dioxide (CO_2) into the solution, the beer must be cool for this process. Carbon dioxide dissolves more efficiently when at cold temperatures (2-5°C). Beer is held in the brite tank at this temperature range while carbon dioxide is pumped into the tank over a period of time until the desired CO_2 level is reached.

Step 6 – Canning/Bottling/Kegging

The beer is now ready to be canned, bottled or kegged. It can then travel to your fridge, where after that long day, you can fill a pint glass and enjoy it responsibly.

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Ingredients typically used in brewing beer

Malt

Malt is barley that has been germinated and then dried. The malting process develops the enzymes α-amylase and β-amylase, which are required for modifying the starches present in the grain into various types of sugars. Malts also contribute to the flavour, colour and "body" (mouthfeel) of the beer. They are dried at different temperatures (toasted) to create lighter malts and darker malts. The combination of malts and water create the mash, which is the first step in the brewing process. Malts can be categorized in the following ways:

Base Malts (Diastatic): malts with the active enzymes for starch conversion. These are used at high percentages in brews so that there are enough enzymes and starch for adequate sugar production.

Specialty Malts (Non-diastatic): malts with inactive enzyme for starch conversion. When malts are toasted to achieve darker colours, the heat deactivates the enzymes. These specialty malts are used at smaller percentages to contribute flavour, colour and body to the beer.

Water

Water chemistry affects the outcome of your beer. Various minerals and salts present in water can either enhance or hinder the flavour of the beer. Brewers use a mash pH to determine the state of their water and alter brewing salt additions to achieve optimal pH and water profile for the style of beer they are brewing.

Hops

Humulus lupulus (hops) are essential in beer making. If you are not using hops, then you are not making a true beer. Firstly, hops contribute bitterness to the beer, but just as importantly, they contribute flavour and aroma. There are hundreds of varieties of hops that contain various levels of bitters and several flavonoid compounds that give each beer a unique flavour profile.

Yeast

Saccharomyces cerevisiae (yeasts) are what create the alcohol in beer. During the fermentation process, yeasts are responsible for creating the alcohol, and they also create compounds that contribute unique flavours to the beer. Again, there are hundreds of different strains of yeast that are used for various styles of beer:

Ale yeasts: there are various types used for many styles of beer. They ferment at warmer temperatures and are what are called top-fermenters. This means they tend to ferment faster, resulting in more visible yeast flocculation at the top of the wort (the resulting liquid after the mashing process).

Lager yeasts: there are various types used for many styles of beer. Most common are the German styles. These work best in cooler fermentation temperatures, and they are called bottom-fermenters. This means they ferment more slowly and do not have a visible yeast flocculation at the top of the wort.

Non-Saccharomyces Fermenters: two most common strains are Brettanomyces and Lactobacillus (bacteria). Brettanomyces stains create "funky" flavour profiles that can be slightly acidic. Lactobacillus are what are commonly used to create the now extremely popular style of sour beer.

Source

The information provided in this fact sheet was summarized from the following book:

Designing Great Beers, Ray Daniels, 1996, Brewer's Publications