Unit IV - Topic 3
Distillation, malting, preparation of sweet wort

Distillation

As mentioned above, the difference in the boiling points of alcohol and water is utilized in distillation to separate these liquids from each other. Basic distillation apparatus consists of three parts: the still or retort, for heating the liquid; the condenser, for cooling the vapours; and the receiver, for collecting the distillate.

The pot still

The simple pot still is a large enclosed vessel, heated either by direct firing on the bottom or by steam coils within the vessel, with a cylindrical bulb at its top leading to a partially cooled vapour line. The bulb and vapour line separate entrained liquid particles from the vapour on its way to the final condenser. The usual pot-still operation involves a series of two or three pot stills. Any vapour falling below a predetermined alcoholic content is fed into a second still, and condensed vapour from the second still falling below the required alcoholic content is fed to the third. The condensed vapours of the desired alcoholic content from all three stills are then commingled in a single receiving container.

The pot still, used primarily in Scotland and Ireland for whiskey production and in France for brandies, has had only brief use in distilled spirits production elsewhere and is gradually becoming obsolete. Even in countries in which the pot still has long been used, it has been replaced by continuous distillation for the major portion of alcoholic-liquor production, and its current use is limited to production of flavouring whiskeys and other flavouring ingredients.

The flavour profile of a pot-still product is more complex than that of a continuous-still product of the same alcohol content. This is a result of the different distillation methods. At a given temperature and pressure, vapours over a boiling mixture have a composition that is a function of the vapour pressures of the components of the mixture. In a pot still, the temperature of the fermentation mixture rises as the lower-boiling-temperature alcohol vaporizes. Meanwhile, the alcohol content of the distillate drops as the rising temperature vaporizes more water along with the alcohol. Distillation is allowed to continue until the alcohol content of the distillate falls to a predetemined level. Because of the rising temperature encountered in distilling a single batch, the composition of the first part of the condensate to leave the pot is different from that of the last part. The composition of the final product is the average of the composition of the vapours condensed during the entire run. By contrast, the temperature of the continuous still is held approximately constant throughout the run. This results in a flavour profile that is more uniform.

The continuous still

The continuous still, which came into use in the early 19th century, consists of a tall cylindrical column filled with perforated plates onto which water-rich vapours condense while alcohol-enriched vapours pass through. These plates thus serve as a series of small pot stills, one on top of the other. Live steam, used as the heat source, is fed into the bottom of the still, and the liquid to be distilled is fed near the top. Steam pressure holds the liquid on the plates, and, with any overflow caught by the plate below, the liquid level on each plate is maintained. Use of a sufficient number of plates assures that the concentration of alcohol in the vapour leaving the top of the still will be appropriate for the desired product and that the liquid leaving the bottom has been stripped of any alcohol.

Many distillation operations combine column and pot stills. The condensed distillate from the column still is fed to the doubler, a type of pot still heated by closed steam coils, and redistilled.

The rectification still

Rectification is the process of purifying alcohol by repeatedly or fractionally distilling it to remove water and undesirable compounds. As mentioned above, a fermentation mixture primarily contains water and ethyl alcohol and distillation involves increasing the percentage of ethyl alcohol in the mixture. Water vaporizes very easily, however, and, unless care is taken, the distillate of a fermentation mixture will contain unacceptably large quantities of water. The fermentation mixture furthermore contains small quantities of complex constituents that can contribute to the flavour of the product even if they are present only in parts per million. It is important to retain those components that make a positive contribution to the product and to remove those that are unwanted, primarily some organic aldehydes, acids, esters, and higher alcohols. The ones that remain in the product are called congeners, and the congener level is controlled by the particular rectification system and by the system's method of operation.

The multicolumn rectifying system usually consists of three to five columns. The first column is always a preliminary separation column called the beer still, or analyzer. It usually consists of a series of metal plates with holes punched in them and baffles to control the liquid levels on the plates. The product coming from this column is between 55 and 80 percent ethyl alcohol. A 95 percent product can be produced on a two-column system consisting of a beer column and a rectifying column. The bulk of congener removal is accomplished in the rectifier—esters and higher alcohols, for example, being drawn off as side streams. However, a multicolumn system of several specialized rectifiers allows better control of the finished product. An aldehyde column, or purifier, is frequently used to separate these highly volatile low-boiling components, and sometimes ethyl alcohol is recovered in an extractive column and returned to the rectifier.

Three characteristics determine the elimination or retention of flavouring compounds: (1) their boiling points, (2) their solubilities in ethyl alcohol and water, and (3) their specific gravities. Some higher alcohols, for example, are removed on the basis of their solubility and specific gravity. These higher alcohols have limited solubility in water, and their specific gravities are less than that of water. Also, their boiling points are higher than that of ethyl alcohol and lower than that of water. Since they tend to accumulate in the rectifying column at the region where their boiling points cause them to condense, they can be drawn off as a liquid side stream. This side stream also contains a considerable amount of water. The limited solubility in water, plus the lower specific gravities, cause the higher alcohols to float to the top of the alcohol–water mixture, from which they can be removed.

THE MALTING PROCESS

Malt is often called the **"Heart of Beer"** for good reason. Malted barley, or malt, is the basic ingredient used in the production of beer, providing complex carbohydrates and sugars necessary for fermentation, as well as contributing flavors and colors that are uniquely characteristic of beer.

STANDARD MALTS AND SPECIALTY MALTS

There are two main categories of malt: standard and specialty. **Standard** (base or brewers) malts contain high amounts of enzymes, complex carbohydrates, and sugars necessary for fermentation. **Specialty malts** are produced when the length of time, temperature, or humidity of the three stages of the malting process—steeping, germination, and drying—are adjusted to develop unique flavors and colors, or distinctive functionality.

More intense heating decreases the amount of enzymes available for fermentation, so many specialty malts are designed to be used in smaller amounts to contribute unique flavors such as intense malty, sweet caramel, nutty, woody, coffee or burnt, and rich colors ranging from golden to red to black.

Handcrafting specialty malts differs from the **basic** malting process in that **batch sizes** are generally smaller, it is a much more **labor** and **resource-intensive** process, it involves more laboratory **testing** for consistency, and it requires the constant vigilance of an **experienced maltster** who relies upon his senses of sight, taste, smell, and touch to achieve the desired finished product from the beginning to the end of the process.

WHY BARLEY?

Barley is the **ideal cereal grain** for malting and, ultimately, brewing. It is self-contained, having a husk to protect the germ, high starch-to- protein ratio for high yields, a complete enzyme system, self-adjusting pH, light color, and neutral flavor.

In addition to barley, wheat and rye are also routinely malted for brewing. Other cereals grains, such as buckwheat and spelt, can also be malted but the finished malt does not perform in the brewhouse as well as malted barley.

STEP 1) STEEPING

The basic malting process, although more of an exact science today than when man first dipped baskets of grain into open wells in Mesopotamia 5,000 years ago to prepare it for brewing, remains a **three-step** process: **steeping, germination, and drying**.

During **steeping** water is absorbed by the raw barley kernel and germination begins. Steeping starts with raw barley that has been sorted and cleaned, then transferred into steep tanks and covered with water.

For the next 40-48 hours, the raw barley alternates between submerged and drained until it increases in moisture content from about 12% to about 44%. The absorbed water activates naturally existing **enzymes** and stimulates the embryo to develop new enzymes. The enzymes break down the protein and carbohydrate matrix that encloses starch granules in the endosperm, opening up the seed’s starch reserves, and newly developed hormones initiate growth of the acrospire (sprout).

Steeping is complete when the barley has reached a sufficient moisture level to allow uniform breakdown of the starches and proteins. One visual indicator that the maltster uses to determine the completion of steeping is to count the percentage of kernels that show “chit.” Raw barley that has been properly steeped is referred to as **“chitted” barley,”** the “chit” being the start of the rootlets that are now visibly emerging from the embryo of the kernel.

STEP 2) GERMINATION

In a process called “**steep out,”** the chitted barley is transferred from the steep tank to the germination compartment. **Germination**, which began in the steep tank, continues in the compartment where the barley kernel undergoes **modification**.

Modification refers to the break down of the protein and carbohydrates, and the resulting opening up of the seeds’ starch reserves. Good modification requires the barley to remain in the compartment for 4-5 days. Germination is controlled by drawing temperature-adjusted, humidified air through the bed. **Turners** keep the bed from compacting and rootlets from growing together, or felting.

STEP 3) DRYING

Germination is halted by drying. If germination continued, the kernel would continue to grow and all of the starch reserves needed by the brewer would be used by the growing plant.

Base malts are kiln-dried. typically with a finish heat of 180-190° F for 2-4 hours. This develops flavors ranging from very light malty to subtle malty.

Specialty malts are dried in a kiln at higher temperatures for longer periods of time, roasted, or both. Varying the moisture level and time and temperature of drying develops the flavor and color characteristics of each specialty malt.

What is sweet wort?

Wort, pronounced wert, is “beer starter” - or unfermented beer - comprised of malt extract (from grain mash) and water. It is the liquid extracted from the mashing process during the brewing of beer. Unhopped wort is known as “sweet wort,” while hopped wort is known as “hopped wort.”

Wort is the liquid extracted from the mashing process during the brewing of beer or whisky. Wort contains the sugars, the most important being maltose and maltotriose,[1] that will be fermented by the brewing yeast to produce alcohol. Wort also contains crucial amino acids to provide nitrogen to the yeast as well as more complex proteins contributing to beer head retention and flavour.[2]

Production

Draining wort

The first step in wort production is to obtain malt, which is made from dried, sprouted cereal grains, including barley. The malt is run through a mill, cracking the husk and exposing the starch inside. The milled grain is then mashed by mixing it with hot water, and then steeped, a process that enables enzymes to convert the starch in the malt into sugars which dissolve in the water. Sometimes the mash is heated at set intervals to alter the enzyme activity. The temperature of the mixture is usually increased to 78 °C (172 °F) for mashout. Lautering is the next step, which means the sugar-extracted grist or solids remaining in the mash are separated from the liquid wort. In homebrewing, the use of grain malt (including milling and mashing) can be skipped by adding malt extract to water to make wort.

The mixture is then boiled to sanitize the wort and, in the case of most beer production, to extract the bittering, flavour and aroma from hops. In beer making, the wort is known as "sweet wort" until the hops have been added, after which it is called "hopped or bitter wort". The addition of hops is generally done in three parts at set times. The bittering hops, added first, are boiled in the wort for approximately one hour to one and a half hours. This long boil extracts resins, which provides the bittering. Then, the flavouring hops are added, typically 15 minutes from the end of the boil. The finishing hops are added last, toward the end of or after the boil. This extracts the oils, which provide flavour and aroma but evaporate quickly. In general, hops provide the most flavouring when boiled for approximately 15 minutes, and the most aroma when not boiled at all.

At the end of boiling, the hot wort is quickly cooled (in homebrewing, often using an immersion chiller) to a temperature favorable to the yeast. Once sufficiently cooled, the wort is transferred to a separate fermentation vessel, oxygenated, and then yeast is added, or "pitched", to begin the fermentation process.

The adjunct grains that can be added to the mash include oats, wheat, corn (maize), rye, and rice. Adjunct grains may first need gelatinization and cooling. They are used to create varietal beers such as wheat beer and oatmeal stout, to create grain whisky, or to lighten the body (and cut costs) as in commercial, mass-produced pale lagers.