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**Objective**

**By the end of this chapter the students will be able to**

* **Define the beer making process.**
* **Differentiate the role of ingredients in the beer manufacturing**
* **Classify beer**

**Beer**

**Beer** is the world's oldest and most popular alcoholic beverage. It is produced by the fermentation of sugars derived from starch-based material — the most common being malted barley; however, wheat, corn, and rice are also widely used, usually in conjunction with barley. The starch source is steeped in water, along with certain enzymes, to produce a sugary wort which is then flavoured with herbs, fruit or most commonly hops. Yeast is then used to cause fermentation, which produces alcohol and other waste products from anaerobic respiration of the sugars. The process of beer production is called brewing.

Beer uses many varying ingredients, production methods and traditions. The type of yeast and production method may be used to classify beer into ale, lager and spontaneously fermented beers. Some beer writers and organizations differentiate and categorize beers by various factors into beer styles. Alcoholic beverages fermented from non-starch sources such as grape juice (wine) or honey (mead), as well as distilled beverages, are not classified as beer.

Brewing

Beer is made by brewing. The essential stages of brewing are mashing, sparging, boiling, fermentation, and packaging. Most of these stages can be accomplished in several different ways, but the purpose of each stage is the same regardless of the method used to achieve it.

The Production of Malt

There are three stages involved in converting barley to malt, namely steeping germination and kilning the overall objective being to provide the brewer with a convenient form of starch and enzymes.

**STEEPING**The purpose of steeping is to achieve an optimal moisture level in the grain normally between 44% and 46%. Previously dried and cleaned barley is soaked in large vessels, usually with conical bottoms for ease of emptying. Normal steeping regimes are between 48 and 72 hours dependant on what is required from the finished malt. This is split between wet steeping (i.e. soaking in water) and dry periods or air rest when the water is drained off.

**GERMINATION**Once steeped the barley or green malt as it is now known is transferred into a vessel for germination. Here cooled, humidified air is blown through the grain bed to maintain the moisture level close to that reached in steeping. Further the cooled air maintains the grain at a consistent temperature between 59°F and 64°F (15°C - 18°C) During this period the grain is allowed to develop a root and the acrospire grows between 3⁄4 and full length of the kernel without actually sprouting. Two major changes occur: Firstly enzymes are developed which break down the cell walls. The cell walls are made up of gum substances insoluble in water, the action of these enzymes gives us freely available starch. Secondly other enzymes are produced which break down proteins. Further enzymes are developed which will convert the starch into fermentable sugars in the mash tun later on in the brewing process. These changes are known as "modification" and the Maltster controls these changes by means of time, temperature of the processing and moisture content in the grain. Germination times can be as short as 84 hours or up to 144 hours.

**KILNING**Here the malt is dried out to make it stable and safe for storage. Subtle biochemical changes take place in the latter stages, which give malts their characteristic flavours and colour. A combination of high moisture and high temperature will destroy the enzymes developed during germination, which is not desirable. To prevent this happening relatively low temperature inputs along with very high air flows are needed in the first 24 hour of kilning. When the malt becomes "hand dry", around about 6% moisture content, the temperature can be increased culminating in air on temperatures between 203°F and 212°F (95°C - 100°C) in the case of ale malts for colour to develop. Lager malts are produced at lower final temperatures usually 183°F - 185°F (84°C - 85°C) resulting in higher enzyme levels and lower colours in the finished product.

**Malt Milling**: The objective of milling is to reduce the malt to particles sizes, which will yield the most economic extract (wort) and will operate satisfactorily under brewhouse conditions and throughout the brewing process. The more extensive the malt is milled, the greater the extract production. However, the fine grind can lead to subsequent wort separation problems and a loss of extract in the spent grains during wort separation. As a result, the brewer needs to consider the equipment used in the brewhouse when determining the particle size when milling the malt. For example, mash tuns require comparatively coarse grists while lauter tuns can use finer grists and mash filters still finer grists.

**Mashing:** Complete breakdown of starches and proteins to sugars, etc. from a combination of malted and unmalted grains mixed with hot water. This process began with the malting of the grain producing enzymes and beginning to break down starch to sugar. manipulates the temperature of a mixture of water and a starch source (known as mash) in order to convert starches to fermentable sugars. The mash goes through one or more stages of being raised to a desired temperature and left at the temperature for a period of time. During each of these stages, enzymes (alpha and beta amylase primarily) break down the long dextrins that are present in the mash into simpler fermentable sugars, such as glucose. The number of stages required in mashing depends on the starch source used to produce the beer. Most malted barley used today requires only a single stage.

**Lautering/Sparging**: Rinsing the resulting sugar out of the spent grain (grist) and into the kettle for the boil. This can be done in a combination mash/lauter tun, or the mash can be transferred to a separate lauter tun. **Sparging** (otherwise known as lautering) extracts the fermentable liquid, known as wort, from the mash. During sparging the mash is in a vessel known as a lauter-tun, which has a porous barrier through which wort but not grain can pass. Vorlauf – Taking the first runnings out of the lauter tun and returning them to the top of the mash gently to not cause channeling, and continuing until the runnings are clear.The brewer allows the wort to flow past the porous barrier and collects the wort. The sparge should be done very slowly to enhance extraction efficiency. The brewer also adds water to the lauter-tun and lets it flow through the mash and collects it as well. This rinses fermentable liquid from the grain in the mash and allows the brewer to gather as much of the fermentable liquid from the mash as possible. The leftover grain is not usually further used in making the beer. However in some places second or even third mashes would be performed with the not quite spent grains. Each run would produce a weaker wort and thus a weaker beer.

**Wort** is the liquid extracted from the mashing process during the brewing of beer or whisky. Wort contains the sugars that will be fermented by the brewing yeast to produce alcohol. After the barley is malted it is ground to grist. The grist is then mashed, that is, mixed with hot water and steeped, a complex and slow heating process that enables enzymes to convert the starch in the malt into sugars. At the end of the mashing, the hot wort is decanted or filtered, boiled, cooled, and the yeast is added to start the fermentation.

Before the mashing of the barley, other grains known as adjuncts can be added 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 American-style lagers. In beer making, it is known as "sweet wort" until the hops have been added, after which it is then "hopped wort."

**Boiling** sterilizes the wort and increases the concentration of sugar in the wort. The wort collected from sparging is put in a kettle and boiled, usually for about one hour. During boiling, water in the wort evaporates, but the sugars and other components of the wort remain; this allows more efficient use of the starch sources in the beer. Boiling also destroys any remaining enzymes left over from the mashing stage as well as coagulating proteins passing into the wort, especially from malted barley, which could otherwise cause protein 'hazes' in the finished beer. Hops are added during boiling in order to extract bitterness, flavour and aroma from them. Hops may be added at more than one point during the boil. As hops are boiled longer, they contribute more bitterness but less hop flavour and aroma to the beer.

**Fermentation** uses yeast to turn the sugars in wort to alcohol and carbon dioxide. During fermentation, the wort becomes beer. Once the boiled wort is cooled and in a fermenter, yeast is propagated in the wort and it is left to ferment, which requires a week to months depending on the type of yeast and strength of the beer. In addition to producing alcohol, fine particulate matter suspended in the wort settles during fermentation. Once fermentation is complete, the yeast also settles, leaving the beer clear. Fermentation is sometimes carried out in two stages, primary and secondary. Once most of the alcohol has been produced during primary fermentation, the beer is transferred to a new vessel and allowed a period of secondary fermentation. Secondary fermentation is used when the beer requires long storage before packaging or greater clarity.

**Packaging**, the fifth and final stage of the brewing process, prepares the beer for distribution and consumption. During packaging, beer is put into the vessel from which it will be served: a keg, cask, can or bottle. Beer is carbonated in its package, either by forcing carbon dioxide into the beer or by "natural carbonation". Naturally carbonated beers may have a small amount of fresh wort/sugar and/or yeast added to them during packaging. This causes a short period of fermentation which produces carbon dioxide.

## Ingredients

The basic ingredients of beer are water; a fermentable starch source, such as malted barley; and yeast. It is common for a flavouring to be added, the most popular being hops. A mixture of starch sources may be used, with the secondary starch source, such as corn, rice and sugar, often being termed an adjunct, especially when used as a lower cost substitute for malted barley.

### Water

Beer is composed mostly of water, and the water used to make beer nearly always comes from a local source. The mineral components of water are important to beer because minerals in the water influence the character of beer made from it. Different regions have water with different mineral components. As a result, different regions are better suited to making certain types of beer. For example, Dublin has hard water well-suited to making stout, such as Guinness, and Pilzen has soft water well-suited to making pale lager, such as Pilsner Urquell. As a result, it is argued that the mineral components of water have an influence on the character of regional beers.

### Starch source

The starch source in a beer provides the fermentable material in a beer and is a key determinant of the character of the beer. The most common starch source used in beer is malted grain. Grain is malted by soaking it in water, allowing it to begin germination, and then drying the partially germinated grain in a kiln. Malting grain produces enzymes that convert starches in the grain into fermentable sugars. Different roasting times and temperatures are used to produce different colours of malt from the same grain. Darker malts will produce darker beers.

Nearly all beer includes barley malt as the majority of the starch. This is because of its fibrous husk, which is important in the sparging stage of brewing, and high concentration of amylase, a digestive enzyme which facilitates conversion of starch into sugars. Other malted and **unmalted grains called as beer adjuncts** (including wheat, rice, oats, and rye, and less frequently, corn and sorghum) may be used. The amount of each starch source in a beer recipe is collectively called the grain bill

### Hops

The flower of the hop vine is used as a flavouring and preservative agent in nearly all beer made today. The flowers themselves are often called "hops". The use of hops in beer was recorded by captive Jews in Babylon around 400 BCE. Hops were used by monastery breweries, such as Corvey in Westphalia, Germany, from 822 CE, though the date normally given for widespread cultivation of hops for use in beer is the thirteenth century.

Hops contain several characteristics that brewers desire in beer: hops contribute a bitterness that balances the sweetness of the malt; hops also contribute floral, citrus, and herbal aromas and flavours to beer; hops have an antibiotic effect that favours the activity of brewer's yeast over less desirable microorganisms; and the use of hops aids in "head retention", the length of time that a foamy head created by carbonation will last. The bitterness of beers is measured on the International Bitterness Units scale. Beer is the sole major commercial use of hops.

In the past, other plants have been used for similar purposes; for instance, *Glechoma hederacea*. Combinations of various aromatic herbs, berries, and even ingredients like wormwood would be combined into a mixture known as gruit and used as hops are now used.

### Yeast

Yeast is the microorganism that is responsible for fermentation in beer. Yeast metabolizes the sugars extracted from grains, which produces alcohol and carbon dioxide, and thereby turns wort into beer. In addition to fermenting the beer, yeast influences the character and flavour. The dominant types of yeast used to make beer are ale yeast (*Saccharomyces cerevisiae*) and lager yeast (*Saccharomyces uvarum*); their use distinguishes ale and lager. *Brettanomyces* ferments lambics, and *Torulaspora delbrueckii* ferments Bavarian weissbier. Before the role of yeast in fermentation was understood, fermentation involved wild or airborne yeasts. A few styles such as lambics rely on this method today, but most modern fermentation adds pure yeast cultures directly to wort.

### Clarifying agent

Some brewers add one or more clarifying agents to beer. Common examples of these include isinglass finings, obtained from swimbladders of fish; kappa carrageenan, derived from seaweed; Irish moss, a type of red algae; polyclar (artificial), and gelatin. Clarifying agents typically precipitate out of the beer along with protein solids, and are found only in trace amounts in the finished product.

## Types and styles of beer

A great many beers are brewed across the globe. Local traditions will give beers different names, giving the impression of a multitude of different styles. However, the basics of brewing beer are shared across national and cultural boundaries.

The traditional European brewing regions — Germany, Belgium, the United Kingdom, Ireland, Poland, the Czech Republic, Denmark, The Netherlands and Austria — have local varieties of beer. In some countries, notably the USA, Canada and Australia, brewers have adapted European styles to such an extent that they have effectively created their own indigenous types.

### Categorising by yeast

A common method of categorizing beer is by the behaviour of the yeast used in the fermentation process. In this method of categorizing, those beers which use a fast-acting yeast, which leaves behind residual sugars, are termed ales, while those beers which use a slower and longer acting yeast, which removes most of the sugars, leaving a clean and dry beer, are termed lagers.

#### Ale

A modern ale is commonly defined by the strain of yeast used and the fermenting temperature.

Ales are normally brewed with top-fermenting yeasts (most commonly *Saccharomyces cerevisiae*), though a number of British brewers, including Fullers and Weltons, use ale yeast strains that have less pronounced top-fermentation characteristics. The important distinction for ales is that they are fermented at higher temperatures and thus ferment more quickly than lagers. Fermentation by ale yeasts at these relatively warmer temperatures produces a beer high in esters and higher alcohols, which many regard as a distinctive character of ale beers.

Ale is typically fermented at temperatures between 15 and 24 °C (60 and 75 °F). At these temperatures, yeast produces significant amounts of esters and other secondary flavour and aroma products, and the result is often a beer with slightly "fruity" compounds resembling apple, pear, pineapple, banana, plum, or prune, among others. Typical ales have a sweeter, fuller body than lagers.

#### Lager

Lager is the English name for bottom-fermenting beers of Central European origin. They are the most commonly consumed beers in the world. The name comes from the German *lagern* ("to store"). Lagers originated from European brewers storing beer in cool cellars and caves and noticing that the beers continued to ferment, and also to clear of sediment. Lager yeast is a bottom-fermenting yeast (e.g., *Saccharomyces pastorianus*), and typically undergoes primary fermentation at 7–12 °C (45–55 °F) (the "fermentation phase") (At these temperatures, lager yeasts grow less rapidly than ale yeasts, and with less surface foam they tend to settle out to the bottom of the fermenter as fermentation nears completion. This is why they are often referred to as "bottom" yeasts), and then is given a long secondary fermentation at 0–4 °C (32–40 °F) (the "lagering phase"). During the secondary stage, the lager clears and mellows. The cooler conditions also inhibit the natural production of esters and other byproducts, resulting in a "cleaner" tasting beer.

Modern methods of producing lager were pioneered by Gabriel Sedlmayr the Younger, who perfected dark brown lagers at the Spaten Brewery in Bavaria, and Anton Dreher, who began brewing a lager, probably of amber-red colour, in Vienna in 1840–1841. With improved modern yeast strains, most lager breweries use only short periods of cold storage, typically 1–3 weeks.

### Pale and dark beer

The most common colour is a pale amber produced from using pale malts. *Pale lager* is a term used for beers made from malt dried with coke (fuel like coal). Coke had been first used for roasting malt in 1642, but it wasn't until around 1703 that the term *pale ale* was first used.

In terms of sales volume, most of today's beer is based on the pale lager brewed in 1842 in the town of Pilsen, in the Czech Republic. The modern pale lager is light in colour with a noticeable carbonation, and a typical alcohol by volume content of around 5%. The Pilsner Urquell, Bitburger, and Heineken brands of beer are typical examples of pale lager, as are the American brands Budweiser, Coors, and Miller.

Dark beers are usually brewed from a pale malt or lager malt base with a small proportion of darker malt added to achieve the desired shade. Other colourants — such as caramel — are also widely used to darken beers. Very dark beers, such as stout use dark or patent malts that have been roasted longer. Guinness and similar beers include roasted unmalted barley.

## Categorisation in General

**Lager:**Two different types of yeast can be used to create alcohol. Bottom-fermenting yeast that ferments slowly at a low temperature creates a smoother, mellower beer. Lager beers are light in color, high in carbonation and tend to be less alcoholic than ales. Lagers are best served chilled (about 48 °F/9 °C).

**Ale:**The other type of yeast rises to the top during fermentation. It also ferments more rapidly and at a higher temperature, resulting in a more aromatic and fruity product. Real ale is produced using traditional methods, without pasteurization. Compared to lagers, ales have a lower amount of carbonation and should be served at a warmer temperature (54-56 °F/12-13 °C). Strong ales should be served at room temperature.

**Amber:**Malty, hoppy beers have a rich golden color. They can be ales or lagers and tend to be fuller bodied due to the addition of specialty grains.

**Bitter:** Highly hopped for a more dry and aromatic beer, bitter is pale in color but strong in alcohol content. It's popular in British pubs.

**Dark Beer:** Beer becomes darker when the barley is kilned for a longer period of time. This also creates richer, deeper flavors from the roasted grain.

**Fruit Beer:**Fruit may be added either during the primary fermentation or later. Fruit beer is usually made with berries, although other fruits can be used.

**India Pale Ale:**The name is often shortened to IPA. This ale was originally brewed in England for export to India. The large quantities of hops added were intended as a preservative and to mask potential off-flavors that might develop during the long voyage.

**Mild Beer:** Developed as a sweeter and cheaper alternative to dark ales and porters. Mild beer was a popular beer in the mid-nineteenth century but has all but disappeared in most pubs.

**Pilsner:** This is the term for the classic lager originally developed in Czechoslovakia, a pale, golden-hued, light beer after which many mass-produced American beers are modeled. Pilsners should be served very cold (43 °F/6 °C).

**Porter:** Very bitter, very dark, this beer was developed in England as a "nourishing" drink for manual laborers such as porters.

**Stout:**Very dark and heavy, with roasted unmalted barley and, often, caramel malt or sugar, stout was invented by Guinness as a variation on the traditional porter. Serve Guinness at a cool temperature (41-43 °F/5-6 °C).

**Wheat Beer (Weizen):**Malted wheat, in addition to barley, is used for this German style beer. Wheat beers were drunk prior to Prohibition and are experiencing a rebirth in the U.S. American wheat beers are markedly different from their German predecessors, which are "spicier."