HERVEY BAY
HOME BREW
beer, wine, spirits & accessories

Some things you need to know about yeast

Beer is made from just four simple ingredients: malt, hops, water, and yeast. While sometimes overlooked, yeast can be the most important of these ingredients, as up to 80% of the flavour profile of beer comes from the yeast activity!

Its duty is to transform sweet, hopped wort into beer. During this transformation, yeast adds flavour and aroma to beer. Yeast is a living, single-cell organism commonly found on plants and animals. On solid media (plates or slants), yeast barely becomes visible as a clump at one million cells. Since a single cell, at five microns in size, is not visible to the human eye, yeast was long considered a mysterious organism.

Until the mid-l9th century brewers knew very little about yeast. To make good beer they had to rely on ancient practice. With the aid of a microscope, Louis Pasteur discovered that yeast was responsible for beer fermentation in 1866.

Fifteen years later at the Carlsberg Laboratory in Copenhagen, Emil Hansen isolated and purified individual yeast strains, and brewer's yeast started to be banked and stored (there are now more 15,000 strains in yeast banks). Many of the pure culture techniques Hansen developed are still in use today.

There is more than 500 species of yeast.

Brewer's yeast is just one of 500 species, but within a single species there can be literally thousands of genetically distinct strains. *Saccharomyces cervisiae* is the species in which brewer's yeast is classified *(cervisiae* is the species name).

Old classification split ale and lager yeasts into different species, *Saccharomyces cervisiae* and *Saccharomyces uvarum,* respectively. The basis for the two-species classification was not only the fact that lager yeast can ferment beer wort at a lower temperature than ale yeast, but lager yeast can also metabolise certain sugars that ale yeast cannot.

The species distinction has made it easier for brewers to classify their yeast. Unfortunately for brewers, recent classifications have united both strains into a single species, *Saccharomyces cervisiae,* due to cross-mating ability.

The brewing industry, grounded in tradition, has influenced brewers to hold fast to the use of both names. The tradition may serve brewers well.

Not only is the distinction useful for brewers, but future genetic studies may restore the *cervisiae/uvarum* classification anyway. To brewers, all other 500-odd varieties of yeast are grouped as 'wild yeast,' because they can't perform the same functions as brewer's yeast strains (this includes baker's yeast).

The characteristics that define brewer's yeast are alcohol tolerance, flocculation (ability to clump together), attenuation (ability to transform sugar into alcohol) and fermentation flavour characteristics.

For example, *Pichia pastoris* is one popular industrial yeast strain that brewers call wild yeast. It is incapable of producing good-tasting beer because its attenuation is very high due to its fast growth rate, it is very non-flocculent, and it produces objectionable flavour compounds.

Yeast is responsible for most of the flavour and aroma compounds in beer.

Yeast contributes more than 600 flavour and aroma compounds to finished beer. Most of these hover around perceivable values, so slight changes in conditions or ingredients can affect flavour profiles.

In addition, what compounds yeast do not make themselves, they can affect. For example, yeast changes the way malt and hop compounds taste and smell.

Hops are affected because different yeast strains adsorb different amounts of iso-alpha-acids, which account for 60 percent of beer's bitterness.

Malt components are affected because they are metabolised by yeast. The American Society of Brewing Chemists has created a 'flavour wheel' to illustrate and evaluate the flavours and aromas associated with beer.

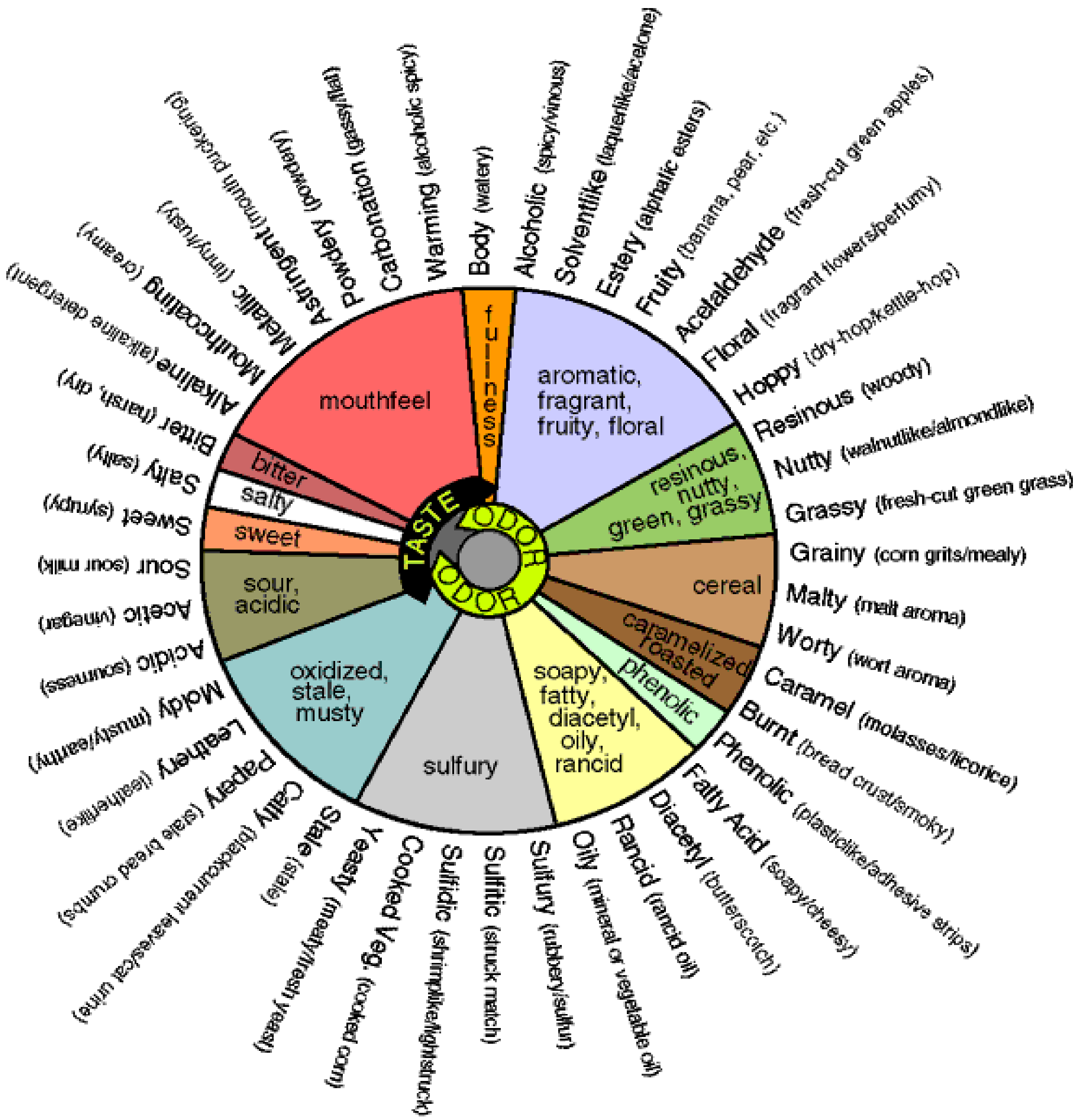
The flavour wheel shows that 59 percent of the aroma (odor) descriptions can be attributed to yeast and 79 percent of the flavour (taste) descriptions also can be attributed to actual yeast byproducts, or components affected by yeast.

When brewers think of yeast flavours, esters (fruity) and diacetyl (buttery) usually come to mind first.

Ethanol (alcohol), fusel alcohols (such as iso-amyl alcohol) and sulfur compounds (particularly in lager yeast) also make a large contribution to the flavour profile of beer.

A typical fermentation will yield 35 grams of ethanol (ethanol is the intoxicating element in beer) per litre of beer, which modifies a beer's mouth-feel and flavour. This is one reason why low-alcohol beers have a different flavour.

THE FLAVOUR WHEEL



The Romans discovered the uses of dried yeast - before the discovery of yeast.

Yeast grows and lives in liquid. For storage purposes it can also be dried once grown. The Romans discovered how to do this when they put baker's yeast (dough) in the sun and could later revive it with sugar. (Of course, they didn't know there was yeast in the dough!)

Today, most yeast used in the bread and wine industry is in dry form. However, many brewers prefer to use yeast that is not dried.

What accounts for the difference?

Production of dried yeast is different than production of beer. Instead of maltose, the main carbon ingredients in dry yeast production are glucose and fructose.

Glucose inhibits maltose-transport genes from being expressed, so dried yeast can take longer to start fermentation if they have never come in contact with maltose. In addition, the drying process is not completely sterile, so potential contaminants are introduced into the pitching yeast.

The quality of dried yeast varies greatly among producers. but has improved significantly over the last 10 years. Today, there is fine quality dried yeast produced.

Besides purity and taste, another drawback of dried yeast is variety of strains. Dried yeast is made in very large quantities, and the availability of different strains is limited. Strains to make true German Hefeweizen or Belgian Trappist beers would be difficult to find in dried form.

Liquid yeast, since it is not subject to the drying process, can be produced to a higher degree of purity. Also, the negative effects of the drying process on yeast metabolism and beer fermentation potential are avoided. Unfortunately, liquid yeast is an extremely perishable product and is best within two weeks of production.

On the other hand, dry yeast can survive and even retain 90 percent viability more than one year after production.

A little waiting is good.

When sweet wort is pitched with yeast, there is a characteristic lag phase before signs of fermentation are evident. This lag phase is an important part of the fermentation process. It can last anywhere from one to 24 hours, depending on the quantity of yeast pitched, fermentation temperature, and oxygen content of wort.

After yeast is pitched into wort, it begins to assimilate into its new environment. The focus on this phase (some split this phase in two parts) is uptake of oxygen and reproduction of new yeast cells.

To make new yeast cells, lipids are required. Lipids make up the cell membrane, and a necessary component of these membranes is sterols. To make sterols, oxygen is required.

Different yeast strains require different levels of oxygen to produce membrane sterols. Generally, the more flocculent strains require higher levels of dissolved oxygen. If wort is pitched with too much yeast, the yeast begins to ferment without multiplying to the appropriate level. This leaves the pitching yeast as the main fermentative agent instead of new, healthy cells.

Over pitching leads to low viability in succeeding generations and adds a yeasty flavour to the beer.

Conversely, if wort is pitched with too little yeast, higher ester levels may be produced due to the higher growth required. Under pitching can also leave the beer exposed to potential growth from other micro-organisms. Home brewers rarely over pitch, but often under pitch yeast.

Yeast transforms sugar into alcohol and C02.

Attenuation is the percentage of sugars that yeast consume during fermentation; sugars are transformed into alcohol and carbon dioxide.

A 100 percent attenuation would result if a beer fermented all the way down to **1.000** final gravity (FG).

For example, a beer with an original gravity (OG) of 1.052 and a final gravity of 1.013 would have a 75 percent apparent attenuation.

An equation using specific gravity is:

% Apparent Attenuation =

$$\frac{OG-FG}{OG-1} \times 100$$

Attenuation is a function of a yeast cell's metabolism, and metabolism is a function of an individual strain's genetic makeup.

Since yeasts differ in their genetic makeup, they usually differ in their attenuation range. Knowing the attenuation range of a particular strain of yeast allows the brewer to judge what type of yeast to use for what type of beer.

For a malty ESB a brewer may choose a yeast strain with a low attenuation, while a dry golden ale may require a yeast strain with a high attenuation.

Each strain has a typical range, and this range is affected by mash temperature, fermentation temperature, pitching rate, and flocculation.

For example, an increase in the mash temperature can decrease the percentage attenuation because there would be fewer fermentable sugars in solution.

Temperature and pitching rate are controllable by the brewer. Flocculation is not.

Some yeast strains really stick together.

Flocculation is the special ability of brewer's yeast to clump together following the end of fermentation and either rise to the surface or fall to the bottom of the fermenter, allowing easy removal from the beer.

Most species of yeast are not flocculent. It is thought the reason brewer's yeast is flocculent is the natural selection process that has taken place in brewing, dating back hundreds of years.

Since yeast was reused in brewing, it needed to be recovered. Usually this was done by skimming the surface of fermenting beer. This selected for yeast that would rise to the surface, hence top- fermenting yeast.

When beer is chilled, flocculated (clumped) yeast drops to the bottom. This selection process took place in many breweries over many years, producing many different degrees of flocculent yeast. For example, London is known to be home of a very flocculent yeast. This yeast will form very large clumps even before fermentation is finished.

This intensive flocculation sometimes necessitates that a brewer rouse the yeast to get it back into solution to finish the fermentation. On the other hand, this simplifies filtration and yeast recovery.

Other ale strains, such as American/California strains, are powdery and do not flocculate out until the beer is chilled. These strains tend to be more attenuative since they are in suspension for a longer period of time.

On the other side of the scale, German ale yeast strains from Bavaria that are used to produce Hefeweizen are usually non-flocculent, and this is a desired characteristic of this beer. One aspect worth noting is that Hefeweizen flavours closely resemble wild yeast flavours, and these yeast flocculate like wild yeast.

Flocculation is one yeast characteristic that is very important to brewers. Professional breweries typically reuse their yeast 10 or more generations, so yeast recovery becomes very important. Home brewers usually do not reuse their yeast so they may not be as concerned about flocculation. On the other hand most home brewers do not filter their beer, so yeast strains with a greater degree of flocculation can make homemade beer clearer.

Yeast would much rather keep warm.

The optimum temperature for yeast growth is 32° c. Yeast cell death occurs above 38℃. Why then, don't we ferment our beers then at 32° C, decreasing the time that it takes to make beer? Why do we make yeast work slower?

Because what is best for yeast, is not best for beer. As they grow and multiply, yeast produces many compounds, the most noticeable of which are esters.

As the temperature fermentation rises, more yeast growth occurs, and consequently more esters are produced. At 32℃ yeast produce so much acetaldehyde (which tastes like apples) that the beer becomes undrinkable. The optimum ale fermentation temperature has been found to be 20° C (18-22). This temperature strikes the best balance between yeast growth and ester levels for most ale strains.

For Hefeweizen-style beers, some brewers like to ferment above 26℃, which increases the level of banana-flavoured esters produced by these strains. Most ale strains are unable to ferment or grow at 12℃, which is the most common lager fermentation temperature. This fermentation temperature greatly reduces the ester-forming ability of most lager strains, creating the clean flavour associated with lager beers. Ester levels are kept low, placing the emphasis on malt and hop flavours.

A Matter of Style

Yeast is a single-cell organism that ferments wort into beer. We know only select strains of yeast are capable of producing good beer. Qualities that define good brewer’s yeast are attenuation, flocculation and flavor profile.

Most brewers want highly flocculent, highly attenuative yeast. Unfortunately, these characteristics usually do not go hand in hand. We know that very flocculent yeast will usually have a lower attenuation percentage.

The brewer’s best option is to match the style of beer brewed with the characteristics of the yeast strain. Therefore, different styles of beer benefit from the use of different yeast strains.

One fun experiment is to split a batch of homebrew into two or more vessels and pitch different yeast. The discovery of different flavors and aromas is truly rewarding!

Yeast strains can be categorised into three groups (high, medium, and low flocculation), according to how quickly they clump together and drop out of solution.

Brewers have created a unique vocabulary. Words *s*uch as pitching, attenuation and flocculation take on special meaning to brewers.

Pitching is adding yeast to wort to start fermentation.

Attenuation is the percentage of sugars that yeast consumes during fermentation.

The magical process of yeast cells coming together and dropping to the bottom of a fermenter is called flocculation. Flocculation is a desirable and important characteristic that is unique to brewer’s yeast.

When brewer’s yeast nears the end of fermentation, single cells aggregate into clumps of thousands of cells and drop to the bottom of the fermenter, leaving clear beer behind.

If yeast flocculates too early, the beer will be under attenuated (not all of the available sugar will be consumed by the yeast) and sweet. If yeast does not flocculate, the beer will be cloudy and have a yeasty taste.

Most strains of yeast, which brewers call ‘wild’ yeast, do not flocculate well and remain in suspension for an extended time. The ability to flocculate is a result of natural selection.

Brewers collect yeast either from the bottom or top of a fermenter. In choosing this yeast that clumps, they select for increasingly flocculent strains. Yeast flocculation can be classified as high, medium, or low. Ale yeast strains are found in each of these categories, while lager yeasts are predominantly medium flocculators.

An English/London ale strain would be considered high flocculators, while a California/American Ale strain is a medium flocculators. A Hefeweizen strain is an example of a low flocculator.

It is difficult to tell which category of flocculator is used to produce individual commercial beers, because most commercial beers are filtered before being bottled or kegged.

High Flocculators

High flocculation is a characteristic of many yeast strains of English origin. The yeast begins to clump in three to five days, and it drops to form a compact yeast cake at the bottom of the fermenter.

When the fermenter is swirled, the yeast cells stay together as a large yeast cake. Some yeast is so flocculent that it can clog openings and valves. High flocculators can require special attention to produce a well-balanced beer.

The yeast cells often need to be ‘roused’ back into the beer by gently swirling the carboy or, for a commercial fermenter, gently blowing $C0_2$ into the bottom of the fermenter.

High flocculation can be associated with lower attenuation and increased levels of diacetyl (with a butterscotch flavour) and esters (with a fruity aroma and flavour). These compounds lend themselves to English-style ales.

Medium Flocculators

Medium flocculators tend to produce ‘cleaner’ beers. They stay in suspension longer and can also reduce diacetyl and esters to a greater degree. The attenuation will likely be greater.

In commercial breweries medium flocculators are slightly more difficult to work with than high flocculators because of the increased work and filtering material (or additional time to let them flocculate) required.

Because home brewers usually do not filter, using medium flocculators simply means having to give it a little more time to settle out than you would for high flocculators.

Medium flocculators flocculate best at cold temperatures, while high flocculators can flocculate well at 18℃ Medium flocculators are well suited for American-style ales, which are usually heavily hopped. The clean flavours from the yeast allow the hop aroma and flavour to come through.

Low Flocculators

Low flocculators are rarely used in brewing. Because they do not settle out of the beer, they create filtering problems and haze. There are some beers that are intended to have yeast in suspension.

For example, German Hefeweizen and Belgian wit beers are fermented with yeast strains that do not flocculate well, leaving the desired cloudy appearance!

Flocculation in Brewing

Most lager yeast is between medium and low in flocculation. Lagers go through an extended cool fermentation and lagering process, and the yeast needs to stay in suspension during this process. The more contact the yeast has with the beer, the better the yeast is able to reduce the diacetyl and ester levels.

The primary determinant of flocculation level is the particular yeast strain itself. Proteins oil the cell surface determine the degree of flocculation, and proteins are coded by the DNA of yeast. Each strain has subtle differences in DNA, so a different set of proteins is displayed on the cell surface of each strain.

Other factors that can influence the degree of flocculation include the original gravity of the wort, temperature of the fermentation, pitching rate of the yeast, and initial oxygen content of the wort. Low temperatures promote flocculation.

More yeast cells will drop out of solution at 4℃ than at 22℃, and more yeast cells will drop out at 3℃ than at 4℃ Some yeast strains require two weeks at 4℃ to completely clear. The flocculation character of a yeast strain has a direct impact on flavour and performance.

Highly flocculent yeast generally is less attenuative (it ferments a lower percentage of sugars in the wort). The ideal yeast strain for most beers is highly flocculent, has good attenuation, and provides the desired flavour contribution.

Beer-making with enthusiasm

Many home brewers leap into beer-making with pints of enthusiasm, progressing from ‘kit and kilo’ (a can plus a bag of sugar) to ‘kits and bits’ (specialty grain and hops).

They soon get a feel for the ingredients available but generally don’t develop an understanding of the yeast fermentation cycle for some time. This is no surprise since yeast is a single-cell organism, too small to be seen by the naked eye (about 4.5μm, or less than 1/500mm).

Yeast, unlike most other organisms, survives with or without oxygen. In the right conditions, it can multiply at an almost exponential rate, to a population of trillions!

While working in an oxygen depleted environment it produces alcohol. Cheers!

As alcohol content increases, the brew becomes less habitable so yeast needs alcohol tolerance. Some strains can cope with, and produce, higher levels of alcohol than others.

Over the centuries, brewers have isolated strains that produce the desired alcohol, aroma, flavour and appearance for preferred beer styles. Most importantly you need to know the affect temperature has on yeast.

It still holds many secrets, but here is a general overview of the yeast life-cycle:

HYDRATION PHASE

Only applies to dry yeast. When introduced to the wort, dry yeast can't do anything until it hydrates, taking about 15 minutes. To avoid this delay, dry yeast may be left to hydrate in a half-cup of tepid water while preparing your wort.

LAG PHASE

Now we wait. Is the yeast doing anything? Yes, it's adapting to its environment! Each live cell is consuming nutrients, mopping up available oxygen and growing (aerobic activity). This can take two or more hours, depending on the health of the yeast and the pitching rate. A small amount of CO_2 is produce during this phase.

LOG PHASE

Now performing an-aerobically, the yeast consumes fermentable sugars, doubling in population every 20 minutes to approach 70 million cells per millilitre. Toward the end of this phase we see the first real signs of activity; large amounts of CO_2 and foam forming on the top of the brew (Krausen). The amount of foaming depends on the yeast strain, temperature and colour of the brew. This is also the time when the yeast produces most of the aromas and flavours.

STATIC PHASE

A stable population of yeast cells continues to consume fermentable sugars, producing CO_2 and alcohol. Foam now collapses into the brew.

SEDIMENTATION PHASE

Sedimentation occurs from the outset as solids fall out of suspension. Sediment continues to form during aerobic and anaerobic phases. Once fermentable sugar levels are almost completely depleted (attenuated), the yeast prepares for dormancy. Most will flocculate (clump together) and fall out of suspension, clearing the brew. By this stage, the yeast count drops to about 50 million/ml at the bottom of the brew to 35 million / ml at the top and gravity has been stable for about 3 days -Time to bottle/keg off.