Beer Fermentation

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After Mashing, Lautering and Boiling your "brew" you still have something that tastes nothing like beer.

It is only after Fermentation that the true beer arises. This is where you add your yeasts and turn the Brew into beer. How good the beer is will depend upon how well you control the fermentation.

The fact is anyone buying a beer kit can make beer and sometimes even get lucky and produce a great beer. But can you do it consistently over and over.

There was a cartoon from a Microbiology Journal in the Microbiology lab I used to run that stated:

"Under the best controlled conditions of Temperature, nutrients, pH etc. the bacteria will do as they please"

This of course is not true, but it does express the frustration of even seasoned Microbiologists in trying to get cultures to do what is expected. The truth is the better you control all of the conditions the more consistent each lot will be.

So for those of you that have made ***the perfect brew the trick to making it over and over again are to control all of the parameter perfectly or at least as well as possible.***
So let's discuss the parameters that you can control at this point.

Temperature

Controlling temperature is a *key* factor in the fermentation process. Temperatures outside of the normal range for ales and lagers can cause yeast strains to die off prematurely, resulting in off-flavors or a ruined batch. Flavors can arise which are not "off", but inappropriate for the beer style being brewed. Yeasts will either rise to the top or sink to the bottom of the fermenter, which may become an insulator and that produces inaccurate temperature readings.

Yeast is critical to brewing. Without yeast the fermentation process that turns sugars to alcohols would not occur and there would be no beer. Yeast has temperature sensitive processes. If the wort is too cold yeast will not turn sugars into alcohol as effectively and the beer will not have the desired amount of alcohol. Sweetness from the unconverted sugars will dominate the flavor of the drink. If the yeast is too hot they will die and similar problems will arise as well as the addition of a yeasty flavor to the beer. The table below illustrates the response of yeast to different temperature ranges. Of course these numbers vary slightly depending on the type of yeast being used.

Yeast Responses to Varying Temperature Ranges:

<10°C <50°F : Dormancy
10-30°C (50-86°F): Growth and multiplication (higher T faster growth)
30-37°C (86-99°F): Optimal growth and multiplication

37-50°C (99-122°F): Growth and multiplication (lower T faster growth)
>50°C >122°F : Death

The optimal temperature for yeast growth, 30-37°C (86-99°F), is not the optimal temperature for fermentation (with a few exceptions). At these temperatures the yeast will produce higher molecular weight alcohols and the beer may have a chalky or solvent like flavor. For most lagers the fermentation temperature should be around 13°C (55°F). This low fermentation temperature will limit ester production in the beer. Esters are compounds that impart sweet or fruity flavors. These low temperatures also cause the buildup of sulfur compounds and diacetyl that cause a myriad of unwanted flavors. This is rectified by heating the lager to around 21°C (70°F) in the secondary fermentation. This allows for the undesired compounds to be metabolized by the yeast and/or dissipated through a more rapid production of CO_2.

Ales on the other hand ferment better at slightly higher temperatures. Depending on the flavors desired in the beer the temperature for ale fermentations can vary between 18°C and 24°C (64-75°F) and even as high as 32°C (90°F) for saisons, a type of French farmhouse ale. Higher ale fermentation temperatures around 21-24°C (70-75°F) result in the production of fruity or banana flavored esters. Lower ale fermentation temperatures (18-21°C or 64-70°F) will result in the production of less of these fruity flavors and more clove flavored esters will be produced. Temperature control during fermentation is essential to controlling the flavor and overall quality of the final product.

Monitoring for temperature during the fermentation process should be arranged using the following methods:

A) Handheld Thermometers - These come in many types and can be provided with customized probes.
B) Data Loggers - We have many types but the EDL-RTD has replaceable and customized probe options allowing for probes to be fitted to thermos wells or inserted into ports. Data is displayed and logged and can be downloaded for easy reports allowing you to see trending and makes analysis easy if troubleshooting is needed.
C) Wireless System - Our Wireless systems can be provided with a wide variety of standard and custom probes. The data is sent live to you for alarming or alerts and can be used for reports and troubleshooting as well. Alarming can be remote and can be integrated with other sensors.
D) Integrating Sensors - with your Current System Custom probes can also be provided for existing PLCs, Controllers, using RS485, USB and a variety of methods. Call us with details of your current systems to see what the best options might be.

Measuring temperature is most effectively conducted using sensors incorporated with a wireless system. Here is an example of a very basic set up:
Wireless Professional Temperature Sensor with 3' Probe
Wireless Gateway Receiver
Wireless Scigiene Premier Cloud Based Software

This system is just an example but we can also offer a wide range of sensors and different probe designs to monitor (and even control) a huge range of needs.

Oxygenation (O_2)

Inadequate oxygenation can cause poor yeast performance as well as incomplete fermentations that do not attenuate to the desired level. Any excess oxygen present during the respiration phase of fermentation can result in off-flavors. Dissolved oxygen should be monitored at this stage, using our dissolved oxygen meters which, are specifically designed for testing samples. The measurements can be displayed in ppm or in % saturation in our Portable Dissolved Oxygen Meter.

Fermentation is the only stage in brewing where oxygen is desired. Yeast needs oxygen to survive. They use it to make cell walls, sterols, and unsaturated fatty acid. Yeast need about 10-12 ppm oxygen in their environment to thrive. The oxygen levels left in the wort post boiling are not sufficient to support the survival of yeast. Adding oxygen is then necessary.

Oxygen should only be added after wort is cooled. If it is added before wort is cooler than 27°C (80°F), then it will bind with various compounds which can cause off flavors. These new oxygenated compounds can also give off oxygen that can cause different oxidized flavors later on.

There are a few different methods employed to increase dissolved oxygen levels in the wort. One method is to add the wort to the fermenter in a very turbulent fashion to dissolve more oxygen from the air. This method does increase the amount of dissolved oxygen, but it is often not enough oxygen and a different method is needed to make sure the yeasts are happy. Another popular method is to slosh, swirl, and mix the wort to dissolve more oxygen. This is a strategy often employed by homebrewers. Another approach is to pump air into the wort using an air pump and filter. By using a sintered stone more oxygen can be forced to dissolve. These two methods increase oxygen levels to around 8 ppm. This is enough for yeast to grow and ferment sugars to alcohols but slightly higher levels are preferred by the yeast. The most effective way to increase the dissolved oxygen content of the wort is to bubble pure oxygen through the wort with a sintered stone. This is able to increase dissolved oxygen levels immensely though (to levels >25 ppm) and great care should be taken when oxygenating wort in this fashion. By pumping pure oxygen through the wort 10 and 12 ppm can be reached. Care should be taken when using pure oxygen as this is the only method capable of increasing dissolved O2 to levels that cause oxidation. Below is a table indicating oxygen levels relative to the technique used.

Method: Oxygen levels achievable
Spray filling: 4 ppm
Mechanical mixing: 8 ppm
Air pump w/ sintered stone: 8 ppm
Pure Oxygen w/ sintered stone: 26 ppm

Too much oxygen results in two things. The first is undesired oxidation of molecules in the wort creating undesirable flavors. This is the reason the rest of the brewing process is kept as oxygen free as possible. The other reason is that the yeast may grow at an elevated rate resulting in too much yeast in the fermenter. This can cause off flavors in the beer but is a minor issue. Dissolved oxygen can be measured easily enough using a dissolved oxygen meter. In most cases oxygen should not be introduced to the wort after primary fermentation has begun, because it will result in the oxidation of several compounds resulting in off flavors. Yeast will also use this oxygen to make early fermentation products such as diacetyl.

pH

Fermentation generally lowers pH. So appropriate pH levels for the beer style being brewed must be maintained, in order ensure the proper conversion to alcohol and a consistent final product. Lower pH levels help to prevent the growth of microbes, and the alcohol produced at this stage helps to fight contamination as well. Our Portable pH meters have a large display which shows readings in an extended range from -2.0 to 16.0 pH (pH56 has a 0.01 pH resolution) and simultaneously shows temperature from -5.0 to 105.0°C or 23.0 to 221.0°F. They have a stability indicator and hold function that freezes the display for easy and accurate recording.

Yeasts thrive at slightly lower pH. They will also change the pH of the environment themselves. Yeast will naturally lower the pH of wort during fermentation via CO2 and succinic acid production. When the yeast is added there will be a sharp drop in pH from near 5.2, where the boil was finished, to near 4.2. The value after the drop is dependent on the type of yeast used and therefore the type of beer being made. For most lagers the pH will drop to between 4.2 and 4.4, and as low as 3.8 for some ales.

The pH control process by the yeast makes controlling the pH during fermentation fairly unimportant. This does not mean though that it is an unimportant measurement. Monitoring pH during fermentation can identify a problem in the beer. If the pH of the beer changes much pass the initial drop then the beer is most likely infect by some undesired bacteria most commonly Lactobacillus or Pedicoccus. In some beers though, a sour flavor is desired and bacteria such as Lactobacillus, Pedicoccus, and/or Bretannomyces is added to give this trait to the beer. The pH is then monitored and when the desired level is reached fermentation is stopped

Turbidity

Turbidity should also be actively measured during fermentation. If turbidity is high, the wort can be recirculated until turbidity has reached the ideal level. A Turbidity Sensor can be directly installed via a wireless system, or a portable turbidity meter can be used to manually get readings during this phase.

Carbon Dioxide (CO_2)

Some brewers recover the CO_2 which is lost and vented off during the fermenting process, and re-add it later or sell it for other uses. Once the desired SG is reached, many seal the vents on their fermenters to allow the remaining CO_2 to enter their batch. The vented CO_2 used at this stage should be monitored for purity.

Conductivity

After fermentation, the change in conductivity between your beer and the yeast can be measured as the fermentation tank is emptied. This will reduce your loss of beer and reusable yeast as these two products are separated, increasing savings and more efficient use of resources. Ideally the sensor will be placed in-line within the tank. We have hand held conductivity meter listed on the website. If you do want inline unit please contact us for a custom quotations since these will be built with the right threading etc. to fit your tanks.

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