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Beer Brewing & Dissolved Oxygen

What Makes Beer?

Having enough dissolved oxygen to feed the anaerobic breathing process of yeast is crucial to the beer-brewing process.

But anaerobic breathing, also known as fermentation, is not the only reason why it is important to control dissolved oxygen in beer brewing. In fact, the presence and absence of dissolved oxygen at the right part of the process is key to having a good batch of beer.

So what's in a mug of beer? The recipe of beer consists following four main ingredients:

1. **Cereal grains, germinated and partially grown**

Barley is more often used, but some also use wheat, oat, maize and rice. In order for cereal grains to germinate, air is blown through the grains during storage and germination to induce an oxygen-rich environment. The malted grain is then mashed and mixed with water to form wort, and boiled for at least 30 minutes to kill any bacteria that could infect the culture.

2. **Yeast**

Yeast, which is added to the wort after it has been boiled and cooled down, is the living organism responsible for producing alcohol in beer through the process called fermentation. Technically, pitching about 10 million to 30 million yeast cells per millimetre of wort is sufficient. However, the amount to add is really dependent on many factors, such as the wort gravity, the strain of yeast used, and the fermentation temperature.

During fermentation, glucose present in the wort is broken down by the yeast to form carbon dioxide and alcohol. Dissolved oxygen level, which is discussed in the later part of this article, plays a very significant role in the success of fermentation.

3. **Hops**

Hops is a plant which produces cone-shape flowers. Known as the "spice of beer" hops contributes to the bitterness, aroma and flavour of beer. Different hops contain different Alpha Acid levels, which in turn, lend to a different tasting beer. Using hops at different part of the beer-brewing process can also produce different results to the brew.

4. **Water**

As the main ingredient of beer, water quality undoubtedly plays an important role in determining the final taste of your beer. Most major and successful breweries operate in locations with a great or clean source of water. Water adjustment is possible by regulating the pH, water hardness, mineral content and other water quality parameters. Good measurement tools, such as pH meters, titrators etc are essentials in the process of adjusting water quality.

Oxygenation: When and How Much?

Before it all begins: Pre-fermentation

Oxygen is introduced to the wort after boiling, and prior to the addition of yeast. Most breweries oxygenate their wort with sterile air after it has cooled off to increase oxygen solubility and to reduce wort oxidation. There are also some who choose to introduce air while the wort is hot to sterilise the air, but this runs the risk of oxidising off flavours in the beer, leaving a stale, garlicky taste.

Whether your preference is to oxygenate when the wort is hot, or after the wort has cooled down, the oxygenation process should take place before, not after fermentation has commenced. As fermentation progresses towards completion, oxygen uptake is reduced, and any additional oxygen injected into the wort will not be used off. Instead, it remains to react with other compounds in the beer, creating staleness and undesirable tastes.

Too much or too little?

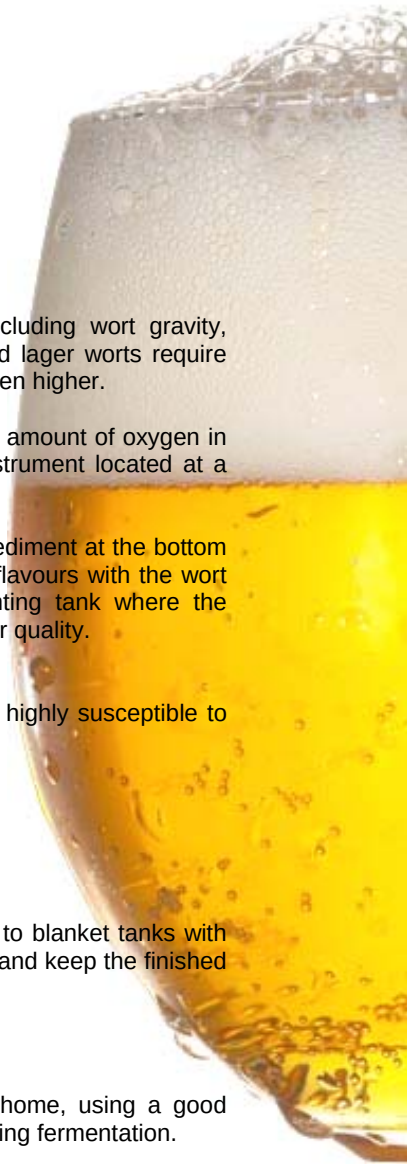
Determining the amount of oxygen or air to inject for fermentation can be tricky.

Too little dissolved oxygen results in

- Low and sticky fermentation
- Off flavours
- Poor yeast crop
- Low ester/ alcohol production

Too much oxygen causes

- Rapid fermentations, resulting in excessive yeast growth and beer losses
- High ester production, resulting in a fruity-tasting beer



Like pitching, the amount of oxygen to add is dependent on a plethora of factors, including wort gravity, temperature, oxygenation/aeration method and the desired end-product. Traditional ale and lager worts require approximately 6 to 8ppm of dissolved oxygen, while high gravity brewing require 16ppm or even higher.

Without a good dissolved oxygen meter, it is impossible to gauge, and therefore, control the amount of oxygen in your wort. Hence, a good oxygenation or aeration system should include a measuring instrument located at a reasonable distance from the injection point in your process.

As the process fermentation begins to slow down, yeast and protein flocculate and form a sediment at the bottom of the fermenting tank. This sediment can cause unpleasant yeasty characteristics and off-flavours with the wort which is still fermenting. It is advisable to transfer the wort to a second clean fermenting tank where the fermentation process can complete and additional settling can occur without affecting the beer quality.

Oxygen control after the beer is brewed

At the end of fermentation, the beer is completely free of oxygen. At this point, the beer is highly susceptible to oxidation, which has the following effects on the end-product:

- Undesirable taste
- Cloudy/ hazy beer
- Increased beer astringency
- Darkened beer colour

There are several ways to prevent oxidation of the beer after fermentation, one of which is to blanket tanks with inert gases. Use only de-aerated water for dilutions, as well as to run through beer transfers, and keep the finished product in cool storage during the supply chain.

Measuring Dissolved Oxygen

Whether it's online measurements in a brewery or ad hoc measuring during a brew at home, using a good dissolved oxygen meter can help to take away the guesswork in dissolved oxygen control during fermentation.

Eutech offers a wide range of high-accuracy dissolved oxygen meters and fast-responding electrodes that allow brewers to track both dissolved oxygen levels (in ppm, mg/L or %) and temperature at the same time. To find out more about our dissolved oxygen meters and electrodes, visit us at http://www.eutechinst.com or email us at eutech@thermofisher.com.

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