The Science of Brewing Beer

Sarah Oppelt
Current member of Tolan Lab, Boston University
Former Microbiologist & QC Manager, Brewery Ommegang
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Overview of Brewing Process & Ingredients

What contributes to the flavor of beers?

Fermentation

How Yeast is Really Controlling Everything
Ingredients

Water

Malted Grains

Hops, or other additives

Yeast
The Mineral Content of Water Will Have Subtle Effects on Flavor

Ca++ and Mg++ (hardness) will effect yeast metabolism and growth rate.

HCO$_3^-$ (bicarbonate) will effect the pH of the fermentation.
Malted Grain Provides the Sugar for Fermentation

The more roasted a grain is, the more it contributes toasted and caramel flavors. However, darker roasted malts provide less simple sugars.
Hops are a surfactant that also contribute to head formation because of their ability to stabilize bubbles by increasing surface tension. Our ability to distinguish levels of bitterness is very imprecise.
Yeast provides all of the flavor!
3 Types of Yeast Used in Brewing

Ale yeasts are top-fermenting, can ferment at higher temperatures, and tend to produce more esters.

Lager yeasts are bottom fermenting, ferment at lower temperatures, and produce a more “crisp” taste.

Wild yeasts produce a lot of unusual compounds and contribute to a “horse sweat” flavor that is more acidic and an acquired taste.
Fermentation in General

\[ \text{C}_6\text{H}_{12}\text{O}_6 \rightarrow \text{C}_2\text{H}_6\text{O} + \text{CO}_2 \]

- glucose
- ethanol
- carbon dioxide
Major Molecules that Contribute to Flavor & Mouth-feel

- Length of carbon chain on alcohol
- Amount of alcohol in the beer
- Amount and type of esters produced
- Residual sulfur compounds
- Carbonation
Metabolism Involved in Molecules that Contribute to Flavor

Glucose → DHAP + Glyceraldehyde-3P → G3P → Pyruvate → Ethanol + longer chain alcohols

Acetyl-CoA → Fatty Acids

Citric Acid Cycle

Esters
Factors effecting Fermentation

Mineral Content of Water

Temperature of Fermentation

Pitch Rate of Yeast

Amount of Aeration

Length of Fermentation
The faster a yeast grows and the longer the exponential growth phase is, the more esters will be produced.
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More Aeration Leads to Less Ester Production

Aeration Discourages Ester Production

Relative Amount of Aeration

Relative Amount of Ester Production
**Common Esters & Their Flavors**

*Ethyl acetate* is the most common ester, and smells like nail polish remover. However, sensory threshold for this molecule is very high, so it isn’t usually noticed.
**Common Esters & Their Flavors**

Isoamyl acetate has a very low threshold for detection. It has a “fake bananas” flavor and is found in a lot of Belgian and wheat style beers.
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Common Esters & Their Flavors

Ethyl butyrate has a low to medium threshold. It gives hints of passion fruit or pineapple.
Ethyl hexanoate has a low to medium threshold. It lends a red apple or anise like flavor.
Budweiser

Grains & Hops: Pilsner malt, medium amount of hops

Yeast: S. ovarum, (formerly S. carlsberges)

Fermentation: 15°C for 2 wks, with longer lagering period. Wood chips are added to help yeast flocculate

Other: Filtered beer and force carbonated.
Pabst Blue Ribbon

**Grains & Hops:** Pilsner malt, medium amount of hops, majority of sugar comes from corn

**Yeast:** *S. ovarum*, (formerly *S. carlsberges*)

**Fermentation:** 15°C for 2 - 3 wks

**Other:** Filtered beer and force carbonated.
Guinness

Grains & Hops: dark roasted malts give the color, light roasted malts provide sugar for fermentation

Yeast: *S. cerevisiae*

Fermentation: 18°C for 2-3 wks

Other: Filtered beer and force carbonated with nitrogen. The creaminess comes from the feeling of the smaller bubbles.
Hoegaarden

Grains & Hops: lighter roasted malts and wheat, low to medium hops

Yeast: S. cerevisiae

Fermentation: 18°C for 2 -3 wks

Other: Beer is unfiltered and refermented in the bottle for natural carbonation
Rodenbach

Grains & Hops: lighter roasted malts and wheat, low to medium hops

Yeast: “wild” fermentation, spontaneous mixed culture

Fermentation: 18°C for 2 -3 wks

Other: Beer is filtered and refermented in the bottle for natural carbonation
Thanks for listening!

Questions?