Beauty and the Yeast

Brewer’s yeast

what, how and why should I care?

Troels Prahl
Vice President of Innovation and European Operations
Agenda

• History of beer yeast
• Yeast metabolism basics - Flavor creation
• White Labs
• Yeast handling
  - Pitching
  - Fermentation
  - Collection and reuse
In the beginning……

- Laboratories for commercial yeast did not exist
- Brewing strains were created by brewers by:
  - Continuing to use strains that performed well and tasted good
  - Passing strains to brewer to brewer
The Beginning of Yeast Banking

- Emil Christian Hansen 1883
  - Developed pure culture techniques
- Strain selection and strain storage
Yeast Used in Brewing

All yeast used in brewing worldwide is non-GMO

Ale Yeast
- Original brewing strain - *Saccharomyces cerevisiae*
- Top ferment
- Warmer fermentation temps
- Wide strain variety

Lager Yeast
- Natural hybrid - *Saccharomyces pastorianus* *(Saccharomyces carlsbergensis)*
- Bottom ferment
- Colder fermentation temps
- Limited strain variety

Other Strains
- *Saccharomyces uvarum*
- *Saccharomyces bayanus*
- *Saccharomyces eubayanus*

*Saccharomyces pastorianus = Saccharomyces cerevisiae + Saccharomyces eubayanus.*
Predictability...

1. Reliable growth and fermentation
2. Short lag phase, normal yield
3. Suited for wort medium and conditions (pH, sugars, nutrients, temperature)
4. High attenuation
5. Low acid production
6. Desired flocculation
7. Desired aroma profile
8. Stable and robust culture
9. Safe for food production
...and Creativity!

Yeast does not care about making beer, it only cares about creating energy to survive and reproduce.

The yeast’s aroma contribution to the beer can be visualized as a spill or overflow of the building blocks needed for cell replication.

59% of the *aroma* descriptors in beer

79% of the *flavor* descriptors in beer are yeast derived or modified by Yeast.
Unique Properties of Brewers Yeast

• Asexual reproduction by budding
• Little to no sporulation
• Therefore mating is rare
• Polyploid
• Phenol Flavor Negative
• Stress tolerant
• Flocculate
• Hundreds of different, stable strains currently used industrially
Brewers domesticated *Sacch. cer.*!
Why are Strains so Important:

**Flavor**

- Alcohol
- Higher (fusel) alcohols
- Esters
- Diacetyl
- Sulfur
- Acetaldehyde
- Phenolic compounds

*Different Yeast strains make different amounts
Different Beers often require different yeast strains*
Fermentation Recap

First few hours
- The yeast uses all the dissolved oxygen; there is no detectable uptake of glucose.

8-16 hours
- The first sign of active fermentation as CO2 bubbles are formed.
- A thin head of foam can be observed.

24 hours
- Budding yeast cells observed.
- The temperature, if uncontrolled, rises due to heat generated by the fermentation.

24-48 hours
- The rate of yeast growth and carbohydrate assimilation reaches a maximum.

Post 48 hours
- The pH falls to a minimum of 3.8 - 4.4 before rising slightly towards the end of fermentation.
- The fall in pH is caused by the release of organic acids and buffering compounds (basic amino acids and phosphates) being consumed by the yeast.

Figure 1. Fermentation profiles, showing relative changes taking place.
Yeast’s flavor and aroma contribution to beer
What we do
New location in San Diego in 2011
An Analytical Lab
More locations around the world

Asheville, NC

Office here since 2007
Boulder, CO

Copenhagen
Yeast is Our Main Focus
Our Yeast Production Process
What you do
Flow chart of a yeast culture

Culture collection
- Laboratory culture
- STEPWISE PROPAGATION
- Brewery scale culture
- Shipping
- PITCHING
- FERMENTATION
- CROPPING
- YEAST STORAGE

6 - 12 generations
Yeast Handling – What Do We Mean?

• Best practices for working with yeast
  – Maintaining a pure culture
  • Avoiding contamination by bacteria, wild yeast, or cross-contamination of brewing strains
  – Maintaining a healthy culture
  – Minimizing stress to yeast
Pitching Yeast

Adding a specific amount of yeast to freshly oxygenated wort, at the correct fermentation temperature

- Yeast can be new, first generation, or reused from previous fermentation
- Yeast can be reused ??? times.
  - Can be 5-10, can be 600 → mutations will occur but brewers choice
- Pitch more yeast for high gravity beers
3 Variables (You Can Control!) in Fermentation

- Pitch Rate
- Fermentation Temperature
- Dissolved Oxygen

Fermentation Rate
Final Gravity
Flavor
Yeast Pitching Rate

<table>
<thead>
<tr>
<th>Low Pitching Rates</th>
<th>High Cell Growth</th>
<th>Increased Flavor Compounds</th>
</tr>
</thead>
<tbody>
<tr>
<td>High Pitching Rates</td>
<td>Low Cell Growth</td>
<td>Decreased Flavor Compounds</td>
</tr>
</tbody>
</table>

Rule of thumb: “1 million cells per ml of wort per degree Plato”
Yeast Health

• 1 million cells/ml/°Plato is based off re-pitching rates
  – This is assuming this yeast has undergone the stressful
    conditions of fermentation
  – Actual pitching rates vary between .75 – 1.5 million
cells/ml/°P

• Yeast grown in a lab is much healthier than the yeast at the
  bottom of your fermenter
  – Grown in the presence of O2
  – Low alcohol production
  – Pure culture
  – High viability (95%+)
Yeast Pitching: A Common Brewery Practice

- Brewers often collect yeast into 5 gallon yeast brink, such as a Cornelius keg. They then store and re-pitch by total volume.

1 liter of yeast slurry per 1 HL of beer is a good rule of thumb.

In a 10HL batch:
10 liters of yeast at 1 billion/ml, would Result in 10 million/ml in 1000 L

It is common to see twice this rate, 20 Liters (5 gallons), which would be 20 Million per ml, too high for most beers
Yeast Pitching Rate

• Underpitching
  – Pros
    • Possibly enhanced yeast flavor
    • Need less yeast
  – Cons
    • Stuck fermentation
    • Stressed yeast, less viable to use again

• Overpitching
  – Pros
    • No stuck fermentation
    • Decrease in some aromas/ flavors
  – Cons
    • Fermentation completes too quickly
    • Can leave some off flavors
    • Ageing yeast culture for re-pitching
Yeast Pitch Rate

Effect on growth rate and flavor byproducts:

![Graph showing percent of cell mass increase with different initial pitch counts.]
Pitch Rate and Flavor

Yeast Count = Yeast

Metabolites = (flavor-active compounds)

Fermentation Speed

Yeast Count

lag, but can get sluggish)

Yeast Metabolites

= Yeast Metabolites

= Fermentation Speed

(short)

(longer)
Yeast Collection & Harvesting
Yeast Collection & Harvesting

*When is the best time to harvest?*

- End of fermentation
- When early flocculating yeasts begin to drop to the bottom of the cone – discard
- Within 3-5 days of start of fermentation
Yeast Collection & Harvesting

How should yeast be collected?

Top Cropping

• Benefits
  – Yeast rises at a time of high vitality and viability
  – Free from trub – better shelf life
  – Faster turnaround time for yeast collection

• Disadvantages
  – Beer & yeast are exposed to environment
Yeast Collection & Harvesting

How should yeast be collected?

Bottom Cropping

• Benefits
  – Equipment design lends well to bottom cropping
  – Some strains can’t be cropped from top

• Disadvantages
  – Breakdown of yeast happens faster – stress from hydrostatics, alcohol, temperature
  – High percentage of trub
  – Turnaround time to collect yeast is longer
Yeast Collection & Harvesting

How should yeast be collected?

• Bottom Cropping – Best practices
  – Timing – end of fermentation, depending on strain
    • Remove as soon as possible without risking integrity of beer
  – Discard the first runnings
  – Use only the middle pack
Yeast Collection & Harvesting

How should yeast be collected?

Cone to cone?

• Need to visually verify yeast
  – Color
  – Trub
  – Concentration
  – Contamination analysis

Aber instrument
Collection Options
Storage

- Cone storage can be stressful
  - Hydrostatic pressure
  - In hospitable environment – alcohol
  - Temperature in the cone

- Storage Medium:
  - On beer, wort, or water?
    - Beer – no transfer; great short term if under 6% alcohol
    - Wort – short term; carbohydrates present can be harmful
    - Water – best long term solution because it’s neutral
Storage
Considerations for yeast storage:

Objective:

Keep metabolic activity to an absolute minimum in order to preserve viability and vitality

1. Chilling the yeast
   - If warmer than 4°C
     - Alcohol toxicity
     - Limited nutrients
     - Depletion of glycogen
     - Loss of viability / vitality
2. Glycogen and lipids

• Glycogen is the major reserve carbohydrate stored within the yeast cell.

• “Store” of to sustain the cell during periods of starvation

• In the presence of oxygen, glycogen is rapidly mobilized to fuel lipid (sterol and unsaturated fatty acids) synthesis.
Yeast Glycogen and Lipid during a 16 °P Lager Fermentation

C.R. Murray, T. Barich and D. Taylor
MBAA Technical Quarterly, 21 (4) 1984
The Effect of Yeast Glycogen Concentration at Pitching on a 16\(^0\)P Lager Fermentation

C.R. Murray, T. Barich and D. Taylor

MBAA Technical Quarterly, 21 (4) 1984
Yeast Maintenance

Re-pitching yeast – what to expect

• How many generations? – conditions & strain
  – Ales: 8-10
  – Lagers: 3-5
  – Wheat & Belgian: 3 or less

• First generation vs. later generations – why the differences?
Summary

- Harvest yeast as soon as the bulk of the yeast has separated from the beer.
- Chill rapidly to ~ 4°C and maintain that temp.
- De-carbonate.
- Exclude air.
- Store for as short a period as possible.
- Pitch accurately.
- Evaluate the culture before using/reusing.
- Keep it clean.
Keep the yeast happy

“All yeast are female by definition, mother cells and daughter cells. If you don’t treat women with respect they will eventually bring you to your knees…”
Thank you

Questions?
Fermentation Control - Strain Selection

- Set Parameters for the beer
  - ABV, IBU, SRM
- Decide on a flavor concept
  - Malty, hoppy, other?
- Determine at least 1 or 2 key requirements
  - Temperature, sugar, and alcohol tolerance, Attenuation ranges, volatile flavor and fusel alcohol production, etc.
Monitor the Actual Values

- Gravity
- pH
- Cells in suspension
- Cell Pack
- Alcohol
- Color
- Clarity
- IBU
- Aroma

The list goes on……

Google sheets (free), excel, fancy software
Fermentation Monitoring

Do experiments!

Ferment the same wort with different yeast strains
Fermentation Temperature

- Temperature affects both yeast metabolism and the speed of fermentation
- Most *S. cerevisiae* strains are optimal between 65-70°F (18-21°C), but there is a wide range
- Higher or lower temperatures can lead to varying fermentation effects

Temperature – one of the most important control factors
Fermentation Temperature

Effects on fermentation rate:

![Temperature Trials – Cell Growth](image)
Fermentation Temperature

Effects on fermentation rate:

- Faster gravity drop
Fermentation Temperature

Temperature = Yeast Metabolites

Metabolites = (flavor-active compounds)

Fermentation Speed = Temperature

Temperature = Fermentation Speed

inhibitory)
Dissolved Oxygen

• Oxygen is necessary for production of lipids for cell wall manufacture
• Allows the yeast to be hardy and withstand environmental stresses (gravity, pH changes, temperature, alcohol)
• Optimal is 8-10ppm in wash, prior to fermentation
Dissolved Oxygen

- Oxygen
- Unsaturated Fatty Acids
- Sterols
- Lipids
Dissolved Oxygen

Without it, yeast are depleted

Resulting in:

Slow fermentation
Incomplete fermentation
Poor growth
Dissolved Oxygen

Effect on fermentation rate:

![Dissolved Oxygen Graph]

Gravity (degrees Plato) vs. Time (hours)

- 2.71ppm
- 5.12ppm
- 9.2ppm
- 14.08ppm
Dissolved Oxygen = Yeast Metabolites = Fermentation Speed (ca. to stuck fermentations)
Dry or Liquid!?
Water is life
Dehydration is damaging

- ester production muted
- background contamination
- low viability
- not suitable for reuse