What you will need

- Notebook
- Pencil/Pen
- Calculator
- Yeast Book
Classroom Requests

- Please silence all cell phones
- Please put away all cell phones
- Do not use cell phones during class
- If you have to take a call, please excuse yourself from the classroom.
- Be respectful
- Breaks will be given about every hour
- Ask Questions!!
What You Will Learn, Part 1

- Yeast Types
- Yeast Nutrition
- Fermentation Variables
- Pitching Rate and Yeast Propagation
- Yeast Cell Counting
Yeast Species

- **Lager Yeast**
  - *Saccharomyces pastorianus*
  - Bottom fermenting
  - Temps 50 °F – 55 °F

- **Ale Yeast**
  - *Saccharomyces cerevisiae*
  - Top fermenting
  - Temps 68 °F – 95 °F
Where does Yeast Nutrition come from?
Yeast nutrition comes from 2 main sources.

- **Grain**
  - Provides natural minerals
    - Mg, nitrogen, folic acid, etc.

- **Yeast Nutrient additives**
  - Adds a “boost” to naturally occurring nutrients from grain
  - Added either into the boil kettle or the fermentation vessel
Yeast Nutrient Additives

- Provides additional nutrients in order for the yeast to be healthy and “happy”.
- Decreases the fermentation time
- Increases flocculation
- Decreases Sulfur notes
- Improves health and viability of yeast
- Provides faster and more complete attenuations
- Increases yeast production for better harvests
- Improves quality of finished product
Common types of Yeast Nutrients

- Servomyces
- GMO free
- Conforms to Reinheitsgebot restrictions
- Added to the boil
Common Types of yeast Nutrients (Cont.)

- WLN 001 (White Labs)
  - Used to increase yeast health
  - Improves fermentation and pitching performance
What is in Yeast Nutrient?

- Ammonia Salts (DAP)
- Alpha amino nitrogen
- Sterols
- Unsaturated fatty acids
- Magnesium Sulfate
- Thiamin
- Folic acid
- Niacin
- Biotin
- Calcium panothane
How is Yeast Nutrient added?

- Most are added into the boil kettle about 10 minutes prior to knock out.
- Some are added to the Fermentation Vessel (FV) and require hydration prior to pitching into an active fermentation.

https://www.whitelabs.com/other-products/nutrients
Questions?
Yeast Definitions

- **Attenuation** – The percentage of sugars yeast consume during fermentation

- **Flocculation** – Aggregation of single cells into clumps of thousands of cells and dropping to the bottom of the FV
Fermentation Chemical Pathway

Glucose + 2 ADP + 2 phosphate $\rightarrow$ 2 ethanol + 2 CO$_2$ + 2 ATP
Fermentation Timeline

- **Lag Phase**
  - Zero to 15 hours after pitch
  - Acclimation to environment
  - Reproduction

- **Exponential Growth Phase**
  - 4 hours to 4 days
  - Sugar consumption

- **Stationary Phase**
  - 3 days to 10 days
  - Slow down of yeast
  - Green beer
Growth of Yeast

- Chapter 4, Yeast, C. White, pages 67-69

Crabtree Effect

- Production of ethanol (EtOH) in the presence of Oxygen
- Generally Oxygen presence is for reproduction purposes
Fermentation Variables

- One or many conditions will effect the way yeast do their job.

- Common Yeast stressors
  - Temperature
  - pH
  - Common sources of acidic pH
    - Lactic acid (bacterial or wild yeast infection)
    - Acidic acid  (bacterial or wild yeast infection; also produced by brewing yeast)
Fermentation Variables (Cont.)

- Storage
- Nutrition
- Decreased $O_2$
- Decreased Zinc
- Increased Na
**Ester formation:**

Ethanol + acetic acid $\rightarrow$ Ethyl acetate (ester) + $H_2O$

*Increased $O_2$ decreases ester formation*
Fusel alcohol formation:

*Increased fermentation temperature increases fusel alcohols (C₃+ alcohols)
Diacetyl formation:

* Diacetyl is formed from acetolactate (a common yeast metabolite)
* Acetolactate diffuses out of the yeast cell into the beer solution and oxidized into diacetyl.
* Diacetyl will be reabsorbed by the yeast cell and not contribute to off flavor.

Acetolactate + O₂ → diacetyl (buttery flavor)
Biochemistry Highlight:

Glycolysis and fermentation

Chemical pathway:

Glucose($\text{C}_6\text{H}_{12}\text{O}_6$) $\rightarrow$ ethanol ($\text{CH}_3\text{CH}_2\text{OH}$) + 2 $\text{CO}_2$
Questions?
What you will learn:

- What is pitching?
- What is pitching rate?
- How to calculate pitching rate.
- What is yeast propagation?
- Why propagate yeast?
- Overview of how to propagate yeast.
What is Pitching?

Pitching is a brewers term for introducing yeast into unfermented wort.
Why use pitching rates?

- Consistency
- Quality
- Cost Savings
Pitching Rates

- Over pitching
  - Low esters
  - Flavors form yeast autolysis
  - Poor head retention
  - Negatively affects yeast health over generations

- Under pitching
  - Slow fermentation
  - Long lag times
  - Allows growth of bacteria and wild yeasts
  - Affects flavor more
Pitching Rates

Both Over and Under pitching can result in:

- High levels of diacetyl
- High levels of acetaldehyde
- Low attenuation
Pitching Rates

Common levels of pitching rates

Ale yeast: 0.40 to 1.00 million cells per ml per 1 °P

Lager Yeast: 1.00 to 1.65 million cells per ml per 1 °P

Handbook of Basic Brewing Calculations, S. Holle, pg.57, Formula 1
### Pitching Rates

- **Common pitching rates based on yeast type and wort extract:**

<table>
<thead>
<tr>
<th>Yeast</th>
<th>Pitching Rate (cells/mL)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Ale</strong></td>
<td>Lower range: 5 million</td>
</tr>
<tr>
<td>5/12°P</td>
<td>Upper range: 12 million</td>
</tr>
<tr>
<td>12/12°P</td>
<td></td>
</tr>
<tr>
<td><strong>Lager</strong></td>
<td>Lower range: 12 million</td>
</tr>
<tr>
<td>12/12°P</td>
<td>Upper range: 20 million</td>
</tr>
<tr>
<td>20/12°P</td>
<td></td>
</tr>
</tbody>
</table>
The common pitching rate is 1 million cells per milliliter or wort per degree Plato.

Cells to pitch = (1 million) x (milliliters of wort) x (degrees Plato of the wort)
Pitching Rates

Practice:
Find the following

How many cells do you need to pitch if you want a rate of 0.70 million cells/mL into 30 bbls of 13°P wort?

How many cells do you need to pitch if you want a rate of 1.5 million cells/mL into 50 bbls of 11.7°P wort?

How many cells do you need to pitch if you want a rate of 1.65 million cells/mL into 15 bbls of 12°P wort?
Questions?
Yeast Propagation

- **Oxygen**
  - 8-9 mg of O$_2$/L needed for healthy reproduction
  - Use flow meter to determine correct amount
Yeast Propagation

“Doubling” or “Multiplying”

Ale Yeasts can be expected to “double” up to 10 times during propagation

Lager Yeasts can be expected to “double” up to 5 times during propagation
Yeast Propagation

- Rule of thumb:
  - Ale yeast starters can be pitched into wort 10 times its size
  - Lager yeast starters can be pitched into wort 5 times its size
Yeast Propagation

How to achieve the desired amount of pitching yeast from a starter

1. Determine the desired pitching rate.
2. Determine the volume of wort to be inoculated.
3. Determine the concentration of yeast cells in the starter.
4. Determine the total number of cells to be pitched.
   
   \[ \text{Total cells} = \text{pitching rate} \times \text{wort volume} \]

5. Determine the volume of the starter to achieve the desired pitching rate.
   
   \[ \text{Starter volume (mL)} = \frac{\text{total cells}}{\text{cells per mL in the starter}} \]
   
   \[ \text{Starter volume (L)} = \frac{\text{starter vol in mL}}{1,000 \text{ mL per liter}} \]
   
   \[ \text{Starter volume (gal)} = \frac{\text{starter vol in L}}{3.785 \text{ L per gal}} \]
Practice:

Find the following

Yeast type: ale

Extract of knockout wort: 12°P

Volume of wort: 10 bbl

Yeast cell concentration in starter: 80 million /mL

Pitching Rate: 1.0 million cells/mL per 1°P
Yeast Propagation

Yeast type: lager

Extract of knockout wort: 12.3°P

Wort volume: 30 bbls

Yeast cell concentration in starter: 120 million/mL

Pitching rate: 1.4 million cells/mL per 1°P
Questions?
Yeast Cell Counting

What you need:

- Hemocytometer
- Microscope with a magnification of more than 400x
- Equipment to dilute yeast samples
  - Pipets
  - Graduated cylinders
Yeast Cell Counting
Yeast Cell Counting

Sample dilution

1. Performed in ratio
   1. 1:1
   2. 1:10
   3. 1:100
   4. 1:1,000
Yeast Cell Counting

Steps to counting cells:

1. Count cells in 5 quadrants
   1. Top Left
   2. Top Right
   3. Bottom Right
   4. Bottom Left
   5. Center
2. Count only cells inside the grid and those touching left and bottom lines
3. Multiply total cells in the 5 quadrants by 5
Yeast Cell Counting

Formula

Cells/mL = (# of cells counted x 5) x dilution factor x 10,000
Yeast Cells Through a Microscope
Questions?
Yeast/Beer Styles Assignment

- Chapter 3, *Yeast*, C. White
- Ale
  - Clean
  - Fruity
  - Hybrid
  - Phenolic/Eccentric
- Lager
  - Dry/Full
Questions?
Part 3 - Yeast Storage

There are different ways to store yeast

- Inside the fermentation vessel
- Yeast Brink
- Kegs
Yeast Storage

Storage times

- Inside the fermentation vessel (FV)
  - No time limit at cold crash temperatures
  - Best to pitch directly after fermentation has completed
- Yeast Brink
  - 1-2 weeks
- Kegs
  - 1-2 weeks
  - Bring yeast temperature to pitching slowly prior to pitch
Questions?
Diacetyl Rest

- Not necessary in ales

- Absolutely necessary in lagers
  - Yeast do not “clean up” after themselves at lager temperatures
  - After fermentation is complete, temperature of FV needs to be raised
  - From lagering temperature to 62-68 °F
  - Time: about a 24 hour period
Diacetyl Force Test

- Tested in large breweries with gas chromatography
  - Tests for VDK levels with a spectrophotometer
- In smaller breweries, cost and simplicity are key

What you will need:
- Two glasses
- Aluminum foil
- Hot water bath
- Ice water bath
- Thermometer
Diacetyl Force Test - Procedure

1. Heat the water bath to 140-160 °F (60-71 °C)
2. Collect beer into each glass and cover with aluminum foil.
3. Place one glass into hot water bath, while keeping the other at room temperature.
4. After 10 – 20 minutes remove the beer from the hot bath, and cool to the same temperature as the other sample. An ice water bath is effective for cooling.
5. Remove the aluminum foil and smell each sample. If you smell the buttery character of diacetyl in either or both samples, you know that your beer has the diacetyl precursor (VDK).

Yeast, C. White, pages 223-224
Questions?