Hands-On Homebrew Science

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- ✓ Started homebrewing in 1986
- ✓ BS in Food Science from Virginia Tech in 1991
- ✓ MS in Food/Brewing Science from UC Davis in 1994
- ✓ Joined BYO Team in 1995
- ✓ SBC Master Brewer 1997 - 2019
- ✓ Paul Mueller Company 1997-2016
- ✓ BSG/Rahr Malting 2016 - Present

Workshop Overview of Day

1. Brewing Science; Before, During, and After Wort Production
2. Cells Counts and Packed Cell Volume
3. Grist Assortment Screening and Mill Adjustment
4. Starch Gelatinization, Liquefaction, Saccharification, and a Decoction Calculation
5. Hot Steeps and Mash pH
6. Pouring and Streaking Plates
7. Lager tips from the Wiz
8. Spindling Beer the Easy Way

What is Brewing Science?

A multi-disciplinary field aimed at understanding, controlling, and improving the production and enjoyment of beer. The study of brewing science includes chemistry, biochemistry, microbiology, sensory science, statistics, and engineering.

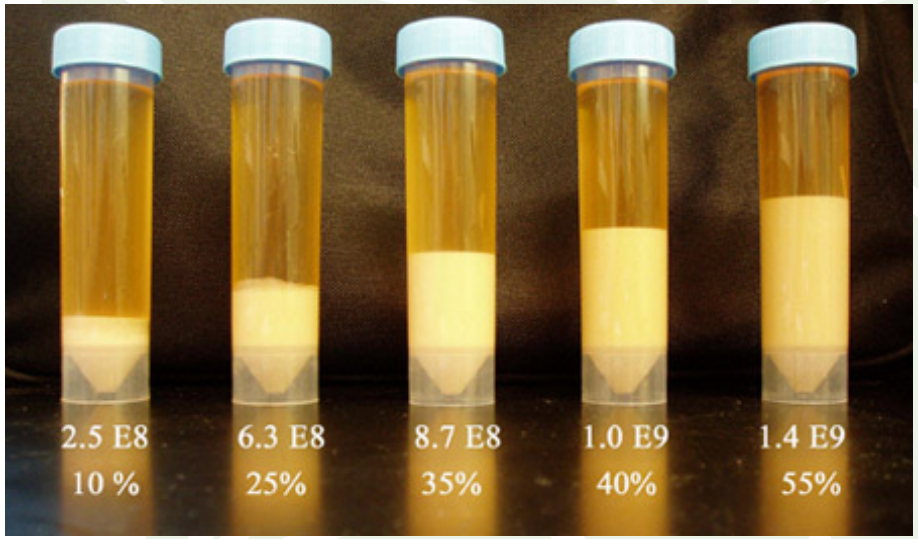
Hands-on Homebrewing Science?

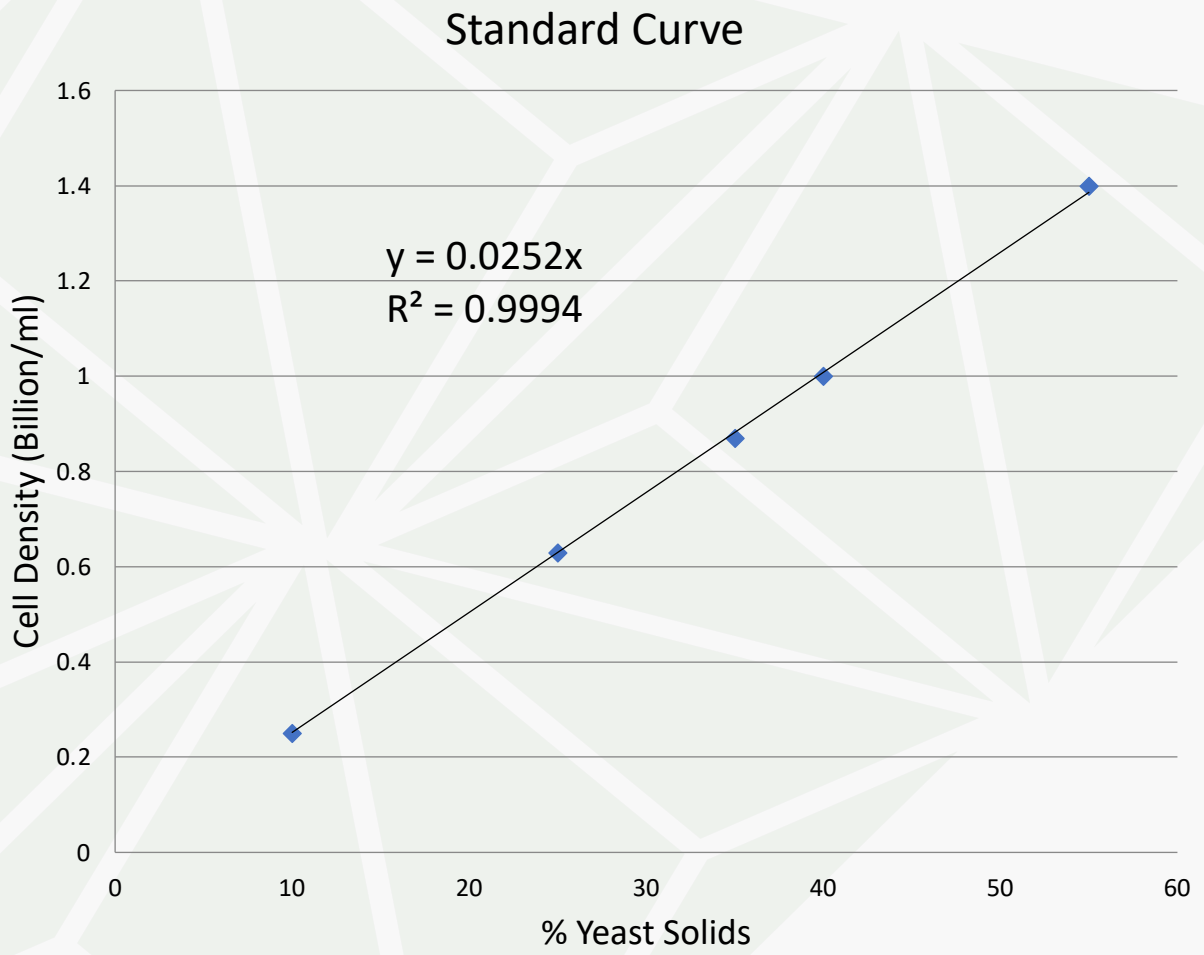
- Some lab-type methods better done when not brewing
- Some lab-type methods used to monitor the process
- Engineering principles applied to the process

Segment #1

Spinning, Counting, and Graphing

Pitching Rate Estimation





-- Gravity sedimentation of 100ml sample --

-- 40% solids corresponds to about 1 billion cells/ml --

Pitching Rate Calculation

How much yeast slurry is needed to pitch 20 liters of 14.5° Plato wort, assuming pitching rate of 1 million cells/ml*Plato and 35% solids in yeast slurry.

Yeast Cells Required?

= 20 liters x 14.5° Plato x 1 million cells/ml*Plato x 1,000 ml/l

= **290 billion cells = 2.9×10^{11}**

Slurry Density?

= 0.0252 billion cells/ml x 35 (from standard curve)

= **0.88 billion cells/ml = 8.8×10^{8} cells/ml**

Pitching Rate Calculation

We now know we want 290 billion cells and that we have 0.88 billion cells / ml slurry.

Slurry Volume?

= 2.9×10^{11} cells ÷ 8.8×10^{8} cells/ml slurry

= 0.33×10^{3} ml slurry

= 3.3×10^{2} ml slurry

= 330 ml slurry

STATION #3

PACKED CELL VOLUME

PURPOSE

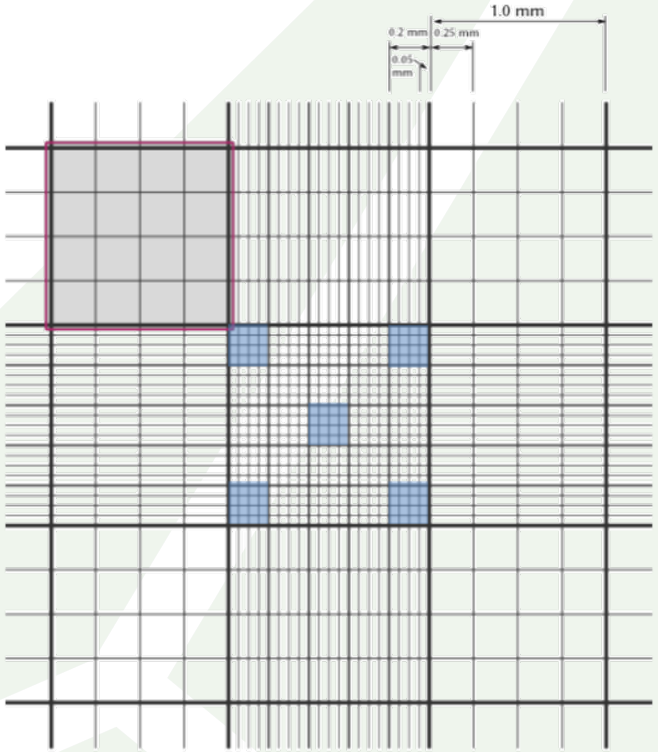
A simple way to determine cell density in a yeast slurry is to determine the packed cell volume (PCV) of a sample, and then to relate the PCV to cell density using a standard curve. At this station, you will determine the packed cell volume of a yeast solution.

MATERIALS

- 1 liter of Stock yeast slurry (this same stock slurry will be used for the entire group today)
- Diluted yeast slurry (same diluted sample for this station **and** the microscope station)
  - Sample 1: 150 ml slurry + 50 ml water (3:4 dilution factor)
  - Sample 2: 100 ml slurry + 50 ml water (2:3 dilution factor)
  - Sample 3: 100 ml slurry + 100 ml water (1:2 dilution factor)
  - Sample 4: 50 ml slurry + 100 ml water (1:3 dilution factor)
- Centrifuge
- Centrifuge tubes

STATION #4

HEMOCYTOMETER CELL COUNT



Numer of cells in a 1mm^2 square (red) x 10^4 = No. cells/ml.

SAMPLE CALCULATION

Given Data:

- 173 cells counted in 5 chambers
- Sample diluted 1:100 in volumetric flask
- Sample diluted 3:4 from stock (Group 1 slurry dilution)

1. Cell Density = $\frac{173 \text{ cells}}{5 \text{ grids}} \times \frac{25 \text{ grids}}{\text{chamber}} \times \frac{1 \text{ chamber}}{0.0001 \text{ ml sample}} \times \frac{100 \text{ ml sample}}{1 \text{ ml yeast slurry}}$

   Cell Density = $\frac{432{,}500 \text{ cells}}{0.0005 \text{ ml}}$

   Cell Density = $\frac{4.325 \times 10^5 \text{ cells}}{5 \times 10^{-4} \text{ ml}}$

   (Scientific Notation Note: Subtract exponents when dividing and add when multiplying. In this example the exponent becomes 4-(-5) or 4+5)

   Cell Density = 0.865×10^9

   Cell Density of Sample = 8.65×10^8 cells/ml = 865 million cells/ml

2. Cell Density of Stock Sample = Cell Density of Group's Diluted Sample ÷ Dilution Factor (3:4)

   Cell Density of Stock Sample = Cell Density of Group's Diluted Sample x Inverse of Dilution Factor (4:3)

   Cell Density of Stock Sample = (8.65×10^8 cells/ml) x (4/3)

   Cell Density of Stock Sample = 1.15×10^9 cells/ml = 1.15 billion cells/ml

Let’s Go Do This!

Segment #2

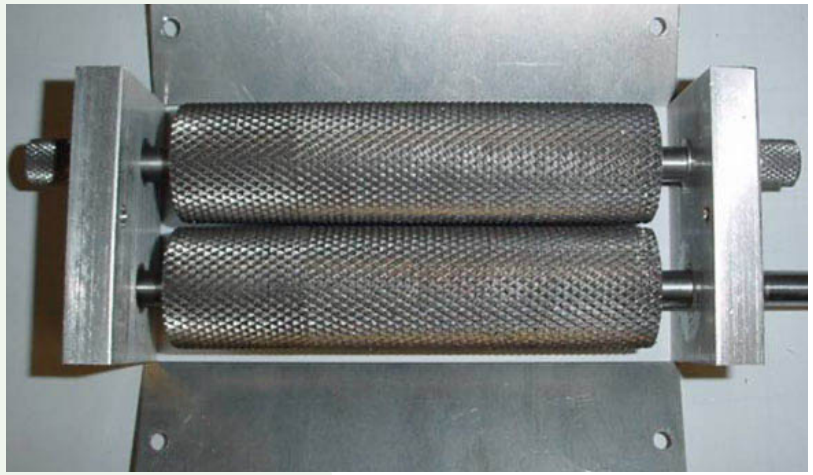
Grist Sieving and Mill Adjustment

Uggh, missed it again!

Target = 12.5˚ Plato

Actual = 12.4˚ Plato

Fine-tuning your mill gap is a good way to improve accuracy.



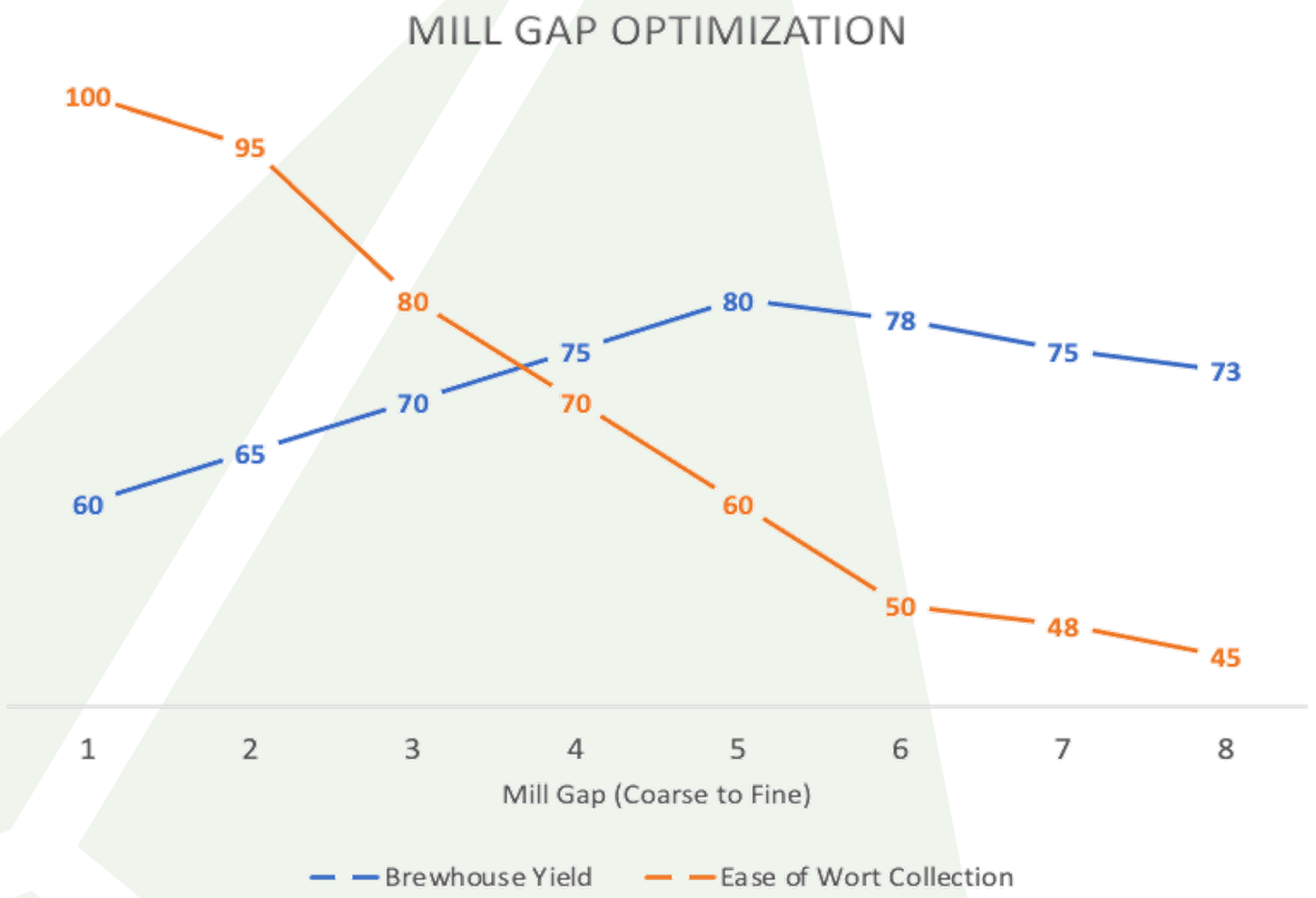
Improving Malt Yield

<u>Mill Adjustment is Key</u>

-- Visual adjustment --

-- Sieve screens --

-- Empirical --



STATION #1

Grist Assortment Screening

PURPOSE

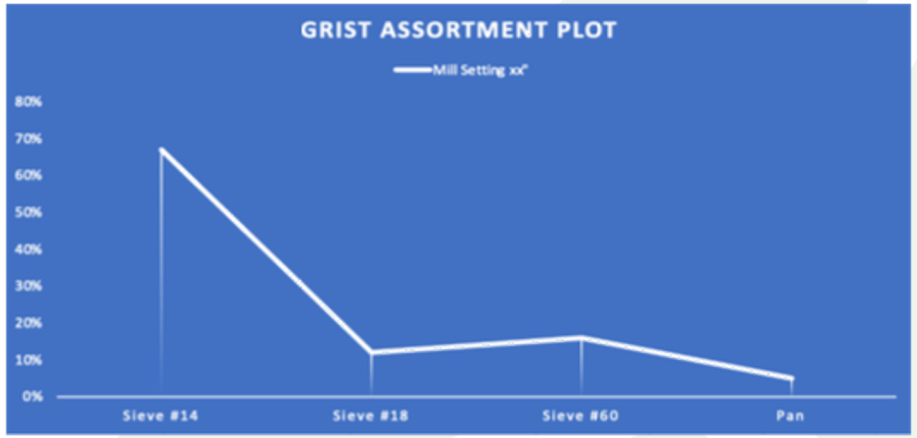
Malt mill adjustment is best performed by evaluating grist composition using assortment sieves to divide milled malt (grist) into fractions. The method is simple, but due to the cost of sieves most small-scale brewers rely on visual evaluation of grist and brewing performance to adjust malt mills. Today, you will manually adjust a malt mill to the crush that your group believes looks right and then this grist will be evaluated with assortment sieves.

MATERIALS

- Malt mill
- Malt
- Scale
- Assortmen sieves (#14, #18, and #60), rubber balls, and bottom pan.

BASIC STEPS

1. Adjust mill by milling malt and evaluating grist until the mill is adjusted to your satisfaction. This is subjective and there is no correct setting.
2. Mill ~200 grams of malt.
3. Stack the assortmen screens by placing the pan on the bottom and stacking sieves from finest (#60) to coarsest (#14). While sieves are being stacked, place two rubber balls in each sieve.
4. Weigh 100 grams of milled malt and pour onto the sieve stack with the #14 sieve on the top.
5. Slide sieve stack east to west for 15 seconds, then tap on table. Slide sieve stack north to south for 15 seconds, then tap on table. Repeat for a total 6 cycles (3 minutes of sliding).
6. Collect the grist from each sieve and weigh.
7. Calculate the percentage of each sieve fraction and plot data on graph like the example shown below.



Segment #3

Amylose, Amylopectin, Iodine Test, and Decoction Calculations

Starch Basics

Amylose – straight chain polymer of glucose; helical; stains with iodine

Amylopectin - branched polymer glucose; leaves unfermentable dextrins behind in beer

Starch Gelatinization – occurs when starch is heated in presence of water; temperature varies by starch type; corn and rice starch is cooked before mashing

What are we going to do? Cook rice starch, add alpha amylase to one sample, alpha amylase and amyloglucosidase to another sample, and keep one sample as a control. Observe!

Decoction / Double Mash Calculation

We have two mashes containing the following:

a) 3.2 kg malt + 12.0 liters of water at 100˚C
b) 7.0 kg malt + 19.0 liters of water at 50˚C

What is the temperature when these two mashes are mixed?

This solution is not simple because the thermal capacity of malt and water are different and the ratio of water to malt in the two mashes is different.

Easy way to solve is to equate malt weight to water volume. The mass balance principles are not required to solve the equation. Trust me ☺!

Decoction / Double Mash Calculation

We have two mashes containing the following:

a) 3.2 kg malt + 12.0 liters of water at 100˚C

We can redefine this as:

- 3.2 kg malt x 0.41 = 1.3 water equivalents at 100˚C
- 12 water equivalents at 100˚C
- Total = 13.3 liters at 100˚C

b) 7.0 kg malt + 19.0 liters of water at 50˚C

We can redefine this as:

- 7.0 kg malt x 0.41 = 2.9 water equivalents at 50˚C
- 19 water equivalents at 50˚C
- Total = 21.9 liters at 50˚C

Decoction / Double Mash Calculation

Here is the combined mash:

$35.2(x) = (13.3)(100) + (21.9)(50)$

$35.2(x) = 1330 + 1095$

$x = 69^{\circ}C$

Summarized Expression:

$((3.2)(0.41) + 12) + ((7)(0.41) + 19)x = ((3.2)(0.41) + 12)(100) + ((7)(0.41) + 19)(50)$

Segment #4

Odds & Ends

Pretzel Logic Unraveled

"I don't want to get into water chemistry for a number of reasons. Like, if I don't know how to develop a water recipe and analyze stuff, I'm better off just using my city water. Right?"

- No, this is not right.
- Deductive reasoning is logic, and logic is science.
  - My base water contains blah, blah (RO water makes this easier!)
  - And blah, blah is added to it
  - Then the resulting water is blah, blah + blah, blah!

This is as easy as it sounds in today's world. Buy salts, weigh, add to RO water, and that's it.

How to Use a Hydrometer

We're gonna do this. But for starters, buy a hydrometer with a built in thermometer.

- Take sample and cool to about 100˚F if "spindling" wort.
- When measuring beer gravity, run your sample through a filter to remove dissolved carbon dioxide.
- Take reading and correct for temperature.
- Yes, accounting for the meniscus is important, but you need to know whether you have a top or bottom reading hydrometer. At the end of the day, the subtle differences are not critical.

Pro Tip: When in doubt don't post hydrometer pics on Facebook. Just don't.

Thank you! Have fun, brew safely, don't let homebrewing stress you out, and, most importantly, brew great beer!

Sincere appreciation to the BYO team, Blichmann Engineering, and BSG Craft Brewing.

Prost!
Ashton "MW" Lewis