Fermentation Strategies

Pitching Rates, Starters, Harvesting, Aeration, & Temp Control

CR Beer Nuts Tech Topic

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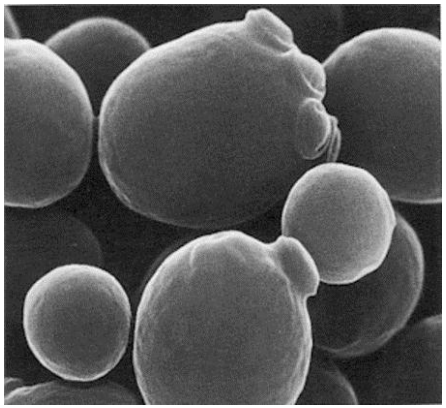
August 2013



Outline

- Why Bother?
- Pitching Rates
- Starters
- Harvesting & Washing
- Aeration
- Fermentation Temps

Goals:

-Move past “just throw some yeast in there”

-Clear up misconceptions

-Provide tools & resources

-Discuss Future Topics

Why Bother?

- "Brewers make wort, Yeast make beer"
  - Better yeast management means better beer
- Each brewing process step can ruin your beer
  - "Planning" & "Brewday" are easiest to understand and receive most attention
  - "Fermentation" factors are the most common culprits of bad homebrew
  - Cause the majority of "off flavors" in homebrew
  - If you want better beer, spend more time worrying about yeast and less time worrying about recipes

Brewing Process Control Areas

Planning	Brewday	Fermentation	Finishing
• Recipe • Malt • Hops • Water	• Mash • Sparge • Boil • Whirlpool • Chill	• Yeast Strain • Pitch Rate • Temperature • Aeration	• Conditioning • Dry Hopping • Fining • Packaging • Carbonation

Why Bother?

Flavor Problem	Under-Pitching	Over-Pitching	Low DO	High DO	Temp
Esters	+	-	+	-	+/-
Fusel Alcohols	++		-	+	+/-
Sulfur	+				*
Acetaldehyde	+	+		*	*
Phenols	+				
Diacetyl	+	*			+/-

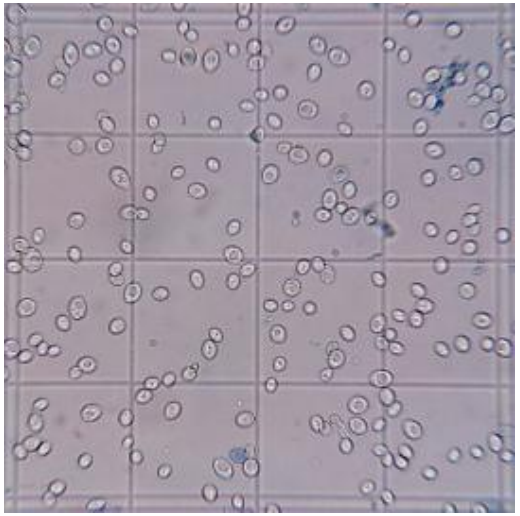
My Order of Importance: Temp Control, Pitching Rate, Aeration

***Possible Cause**

From “Yeast” by White & Zainasheff, Chapter 7 – “Troubleshooting”, Figs 7.2 & 7.3

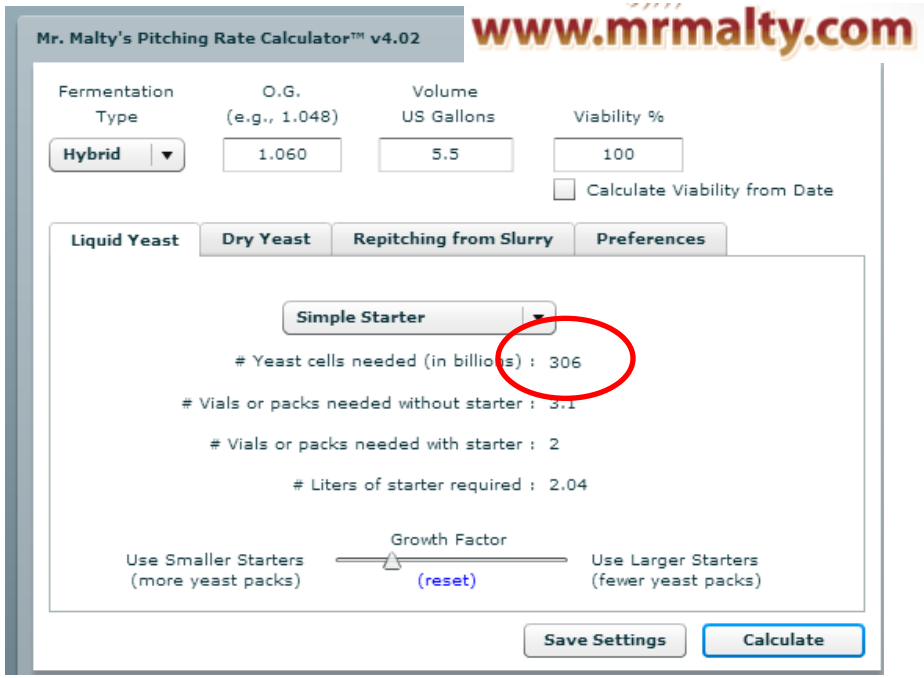
Pitching Rates

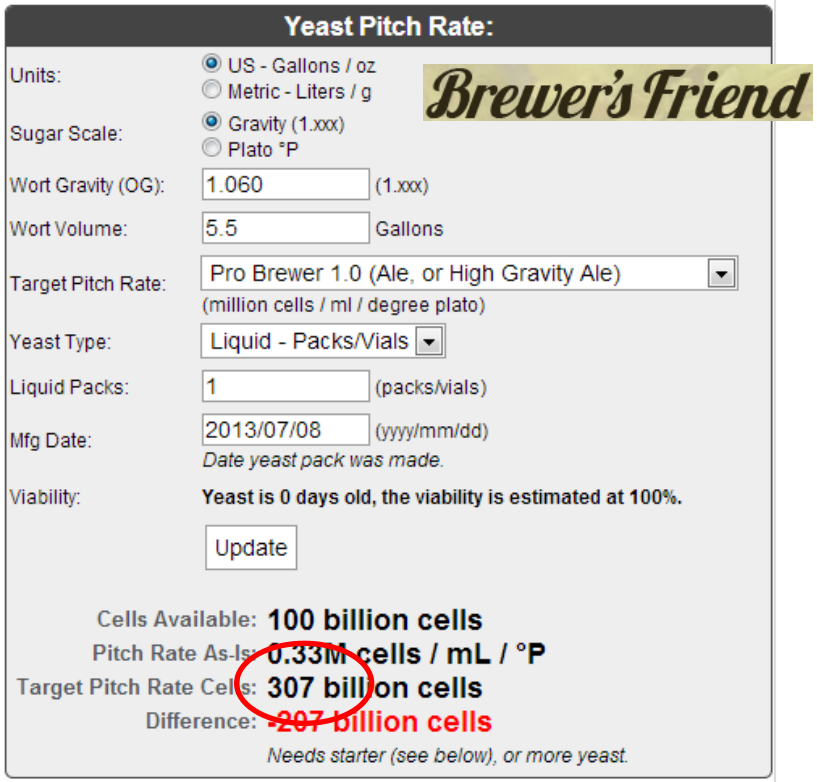
- How much do I need?
  - That depends on whom you ask.
  - White Labs / Wyeast : 1 vial/pack
  - Pro Brewers : ~1.0×10^6 cells/mL/°P (MC/mL/°P)
  - Everyone agrees you want some growth, but not "too much"
- Pitching at a given "rate" accounts for obvious changes with wort volume & gravity.
  - Pitching Rate = (# of yeast cells) / (volume of wort) / (gravity of wort)
  - Higher Volume = More Yeast Cells
  - High Gravity = More Yeast Cells
- How do you know how much I have?
  - Calculator
  - Weight
  - Volume
  - Hemocytometer
- What works for Me?
  - Smaller Ales : ~1.0 MC/mL/°P
  - Bigger Ales : ~1.5 MC/mL/°P
  - Smaller Lagers : ~1.5 MC/mL/°P
  - Bigger Lagers : ~2.0 MC/mL/°P



Exemplary Pitching Rate

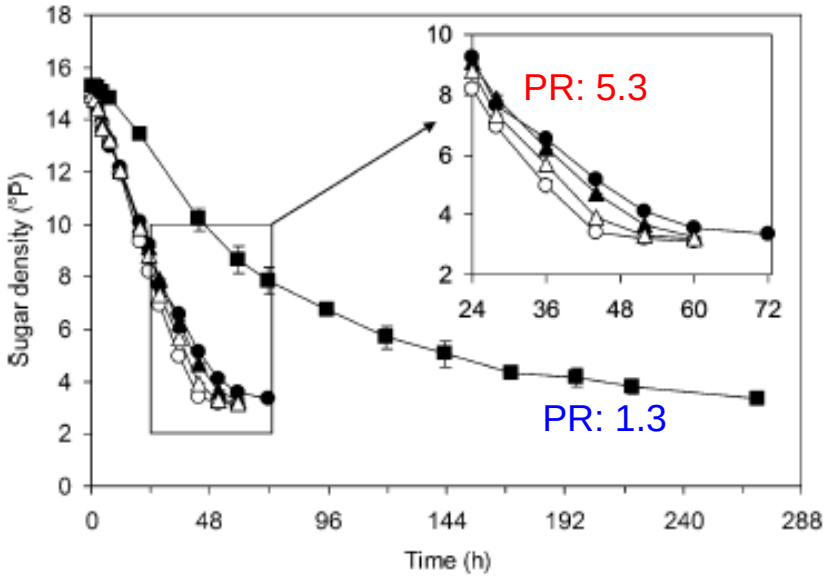
- 5.5 Gallons of a 1.060 IPA
  - 22L at 14.8 °P
- Pitching Rate: 1.0 Million Cells / mL / °Plato
- Cells Required = PR * Volume * Gravity
  - $(1x10^6)*(20,820)*(14.8)$ = 308 B cells ~= 300B cells
- This is 3 vials of 100% viable yeast





Pitching Rates

- Why not just over-pitch?
  - e.g. use an entire yeast cake
  - Study found that very high pitching rates (5+ MC/mL/°P) in lagers finish faster, but produce 5-10x more diacetyl
  - May work better with some strains than other, will likely produce a less clean beer



	PR: 5.3			PR: 1.3	
Alcohol (% *v/v*)	6.62±0.02	6.72±0.06	6.46±0.03	6.72±0.01	6.73±0.01
pH	4.28±0.01	4.16±0.01	4.25±0.01	4.22±0.01	4.51±0.03
Flavour profile					
Acetaldehyde (ppm)	4.96±0.02	2.57±0.24	7.00±0.80	4.25±0.19	7.48±1.46
DMS (ppb)	15.0±0.4	11.7±0.5	11.4±0.7	12.6±0.3	16.8±0.4
Higher alcohols (ppm)					
Propanol	11.4±0.2	13.0±0.2	12.1±0.2	11.8±1.0	11.1±0.1
Isobutanol	8.59±0.12	8.64±0.22	8.27±0.03	7.80±0.67	6.66±0.10
Isoamyl alcohol	54.9±0.9	58.9±0.3	57.9±1.0	56.6±2.5	44.5±0.6
Total higher alcohols	74.9±1.2	80.6±0.7	78.3±1.2	76.2±4.3	62.3±0.8
Esters (ppm)					
Ethyl acetate	24.9±0.5	19.2±0.5	22.8±0.1	21.6±0.6	27.9±0.5
Isoamyl acetate	1.30±0.03	1.12±0.06	1.44±0.02	1.38±0.04	1.19±0.06
Ethyl caproate	0.17±0.01	0.12±0.01	0.18±0.01	0.15±0.00	0.16±0.01
Total esters	26.4±0.6	20.5±0.6	24.4±0.1	23.2±0.6	29.3±0.6
Diacetyl (ppb)	528±2	334±7	626±6	538±10	60.9±16.8

(Verbelen, 2008 “The Role of oxygen in yeast metabolism during high density brewery fermentations”)

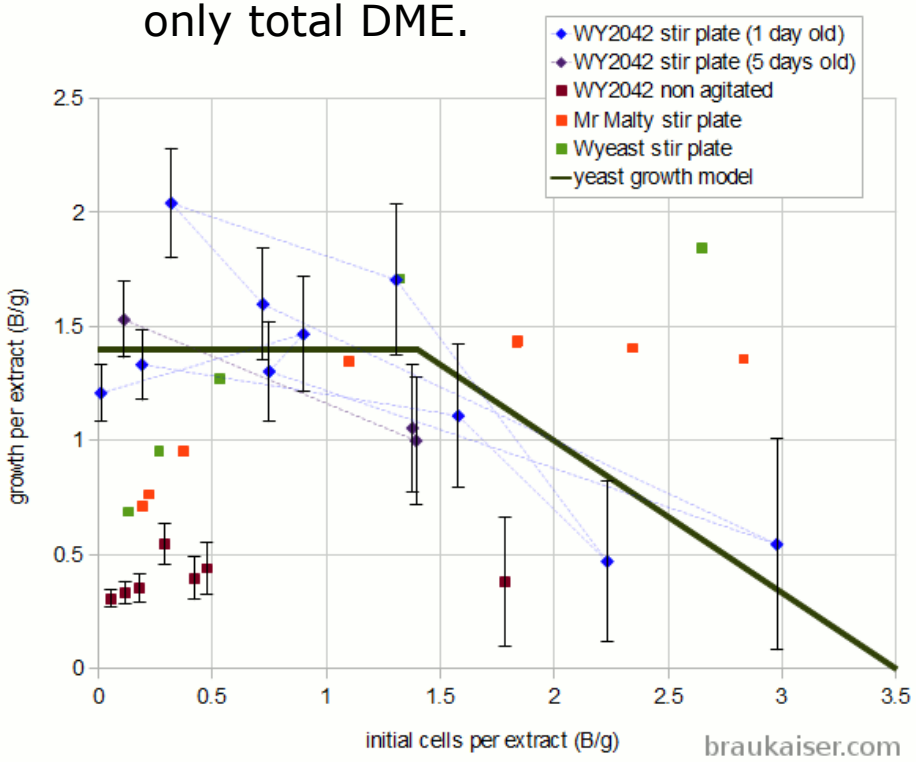
Yeast Starters

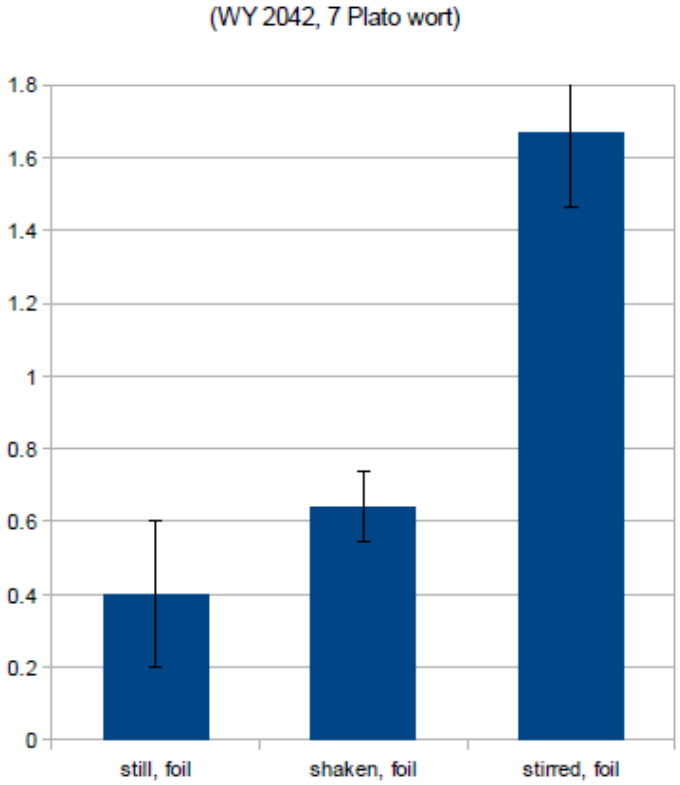
- A starter is simply a small batch of wort built only for growing yeast.
- <u>Process</u>

1. Start ~1 day before you need the yeast
2. Figure out how much yeast you need
3. Figure out how much starter you need
4. Add tap water (~65F) to a sanitized fermentor
5. Dissolve enough DME (not sugar!) to get near 1.040
   - Some boil & chill the wort at this point. I consider this a waste of time.
6. Add yeast
7. Cover in foil or use a foam stopper
8. Wait, Shake, or use a stir plate
9. Pitch everything into the fermentor
   - Alternatively, cold crash, decant, & only pitch the slurry.

Yeast Starters

- Still, Shaken, or Stirred?
- How much growth?
  - No perfect models exist
  - Use an online calculator
  - I prefer Brewer's Friend
  - The starter volume does not matter, only total DME.





Stir plates force extended aerobic respiration & additional yeast growth.

Yeast Starters

- Same IPA as before: 5.5 Gallons, 1.060 OG
- Need 300 B cells

Yeast Pitch Rate:

Brewer's Friend

Units: US - Gallons / oz / Metric - Liters / g

Sugar Scale: Gravity (1.xxx) / Plato °P

Wort Gravity (OG): 1.060 (1.xxx)

Wort Volume: 5.5 Gallons

Target Pitch Rate: Pro Brewer 1.0 (Ale, or High Gravity Ale)
(million cells / ml / degree plato)

Yeast Type: Liquid - Packs/Vials

Liquid Packs: 1 (packs/vials)

Mfg Date: 2013/07/08 (yyyy/mm/dd)
Date yeast pack was made.

Viability: **Yeast is 0 days old, the viability is estimated at 100%.**

Update

Cells Available: **100 billion cells**
Pitch Rate As-Is: **0.33M cells / mL / °P**
Target Pitch Rate Cells: **307 billion cells**
Difference: **-207 billion cells**
Needs starter (see below), or more yeast.

Yeast Starter - Up To 3 Step-Ups:

Starting Yeast Count: 100 (Billion Cells) Grab From Above

Enter the number of cells you are starting with, or click the 'grab from above' button if you set up your yeast in the previous section.

Starter - Step 1:

Starter Size (L) | Gravity (1.xxx) | Growth Model and Aeration | Update

1.5 | 1.036 | Braukaiser - Stirplate

DME Required: **5.4 oz, 154.1 g**
Growth Rate: **1.4**
Intial Cells Per Extract (B/g): 0.65
Ending Cell Count: **316 billion cells**
Resulting Pitch Rate: **1.03M cells / mL / °P**
Starter meets desired pitching rate!

Starter - Step 2:

Starter - Step 3:

Model	Final Count	Pitch Rate
Kai – Stirplate	316B	1.03
JZ – Stirplate	282B	0.92
JZ – Shaking	232B	0.76
JZ – Still	182B	0.59

Dried Yeast

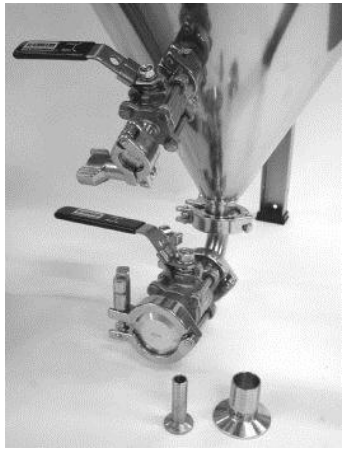
- How many cells per packet? No one agrees!
  - MrMalty.com – 20B cells/gm
  - Fermentis – 6B cells/gm
  - Danstar – 5B cells/gm
  - Van Den Berg Study – 8-18 B cells/gm
  - Brewer's Friend assumes 10B cells/gm

- Assuming 10B cells/gm, an 11 gm packet = 110 B cells
  - A single vial of White Labs is 100 B cells
- Must rehydrate for maximum viability
  - "Rehydrating" in wort can result in 50%+ cell death!
  - At ~105F, use 10gm of water per gm of yeast (110 gm per pack)
  - Tap water or hard water is preferred
  - Sprinkle, cover, & let sit for 15 mins, then stir & let sit for 15 more mins before pitching

Harvesting

- Three basic approaches
  - Bottom Cropping : dump valve in a conical
  - Top Cropping : capture through a sanitary blow-off vessel
  - Trub Cropping : grab the entire yeast cake from the primary
- Sanitation, sanitation, sanitation!
- Harvested yeast seems to lose viability just like White Labs or Wyeast (use within 4 months)
- If stored for 1+ months, a small starter will help wake up the yeast before pitching

Bottom Cropping

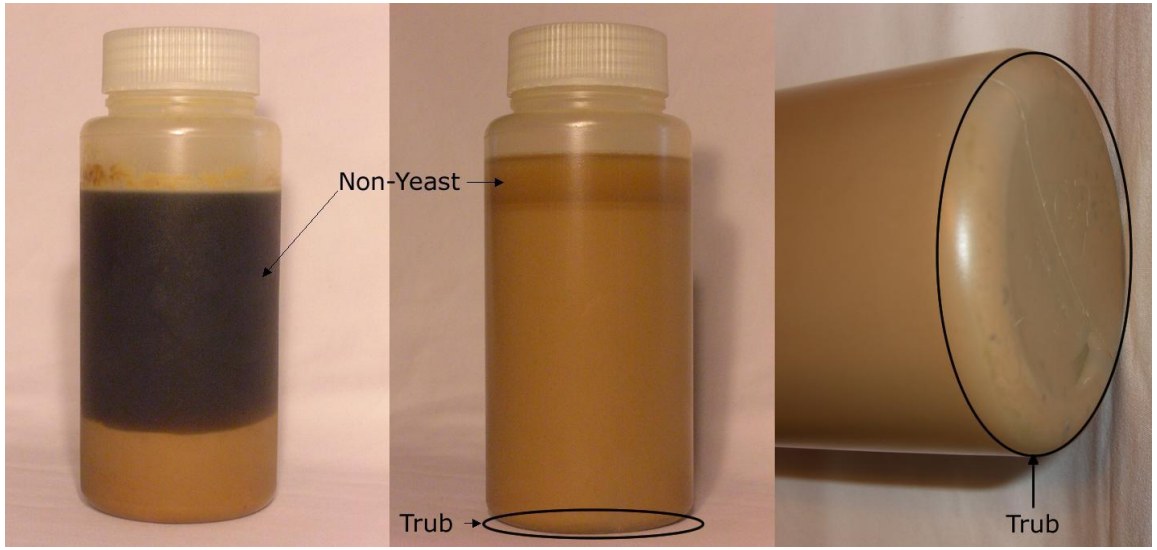


Top Cropping

Trub Cropping

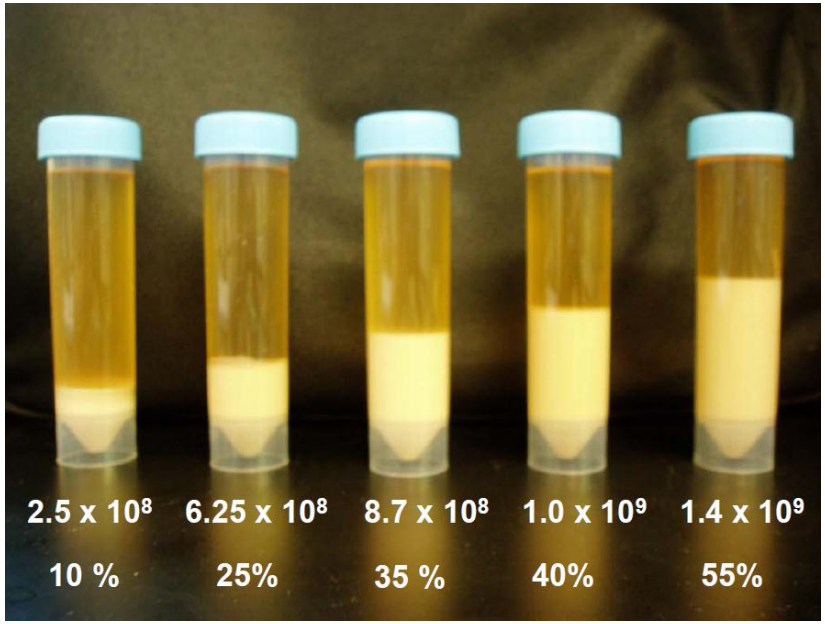
Washing

- Start with the cleanest wort possible.
  - Dirty wort is very hard to “wash” properly. Decant as much as possible.
  - Dry hopping in the primary can make this challenging.
  - Cold crashing pulls more yeast into the cake.
- Rack off your beer, add sterile, cool water, then let it settle for 10-20 mins.
  - Trub will settle to the bottom, leaving yeast in suspension above.
- Pour the yeast/water into a sterile jar & repeat.



Harvested Cell Counts

Volume



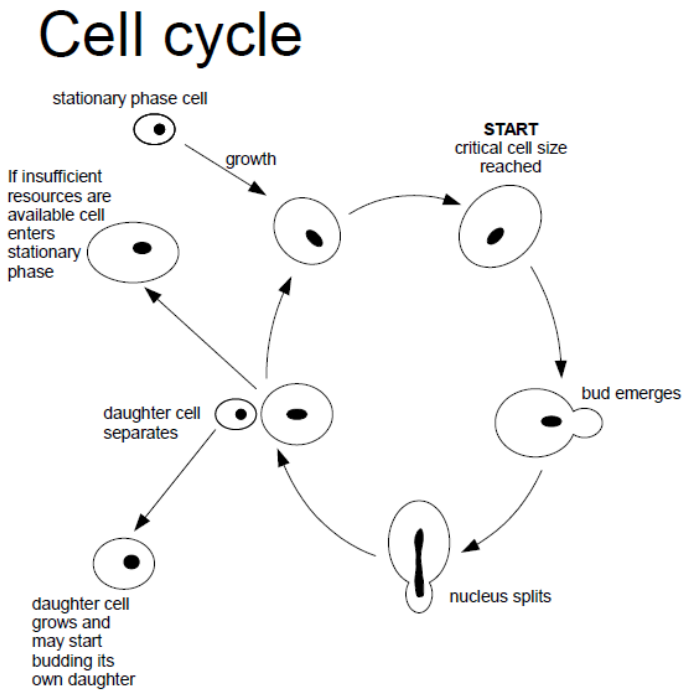
Estimated Cell Count per mL

Weight

~2.5 B cells per gram

Aeration

- Why do yeast need oxygen?
  - Needed during lag phase for new cell growth.
- How much oxygen?
  - Sierra Nevada : ~8 ppm (Air)
  - Michael Lewis : ~8 ppm
    - Yeast naturally evolved towards air-saturated wort
  - White Labs : 8-10 ppm (more for bigger beers)
  - Wyeast : 10-12 ppm (more for bigger beers)
  - My experience : 8 - 12 ppm
- Do Dry Yeast need oxygen?
  - Danstar : Maybe…0-15 ppm
  - Fermentis : Yes, ~9 ppm
  - My experience : YES!
- What about Olive Oil?
  - Maybe. Must be dissolved in ethanol then added to a stir plate starter.
  - Some people still recommend adding 5 ppm oxygen
  - Adding directly to the main wort will result in excessive Ethyl Acetate
- When to add Oxygen
  - First 12 hrs of fermentation
  - I prefer to do this before pitching

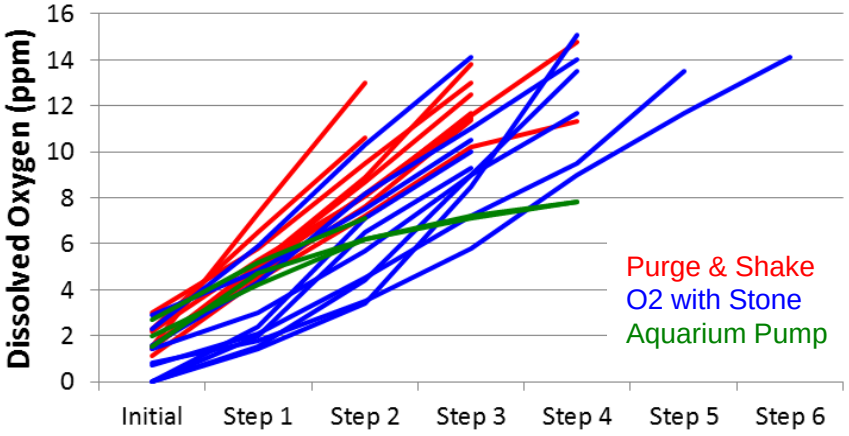


Aeration Experiment

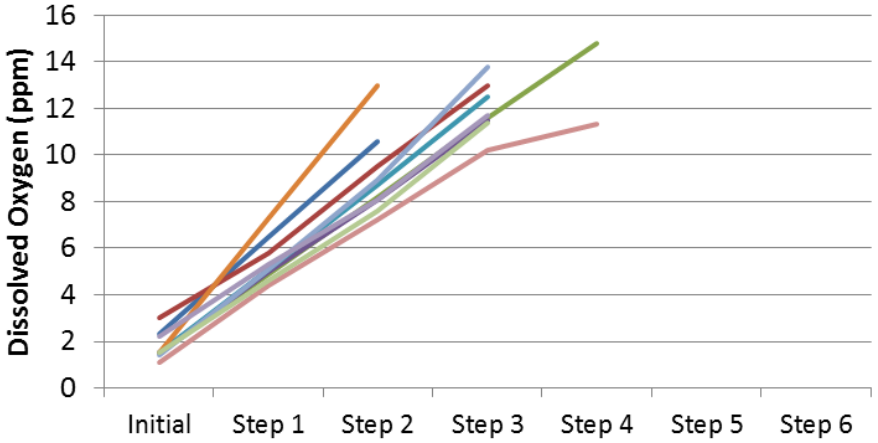
- Aeration Experiments with MW600
- Goal: Build a repeatable "good enough" model for wort aeration methods
- Purge & Shake – 10 batches
  - Fill headspace with O2 for 5 secs, Shake for 30 seconds, repeat
- O2 with Diff Stone – 10 batches
  - Cheap oxygen bottle, surface slightly active for 30 seconds, repeat
- Aquarium Pump with Diff Stone – 3 batches
  - Bubble for 5 mins, repeat

Aeration Data

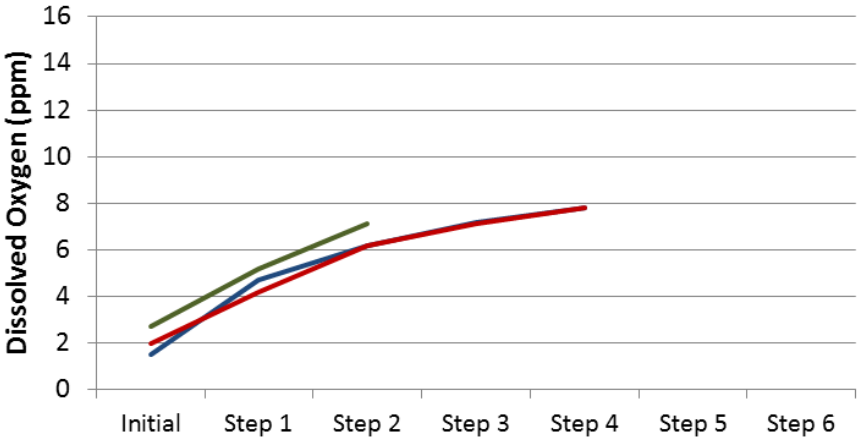
Dissolved Oxygen vs Process Step



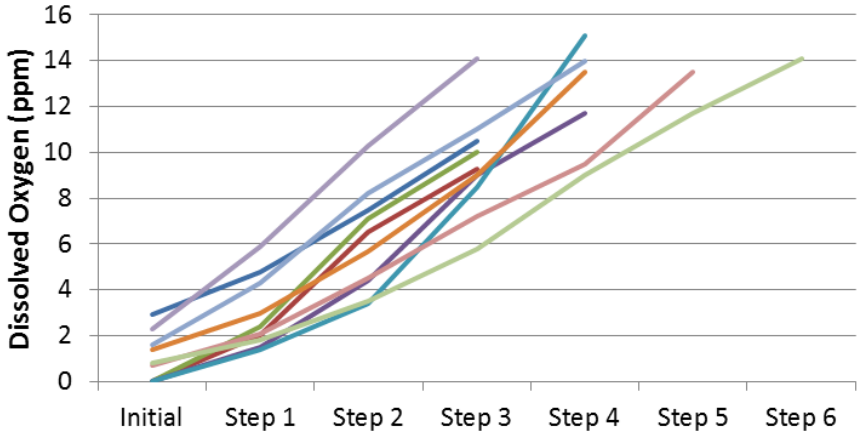
Purge & Shake



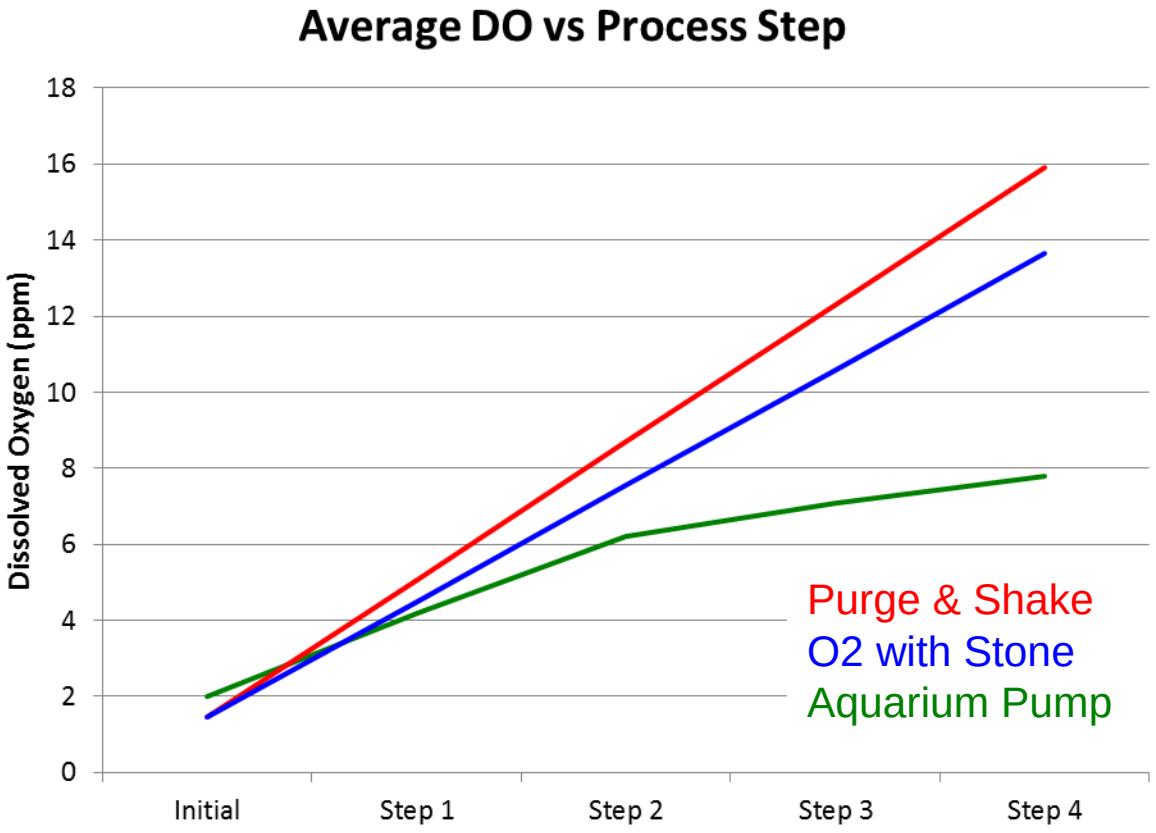
Aquarium Pump with Diff Stone



O2 with Diff Stone



Aeration Guidelines



Average DO/Step

1. Purge & Shake : **3.6 ppm**
   - ✓5 sec purge, 30 sec shake
2. O2 : **3.1 ppm**
   - ✓30 sec, active surface
3. Aquarium Pump : **1.8 ppm**
   - ✓5 mins

Summary of techniques

- Do nothing: 1-2 ppm
- Simple Splashing: 2-3 ppm
- Mix Stir: 3 ppm
- Vigorous Shaking: 5 ppm
- Aquarium Pump : 7-8 ppm
- O2 + Stone : 6-15 ppm
- O2 + Shaking : 6-15 ppm

Fermentation Temps

- All Beer : Pitch cool, then let warm up
- Temp control is most important during the growth phase (first 2 days).
- Diacetyl Rest : Bump temp up 6-10F when activity slows
- This regimen works for me:

Beer	Pitch	Ferment	Diacetyl Rest
American, British, German Ales	60F	64F	70F
Belgian Ales	68F	75F	85F
Lagers	48F	52F	65F

References

- Books
  - "Yeast: The Practical Guide to Beer Fermentation" by Chris White & Jamil Zainasheff
  - "How to Brew" by John Palmer
  - "Brewing" by Michael Lewis & Tom Young
  - "Brewing Science & Practice" by Briggs, et al.
- Pitching Rate Calculators
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