

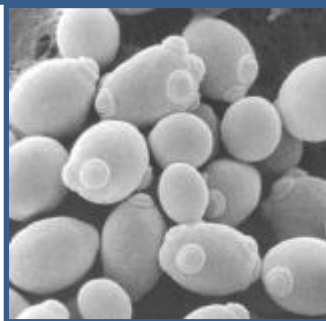
Zinc in Fermentation

Yeast Health and Nutrition

Joe Kinney, M.S.

Microbiologist F.X. Matt Brewing Co. Utica, NY

“Oh no, we’re not having wort *again...*”

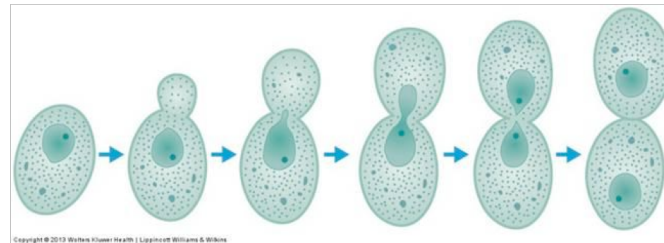


Yeast Requirements

- Wort (carbon, nitrogen, water, some minerals)
 - B, Ca, Co, Cu, Fe, K, Mo, Mn, Mg, Ni, Zn
 - Mg and K are required at higher concentrations
 - Zinc is commonly added to the wort in the fermentor.
 - Other growth factors (vitamins, purines, pyrimidines, polyamines, nucleosides, nucleotides, etc.) [1]
- Oxygen
 - Sterilized air or compressed sterile oxygen
 - Necessary for the synthesis of sterols and unsaturated fatty acids.
 - 1 ppm dissolved oxygen (DO) for every wort °Plato (i.e., a 16°Plato wort would require 16 ppm DO) [1]

Growing Yeast or Fermenting Beer?

- Both!
- Brewers pitch less yeast than what ultimately ferments wort
 - 3-4 splits (budding) or “duplications” in the first few hours of fermentation
 - Any molecule or element not synthesizable by yeast will get be consumed by mother cells and distributed to daughter cells
 - Wort is very nutritious, and will supply most of these requirements
- Once oxygen is consumed, fermentation proceeds
 - Alcohol production!
 - Yeast “do their job”
 - Brewers are happy



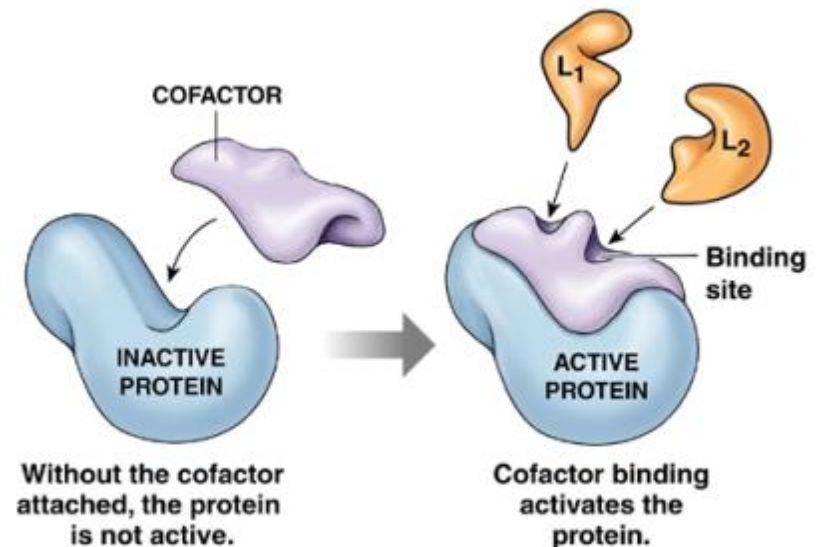
From The Text:

- “Some brewers add zinc (e.g. 0.2 ppm) to promote yeast action—it is a cofactor for the enzyme alcohol dehydrogenase.”
- Food Fermentation and Microorganisms [3]
- “Any other factor that hinders fermentation (e.g. a lack of zinc or vitamins) will also lead to an exaggeration of H₂S levels in beer.”[2]
- “The most common nutrient addition is Zinc, usually added as a solution of the hydrated sulphate and at a concentration of 0.05 to 0.15 ppm Zn²⁺”[2]
- Brewing Yeast and Fermentation

Impact of Zinc

- Enzyme cofactor (over 100 enzymatic reactions)
- Cofactor for alcohol dehydrogenase
- Governs protein synthesis and phospholipid composition of membranes in yeasts
- Required for yeast growth and metabolism
- Stimulates uptake of maltose and maltotriose
- Increases fermentation rate *
- Stimulates ester production
- Plays a role in yeast flocculation

[5]



Common Sources of Supplemental Zinc

- Yeastex
 - Zinc Sulfate
 - Manganese Sulfate
 - Organic and inorganic FAN (DAP and dead yeast hulls)
- Microelements
 - Zinc Sulfate (.030 ppm)
 - Manganese sulfate
 - Yeast derived ingredients (dead yeast hulls?)
 - Excipients, Vitamins and Minerals
- Pure Zinc Sulfate Heptahydrate
 - $\text{ZnSO}_4 \cdot 7\text{H}_2\text{O}$



How Much Zinc Do I Need?

- Malted barley contains SOME zinc
 - Depends on variety and crop
 - Much of the available zinc gets bound up in trub
 - Analyze wort to determine the amount of free zinc available
 - Atomic Absorption Spectrophotometry
- Yeast Strain Dependent
 - Lager Needs Less
 - 0.050-0.150 ppm (variety specific)
 - Ale Needs More
 - 0.150 – 0.300 ppm (variety specific)
- Recipe
 - High gravity brews or high adjunct may need more supplemented zinc



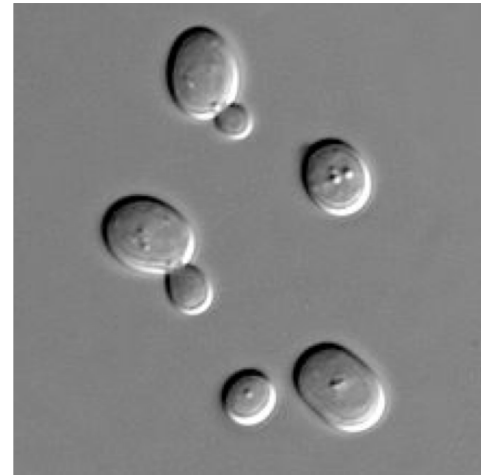
When to Add Zinc

- Chilled wort (preferred)
 - Inline after wort chiller
 - Directly into the fermentor
 - Diluted with water and added directly to yeast
 - Must be done *immediately* before pitching
- Hot wort
 - Into the kettle
 - Much of the zinc will be bound up in trub
 - Less effective, less desirable



Benefits of Adding the Right Dose of Zinc

- Shorter fermentation times
- More consistent fermentation rates
- More complete fermentations
 - Higher RDF values achieved
- Healthier yeast
 - Higher generations
 - Greater consistency in flavor
- Better flocculation
 - Increased yeast collection
 - Clearer beer, less effort for filtration



Signs You've Added Too Much Zinc

- Zinc is a TRACE metal
 - We only need *tiny* amounts
 - Yeast will very rapidly absorb trace metals in solution
- Decreased fermentation rate
- Decreased RDF values
- Early dormancy before fermentation is complete
- Increased yeast cell death (over-dose)
- “Cement-like” yeast on the tank bottom
- The effects of zinc are CUMULATIVE
 - Some effects will show an immediate change
 - Others will need 2-4 generations of repeated dosing

Determining Dosage Rates

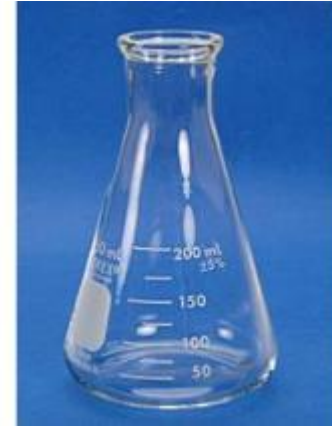
1. Send wort out for analysis, determine base zinc levels
2. Use common guidelines for your yeast strain (Ale vs. Lager)
3. Using a small balance, make a known percentage solution (w/v)
4. Run test fermentations with increasing zinc concentrations
5. Analyze results



Lab Fermentations

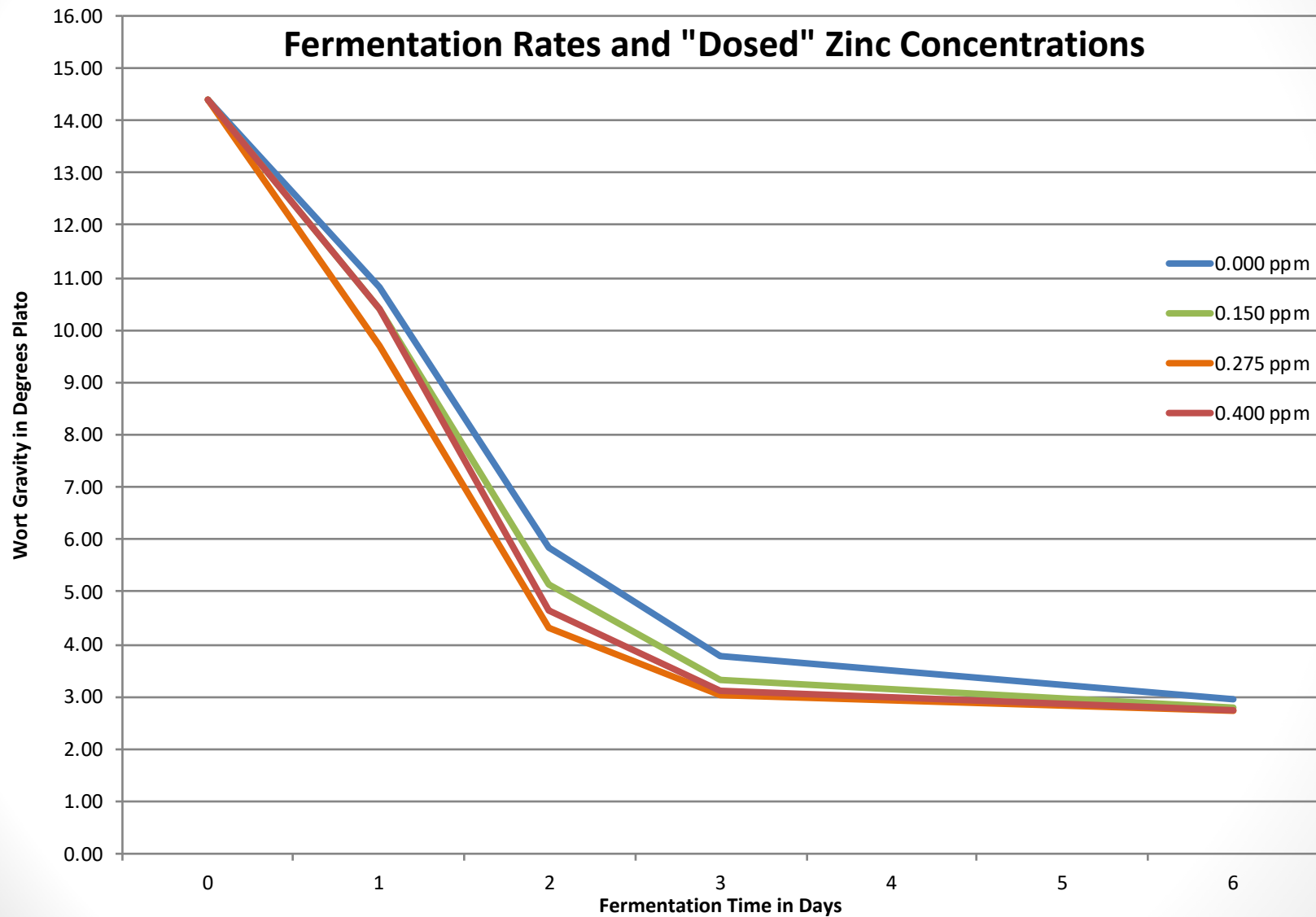
- Objectives:
 - Demonstrate the cumulative effects of Zinc dosing over multiple generations
 - Determine the optimal dosing rate for a yeast strain (variety) in a given wort.
- Controls:
 - Wort gravity and composition, oxygenation, yeast strain, pitch rate, fermentation temperature, vessel size and shape
- Variable:
 - Initial zinc dosing, 0.00ppm, 0.150ppm, 0.275ppm, 0.400ppm
 - Yeast was collected from week one to pitch into week two
i.e. yeast from 0.00ppm week one was collected and pitched into 0.00ppm week two fermentation
yeast from 0.150ppm week one was collected and pitched into 0.150ppm week two fermentation, etc.
 - 0.400ppm was not repeated, 0.075ppm was created instead

Lab Fermentations

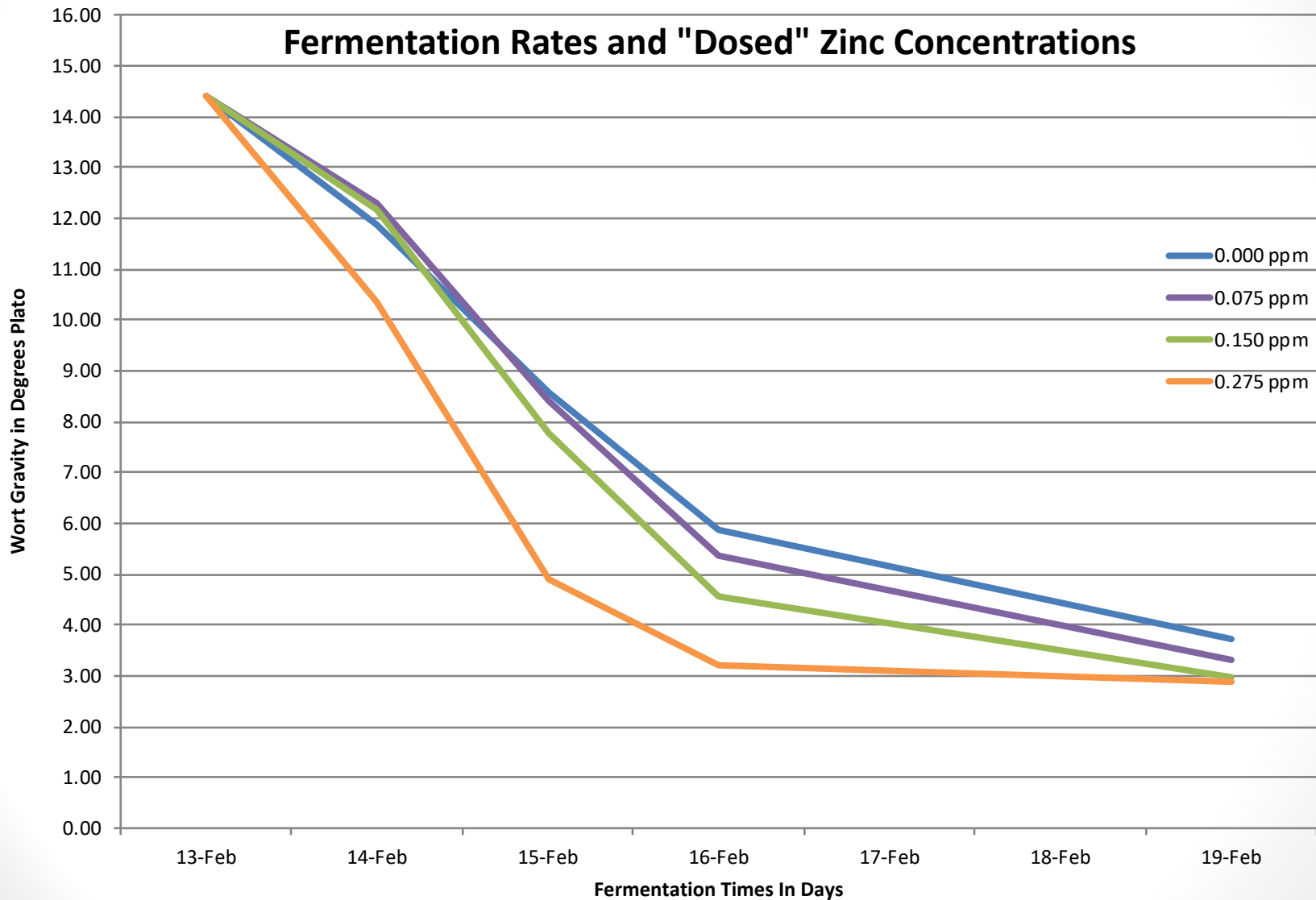


- Week 1:
 - Approximately 14.4°Plato Wort
 - 16.0-18.0 ppm Dissolved Oxygen
 - 1000mL Fermentation Size
 - 750,000 cells per mL per degree plato pitch rate
 - Room temperature fermentation (21°C), no vessel temperature control
- Week 2:
 - Approximately 14.0°Plato Wort
 - 16.0-18.0 ppm Dissolved Oxygen
 - 1000mL Fermentation Size
 - 750,000 cells per mL per degree plato pitch rate
 - Room temperature fermentation (21°C), no vessel temperature control

Determining Dosage Rates (Gen1)

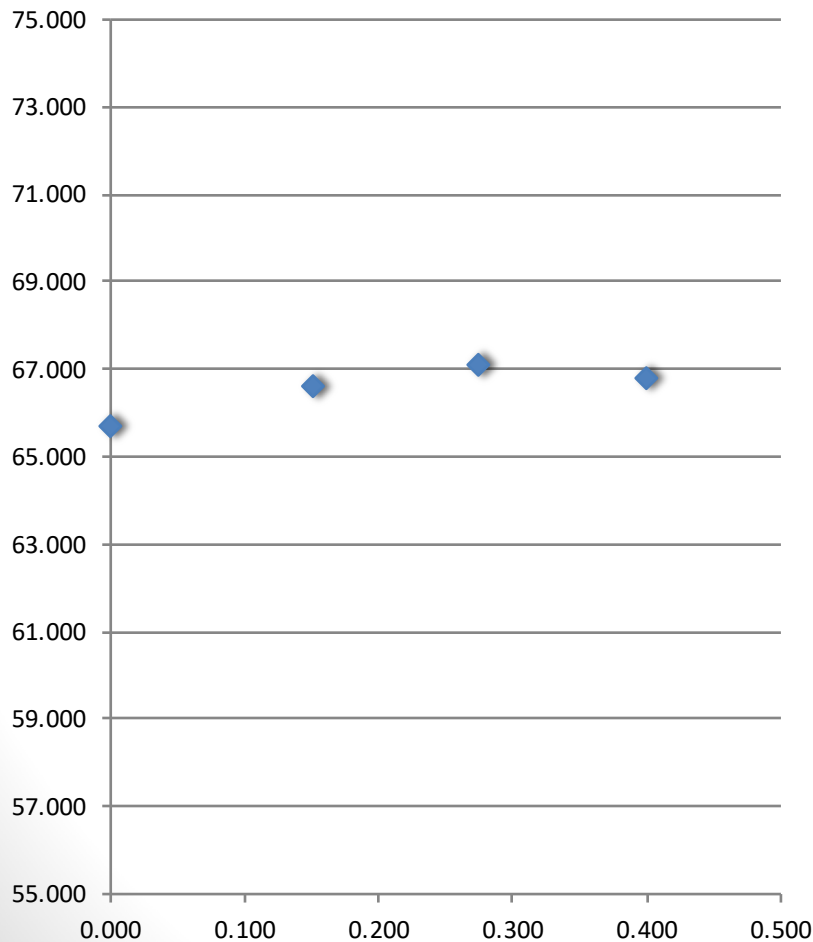


Determining Dosage Rates (Gen2)

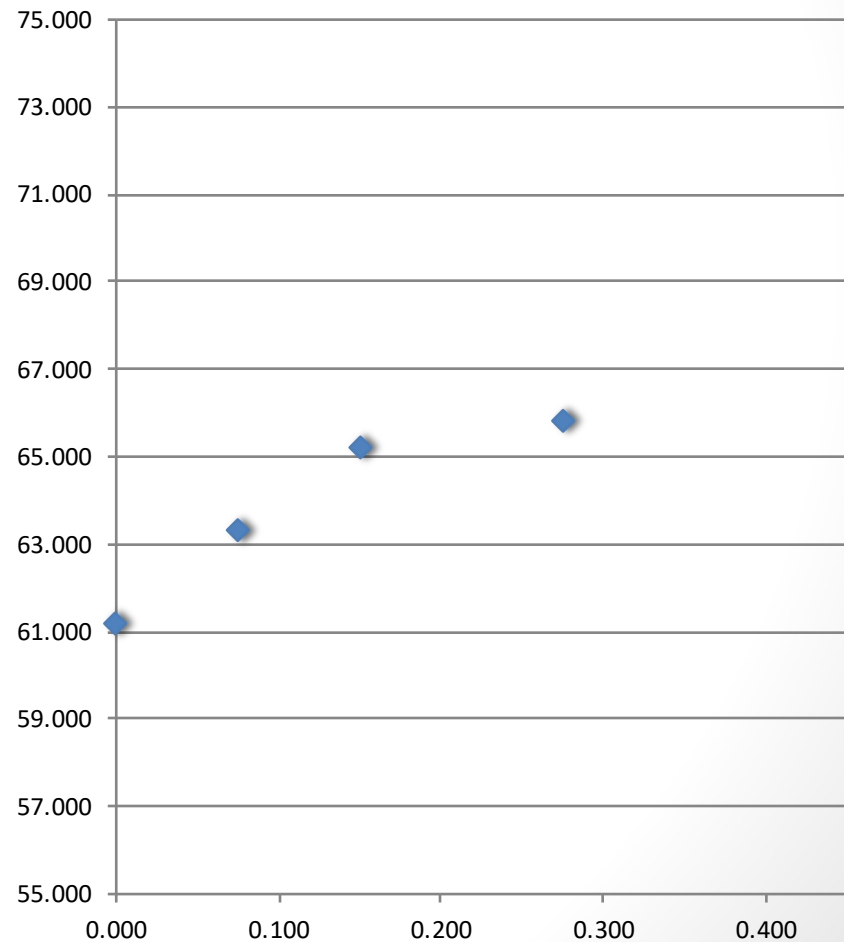


Determining Dosage Rates; RDF Values

**Real Degrees of Fermentation vs
Dosed Zinc, Generation 1**

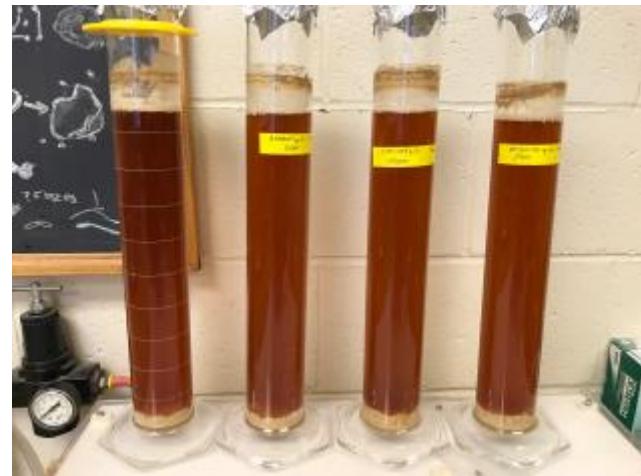


**Real Degrees of Fermentation vs
Dosed Zinc, Generation 2**



Future Research

- Ferment with ale yeast for a third generation of “dosing”
- Repeat with lager yeast
- Determine dosing per yeast cell pitched?
 - As craft brewers we have many wort streams, with different sugar concentrations and pitch rates
 - Zinc is dosed specifically to be consumed by yeast; perhaps we should add zinc as a function of cells pitched, instead of a general ppm number?



Summary

- Zinc plays important roles in yeast cell growth and wort metabolism
- Zinc also plays a role in yeast membrane interactions, aiding in flocculation
- Wort alone does not provide enough zinc for consistent fermentations
- Yeast requires between 0.050 and 0.300 ppm available zinc
- Zinc should be added to the wort on the cold side, immediately before pitching
- High levels of zinc may be detrimental to yeast health and fermentation performance

Questions?



Thank You

Please Make Changes only to Fields in GREEN		
Select Target Zinc ppm:	0.275 ppm	
Enter Zinc Solution Concentration % w/v :	0.01	(grams per 100mL) Optional
Select Brew Size Units:	Barrels	
Enter Brew Size:	500	
mL of Wort:	58,673,855.00	
Please Dose this Amount of ZnSO4 (grams):	70.9494	Grams Zinc Sulfate Heptahydrate
Please Dose this Amount of ZnSO4 Solution (mL):	7,094.94	mL Zinc Sulfate Heptahydrate Solution

References

- [1] Briggs, D. E. Brewing: Science and Practice. Boca Raton: CRC, 2004. Web.
- [2] Boulton, C., Quain, D. Brewing Yeast and Fermentation. Blackwell Science Ltd. 2006.
- [3] Bamforth, C. Food, Fermentation and Micro-organisms. Blackwell Science Ltd. 2005.
- [4] Daveloose, M. An Investigation of Zinc Concentrations in Brewhouse Worts. MBAA Technical Quarterly, Vol. 24, pp 09-112, 1987.
- [5] Martin, R. Trace Metals in Brewing. [PDF File] Craft Brewers Conference. Retrieved from:
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