High Gravity Brewing

Or

Brewing Above the Rim

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Key Points to Consider

- The Limits of your Brewing System
  - How much malt can you squeeze into your mash tun?
- How to make a High Gravity Wort
  - Novel recipes or Scale Up
- Terminal Gravity
  - Design a recipe that isn't to big or too thin
- How To Ferment a High Gravity Wort and have it taste good
  - Make your yeast do that

Mashing: Tun Limits & Capacity

- What volume is your mash tun, and how much malt can you stuff in there?
  - The upper limit to the OG you can make in your mash tun depends on:
    - Qts/lb x Mash Efficiency (1 Qt/lb x 65% m.e.)
    - Volume of the Mash tun (40 lbs malt @35points/gal)
  - Makes 10 gallons @ 4 x 35 x 0.65 = 1.091 gravity (estimated)
    - Reduced by recovery losses
    - Efficiency can drop with higher gravity beers.
    - Conversion Efficiency vs. Brewhouse efficiency
  - Undiluted wort is king!
  - Keep pH and Ca++ Optimal for enzyme efficiency
    - pH ~ 5.2 – 5.4, Ca++ ~ 50 ppm for healthy yeast, more for some styles.

Mashing: Limits of Sparging

- Do not dilute your high gravity 1st runnings wort!
  - Sparging dilutes the gravity of the wort as it comes out of the tun.
  - So, sacrifice some volume and efficiency to keep your gravity high.
  - Sparging tips for high gravity beers:
    - Sparge slowly to push the high gravity wort out of the tun, but don't dilute it. Sparging at ≤1 liter/min (~1 Qt/min) avoids mixing wort & water in the tun. (Laminar flow)
    - Monitor the gravity of the wort as you sparge, stop collecting when it starts to fall.
    - For the thrifty, once the runoff gravity starts to drop, keep sparging into another container and make a 2nd runnings beer. Can be excellent. Watch pH and husk extraction.

Shovel it in:
Increasing the Wort Concentration for Even Higher Gravity

- Add More Malt
  - Fill up your mash tun to capacity
  - Don't plan on getting the same volume of high gravity wort as you do for a 1.050 beer: settle for less volume!
- Recycle the wort, mash a 2nd batch of grain with wort from a 1st mash (Randy Mosher)
- Boil it Down
  - Boiling off 10% of volume an hour can make 1.090 into 1.112 in 2 hours.
- Adding Malt Extract or Sugar
  - Be sure to balance the terminal gravity to target.

Fermenting a High Gravity Wort: Pitching Rate

- Pitch Rates & Yeast Selection
  - 1 million cells/ml/plato ~ 20 million cels/ml for 1.080 wort
  - Pick a yeast strain with appropriate high alcohol tolerance.
  - Use a yeast calculator to figure out how much to pitch.

  http://www.wyeastlab.com/hb_pitchrate.cfm

  http://www.mrmalty.com/calc/calc.html
- Healthy Yeast
  - A starter is recommended. 1.030-1.040 oxygenated wort yields yeast with healthy cell membranes and high glycogen content. These enable survival in a higher alcohol environment.
- Do a Trial Ferment?
  - Overpitch a pint of wort and keep it warm while your main batch ferments – use to check terminal gravity target when done.

Fermenting a High Gravity Wort: Fermentation Temperature

- Increased Temperature leads to:
  - Faster Ferment, and maybe more complete too (good)
  - Increased secondary metabolites (acetaldehyde, bad)
  - Increased flavor active compounds (esters, higher alcohols, good or bad)

- Since your beer is already high gravity, consider keeping the temperature down.
- But, high temperature can help the beer finish.
- Consider a cool starting temperature and ramping up to warmer temperatures near the end of the ferment.

	75 F	66 F	Threshold
Ethanol	5.04% abv	4.74% abv	1.4% abv
1-Propanol	22.76 ppm	23.78 ppm	600 ppm
Ethyl Acetate	33.45 ppm	22.51 ppm	30 ppm
Iso-amyl alcohol	114.92 ppm	108.43 ppm	70 ppm
Total Diacetyl	8.23 ppb	7.46 ppb	150 ppb
Total 2.3-pentanedione	3.17 ppb	5.09 ppb	900 ppb
Acetaldehyde	152.19 ppm	7.98 ppm	10 ppm

Table from Chris White, “Optimizing High Gravity Fermentation”, AHA Conference, 2008

Fermenting a High Gravity Wort: Oxygenation

- Oxygenation
  - The higher the dissolved oxygen level, the more complete the ferment and the drier the beer.

Time for O2 injection is time of injection of O2 with a 0.5 micron sintered stone into 20 liters of wort.

Table from Chris White, “Optimizing High Gravity Fermentation”, AHA Conference, 2008. Also in White & Zainasheff, “Yeast” p79

Gravity (plato) vs. Time

	2.71ppm	5.12ppm	9.2ppm	14.08ppm
	shake	30 seconds	1 min	2 min
Time (hours)				
0	18.7	18.7	18.7	18.7
24	17.6	17.3	17.5	16.9
48	13.5	12.8	12.7	11.9
72	11.7	10.7	9.9	9.5
96	10	9	8.8	7.8
120	7.8	7.3	6.5	6.2
144	6.4	6.3	5.5	5.2
168	5.3	5	4.3	4.3

Aiming for Terminal Gravity

- Most yeasts ferment to 74-79% attenuation, with some exceptions
- Mash Temperature:
  - Get 1-2% more attenuation at 151 – 153 ^{o} F (counter to conventional wisdom)
  - Get less attenuation above 155 ^{o} F, drops ~ 1.3% per 1'F ↑ in ^{o}F
- Adding specialty malts changes the terminal gravity (Add to 10% of total and see…)
  - Munich or wheat malt ↓ attenuation by ~1%
  - Crystal malt ↓ attenuation by ~3%
  - Roast malts ↓ attenuation by ~6-7%
  - Sucrose ↑ attenuation by ~ 4%
- Mash Time: attenuation peaks at 75 minutes mashing (2% more attenuation than at 60 minutes)
- By controlling these, can vary terminal gravity by 2-3 points or more.

From Greg Doss, Wyeast Labs, "Exploring Attenuation" NHC 2012 talk

The Bitter End

- Decreased Hop extraction rates: The Gravity Correction:
  - Extra Hops needed at High gravity =

    GF = ((Boil Gravity – 1.050)/0.2)+1
  - For a 1.110 wort:

    GF = ((1.110 – 1.050)/0.2)+1 = 1.3
  - Use 1.3 times the amount of hops calculated without the correction.

Formula from Mark Garetz “using Hops”, is same as Rager formula

Credits

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