High Gravity Brewing

Or

Brewing Above the Rim

Lee Shephard
November 2012
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.
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 2\textsuperscript{nd} batch of grain with wort from a 1\textsuperscript{st} 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.

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

<table>
<thead>
<tr>
<th>Compound</th>
<th>75 F</th>
<th>66 F</th>
<th>Threshold</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ethanol</td>
<td>5.04% abv</td>
<td>4.74% abv</td>
<td>1.4% abv</td>
</tr>
<tr>
<td>1-Propanol</td>
<td>22.76 ppm</td>
<td>23.78 ppm</td>
<td>600 ppm</td>
</tr>
<tr>
<td>Ethyl Acetate</td>
<td>33.45 ppm</td>
<td>22.51 ppm</td>
<td>30 ppm</td>
</tr>
<tr>
<td>Iso-amyl alcohol</td>
<td>114.92 ppm</td>
<td>108.43 ppm</td>
<td>70 ppm</td>
</tr>
<tr>
<td>Total Diacetyl</td>
<td>8.23 ppb</td>
<td>7.46 ppb</td>
<td>150 ppb</td>
</tr>
<tr>
<td>Total 2,3-pentanedione</td>
<td>3.17 ppb</td>
<td>5.09 ppb</td>
<td>900 ppb</td>
</tr>
<tr>
<td>Acetaldehyde</td>
<td>152.19 ppm</td>
<td>7.98 ppm</td>
<td>10 ppm</td>
</tr>
</tbody>
</table>
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.

Aiming for Terminal Gravity

• Most yeasts ferment to 74-79% attenuation, with some exceptions

• Mash Temperature:
  – Get 1-2% more attenuation at 151 – 153 °F (counter to conventional wisdom)
  – Get less attenuation above 155 °F, drops ~ 1.3% per 1°F ↑ in °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 =
    \[ GF = \frac{\text{Boil Gravity} - 1.050}{0.2} + 1 \]
  – For a 1.110 wort:
    \[ GF = \frac{(1.110 - 1.050)}{0.2} + 1 = 1.3 \]
  – Use 1.3 times the amount of hops calculated without the correction.

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

• Thanks to all the BAM 2012 Barrel Project participants who helped research this topic earlier this year:
  – Brian Ballantine, Grant Kinney, Andrei Zmievski
  – David Wood, Douglas Smith, Rylan Ortiz, Peter Festl, Paul Keefer, Daniel Langmaid, Damien Clauson, Arlyn Jons, Cortland Toczyloski, Michael McCurdy, Dave Lubertozzi, Jack Englage, Chad Gallagher, Andrew Peters, Bob Rickshem, Jon Sheehan

• And to Mike Riddle for advice on yeast pitch rates.
• And to the referenced speakers at the 2008 and 2012 National Homebrew Conferences