High Gravity Brewing

Grady Hull

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Overview

- Oversized malt handling, mill, mash tun, lauter tun and bright tanks
- All other equipment size is reduced
  - Kettle
  - Heat exchangers and pipes
  - Boiler and cooling systems
  - Fermenters and maturation vessels

Mash

- Mash water to grain ratio
- Extraction efficiency
- Enzyme activity
- Limitations of mash mixer, mill, mash pump

Lauter

- Sparge water
- Lauter Tun efficiencies
- Pull downs to compact bed
- Delayed sparge start
- Last running's

Kettle

- Volume reduced
  - Kettle capacity
  - Thermal mass
  - Boiler capacity
  - Energy consumption

Kettle

- Density increased
  - Color development
  - Hop oil and alpha acid extraction efficiency
  - DMS removal
  - Trub separation efficiency
  - Kettle fouling

Fermentation

- Volume reduced
  - Fermentation capacity
  - Thermal mass
  - Cooling system capacity
  - Energy consumption

Fermentation

- Density increased
  - Headspace requirements
  - Yeast strain limitations
  - Pitching rate adjustments
  - Yeast flocculation
  - Yeast viability
    - Storage and handling

Fermentation

- Esters and higher alcohols
  - Dissolved oxygen requirements
  - Fermentation temperature
  - Fermenter residency time

Finishing

- Point of water addition
- Dilution water treatment
  - De-aeration
  - Filtration
- ABV, density, and CO2 addition
- BBT sizing

Advantages

- Reduced equipment costs
- Reduced operating costs
- Reduced environmental footprint
- Improved product consistency
- Improved physical stability

Tailoring High Gravity Brewing Techniques in a Brewpub

Craft Brewer's Conference 2011

Brian Allen

Mother's Brewing Company

Demand exceeds supply

- Solution 1- brew more frequently
- Solution 2- brew more volume ★
- Solution 3- acquire more tanks expansion
- Solution 4- increase yields ★
- Solution 5- contract / bring beer in from other breweries

Identify Brewpub Bottlenecks

- Tank Capacity
  - Brewhouse
  - Fermenters
  - Brights / servers
  - Kegs / cold storage
- Labor / personnel

High Gravity Brewing is one tool to break through two of these bottlenecks

- Water added:
  - Prior to fermentation
  - Post fermentation / prior to filtration
  - Post filtration

Limited Fermentation Space

- If fermentation space is the limiting factor- High Gravity Brewing allows for increased output with the same amount of wort in each vessel
- Water added after FV either prior to filtration or post filtration

Plans / projections

- Use empirical data from brewery records
- Research how the big boys do it
- Address water issues
- Address beer factors
- Address logistical / scheduling details

Capabilities of brewery

- Mash tun size- how strong of a wort can you make?
- BME- what sort of extract do you get at different O.G.s?
- Hop utilization levels- what are they relative to different strength worts?
- Fermentation character, ester production at different wort strengths, affects of over / under pitching your beer flavor?

Water issues

- Removal of oxygen
- Sterility
- pH adjustment
- Alkalinity adjustment
- Carbonation

Beer factors

- Flavor matching / color matching
- Determine new OG
- Determine new target color
- Determine new residual sugar
- Determine new hopping levels
- Account for stronger wort during fermentation

Logistics

- Production schedule - personnel schedule
- Necessary bright beer capacity
- Means of dilution, mixing, and finishing
- Target brands to utilize this process

Tools & necessary equipment

- Empirical data
- Mixing formula: aa+bb=cc
- Basic lab supplies
- Excess cold storage or finished beer capacity
- Sensory panel

Trial on new beer?

- Pubs often have rotating handles, can you test on a new beer and remove flavor matching from the equation?
- Firm up the process and assess results before employing on existing brands

Implement plan

- Use techniques on existing beers
- Assess flavor matching via sensory panels and basic quality controls
- If results are within spec, proceed and fine tune
- If results are out of spec revisit assumptions, process, and make changes to correct

Labor / personnel issues

- If brewery labor is limited- employing aspects of high gravity brewing techniques can increase brewer output by creating 33+ % more beer per brew cycle
- Double batch FVs: water added prior to FV

Dilution prior to FV

- Determine how much volume is to be increased
- Removal of oxygen no longer paramount
- 200 F+ water for sterility
- Water added to kettle during knock out

Beer issues

- Increase OG
- Increase color
- Increase target apparent gravity
- Increase hop rates
- Flavor matching should be simpler, no fermentation issues as wort is now back to original strength
- Interference with trub separation

Conclusions

- Given the right conditions High Gravity Brewing can be used by the pub brewer to increase volume upwards of 40%
- Design a strategy and scheme that fits your needs and your brewery’s design

Yeast Stress! No Worries? Getting to High Gravity and Getting More Out of the Brewhouse

Gary Spedding, Ph.D.

BDAS, LLC.

HGF- History - I

- 1960's Gen Brewing Co (SF, Vancouver (WA) & Salt Lake City (aka Lucky Lager Brewing Co)
- Labatt takeover > HG Brewing Techniques
- Labatt Blue [inc. wort gravity – reduced hop utilization!]

HGF- History - II

- 1970's Labatt [flocculation issues – move to non-flocculant yeast strain]
- Successive increases in gravity – dilution to 5%

HGF- History - III

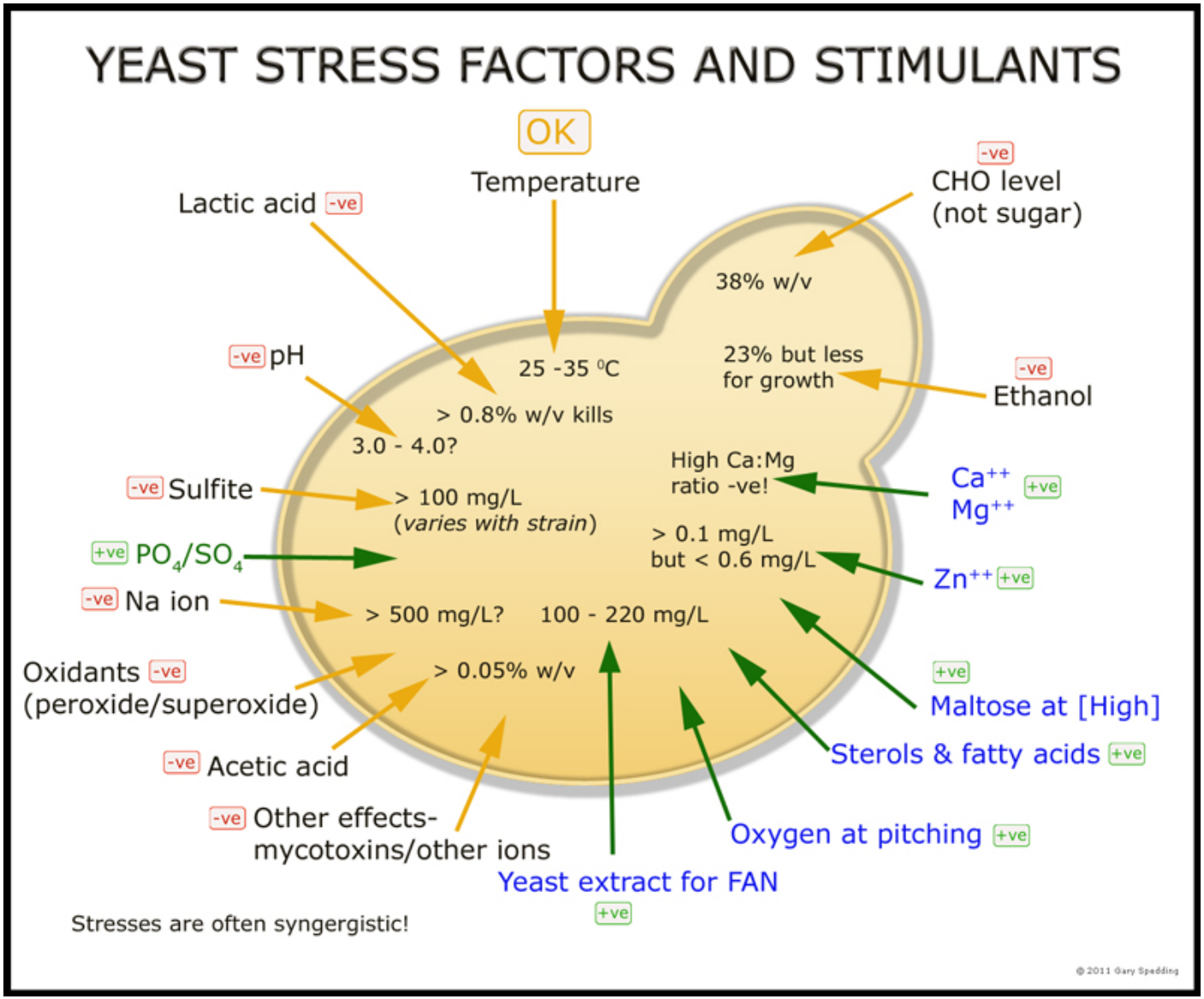
- Coors: 1970's Banquet [incr. in esters NBF – new beer fruity]
- But use Cascades (24 IBU) gave a preferred grapefruity note
- Coors Light – HG Wort > 4% low cal.[Banana ester and iso-amyl]

HGF- History - IV

- AB [No ester issues]
- Schlitz [Graham Stewart]
- Old Milwaukee:
  - Highest gravity brewing conducted at time
  - Estery, poor foam stability and inc. physical instability

HGF- Focus on Yeast

- This section is to focus on yeast and stress factors
- And…
- Yeast agonists or stimulants
- Only a brief outline!
- See how main figure fits the story


YEAST STRESS FACTORS AND STIMULANTS
OK
Temperature
25 -35 °C
Lactic acid -ve
-ve pH
3.0 - 4.0?
-ve Sulfite
> 100 mg/L
(varies with strain)
+ve PO4/SO4
-ve Na ion
> 500 mg/L?
Oxidants -ve
(peroxide/superoxide)
> 0.05% w/v
-ve Acetic acid
-ve Other effects-
mycotoxins/other ions
-ve
CHO level
(not sugar)
38% w/v
23% but less
for growth
-ve
Ethanol
> 0.8% w/v kills
High Ca:Mg
ratio -ve!
Ca++ +ve
Mg++
> 0.1 mg/L
but < 0.6 mg/L
Zn++ +ve
100 - 220 mg/L
+ve
Maltose at [High]
Sterols & fatty acids +ve
Oxygen at pitching +ve
Yeast extract for FAN
+ve
Stresses are often syngergistic!
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HGF: Ethanol toxicity

- EtOH inhibits both growth and fermentation – non-competitive
- Growth more sens. than ferment^{n}
- Ale yeast less tolerant
- Yeast + unsaturated fatty acids less alc. sensitive

HGF: Ethanol toxicity

- Inc. temp increases toxic effects of EtOH
- EtOH affects yeast cell viability

HGF: Flavor and Sensory

- Poor yeast growth leads to:
- Stuck fermentations
- H_2S
- Abnormal ester formation
- Abnormal diacetyl formation

HGF: Flavor and Sensory

- Subtle differences in flavor
- Yeast strain dependent
- Flavor Matching?
- Relate changes in congeners and flavors to sensory stimuli.
- Sensory panels?

HGF: Yeast and Contaminants

- Viability of yeast from HGF
- Yeast strain dependent
- Microbial contaminants in yeast?
- *Lactobacilli* detrimental to saccharification and fermentation
  - Issues with specialty beers?

Requirements for HGF

- Poor yeast viability & stuck fermentations overcome by:
- Supply of extra nitrogen, sterols and unsat. Fatty acids
- Added Mg^{++} and Ca^{++} incs. EtOH yields in HGF

Considerations for HGF

- Overcome:
- Flavor issues
- Foam stability issues
- Flocculation issues
- Colloidal/haze stability +ve w. HGF
- Product flexibility “stream brewing”

Successful Fermentation of 20 Plato Worts & Reduced Stress

- Increased dissolved O_2 at pitching: ROT: 1 ppb. DO/1 degree Plato wort
- Increased yeast pitching: ROT: 1 million cells/mL per degree Plato wort

Successful Fermentation of 20 Plato Worts & Reduced Stress

- Reduced Yeast cycles (strain specific) 20 ^{O}P wort - ROT: 5 cycles (then fresh prop.)
- Better yeast storage between fermentations

Successful Fermentation of 20 Plato Worts & Reduced Stress

- Reduced effect on beer foam stability
  - Use 5% wheat malt or foam enhancing agent.

Successful Fermentation of 20 Plato Worts & Reduced Stress

- Elevated ester formation (Et. acetate and iso-amyl acetate) alleviated by use of very high maltose syrup
- Even with otherwise all-malt worts!
- Avoid centrifuges – higher yeast stresses on 20 Plato vs. 12 Plato worts – issues!

Conclusion

- Extensive references available upon request - complex topic!
- Thanks to Graham Stewart and Dave Radzanowski for input
- For getting more out of the brewhouse the subject goes way beyond HGF. This is just a start to maximizing efficiency.