

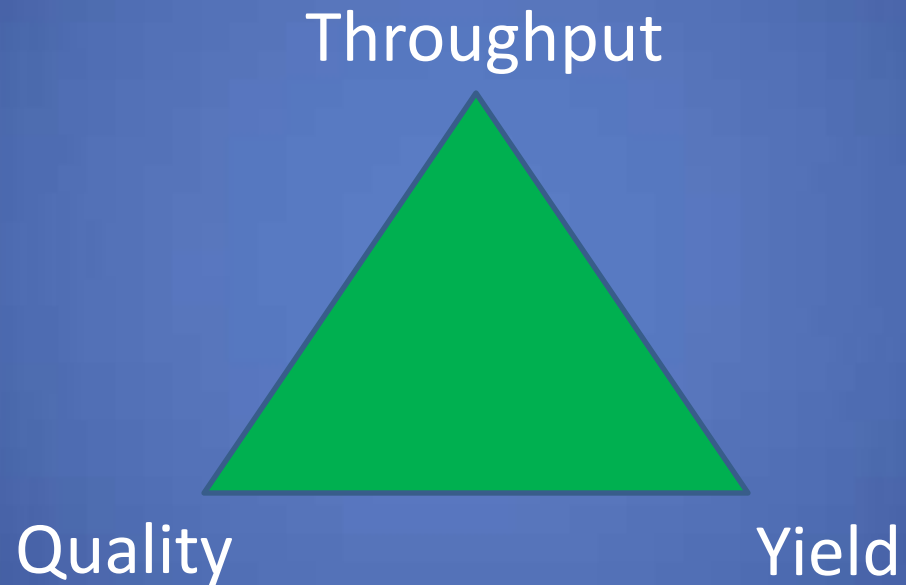
Impact of Brewhouse Operations on Beer Quality

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Fort Worth Brewery

- 8.5 million bbl/yr capacity
- 2 brew lines (600 & 1000 bbl)
- 74 fermenters (6 geometries, vertical/horizontal)
- 114 aging tanks
- 45 finished beer tanks
- 5 filter lines
- 3 sterile filter lines
- 20 wort streams – 40 finished beer streams
- 4 yeast strains
- Soda and Flavored Malt Beverages
- 9 Packaging Lines – Aseptic & Pasteurized

Finding the Balance



Objectives

- Throughput
 - 11 brews per day
- Yield
 - 97-98% extract recovery
- Quality
 - Meet myriad of product specifications
 - Ensure product integrity going forward in the process.

Areas of Focus

- Mashing
- Lautering
- Wort Boiling
- Hot Wort Settling and Cooling
- Flavor Stability

Mashing

- Mash in
 - Ensure water balance is correct – no clumping
- Protein Rest
 - Becoming less common due to improved malt quality.
 - Use the time for longer conversion times.
- Grits/Cereal Adjuncts not used.
 - Improved consistency
 - Improved flavor & foam stability (lipids)

Lautering

Wort Clarity

- It is vital that the worts brought into your kettle be clear.
- Turbid wort will cause several negative effects
 - Harsh / grainy flavors
 - Reduced physical and flavor stability
- Vorlauf (Recirculation) is a critical step regardless of your wort separation system.
- Wort should be recirculated just below the liquid level to prevent oxygen pickup.

Lautering

Wort Clarity

- Measuring wort clarity



Imhoff Cones



Inline Haze Meter

Lautering

Last Runnings – how low do you go?

- Last running below 1.5 Plato have little brewing value.
- Potential with higher pH to extract tannins from the malt husk
- Water balance of brews should be configured such that last worts are above 1.5 Plato AND kept to a minimum.

Wort Boiling

Evaporation is not necessary in brewing...

But...

...it is only indicator brewers have that ensures other processes are occurring.

Wort Boiling

Boiling Objectives	Heat Required (95 C)	Mechanical Action	Evaporation Required
DMS Formation and Removal	✓	✓	
Microbiological Stabilization	✓		
Coagulation of Proteins	✓	✓	
Isomerization of Hop Acids	✓	✓	
Color Formation	✓		
Enzyme Deactivation	✓		
Flavor Development	✓		

Wort Boiling

- Globally, the trend is toward less boiling
 - Stripping technologies (thin film)
 - Simmering with forced mechanical action
 - Pump
 - Inert gas sparging
- Sustainability is the driving force
 - Reduced energy input (CO₂ output)
 - Reduced water usage

Wort Boiling

- Think of steam as an ingredient.
 - Control mass flow
 - Consistent input = Consistent output
- Keep delta-T as low as possible
 - Prevents scorching
 - Thermal stress

Wort Boiling

Door Open or Door Closed?

- It depends on your system
 - If you have a strong draft (natural or fan driven), closed or mostly-closed door is preferred.
 - Must prevent cooling of the kettle headspace, but still enough draft to carry DMS out of the kettle.
 - “Capping” or sealing the kettle following boil to preserve hop aroma is not recommended.

Wort Settling and Cooling

- Settling Time

- Settling time should be kept to the minimum required to achieve the results required.
- Impact of long holds prior to cooling
 - Potential DMS formation and carryover.
 - Unwanted color formation.
 - Too much trub removed.

Wort Settling and Cooling

- Trub Removal
 - Complete trub removal is not recommended.
 - Yeast needs a little fat. Trub is a good source of unsaturated fatty acids.
 - Too much trub will inhibit the formation of esters that you may want in your product.
 - Too little trub will cause yeast health issues
 - Slow fermentations
 - High Sulfur Dioxide (requires label declaration over 10 ppm)
 - Trub will contain heavy metals (Cu⁺⁺, Fe⁺⁺)
 - Catalysis of oxidative reactions later

Wort Settling and Cooling

- Trub Removal
 - Measuring Trub carryover



Composite Wort Sampler

Wort Settling and Cooling

- Wort Cooling and Oxygenation/Aeration
 - Wort should be cooled as quickly as possible to prevent darkening, DMS or spoilage.
 - Wort flow should be sufficient to encourage mixing in the fermenting vessel
 - Oxygen is preferred to air for higher gravity worts or when adjuncts are used. Rule of thumb is 1 ppm O₂ per deg Plato...but it depends
 - Yeast strain
 - Desired ester levels
 - How long fermenting vessel is being filled (multi-brew)
- Ultimately the brewer needs to balance O₂ levels and trub to achieve the desired fermentation performance.

Flavor Stability

- Current belief is that control of oxygen inclusion in the brewhouse is important.
- Precursors of staling compounds (T-2-N) are believed to be formed via lipid oxidation.
- Some debate as to whether this is as impactful as believed.
- Beer's natural antioxidative potential can be reduced by excessive oxygen uptake in the brewhouse

Flavor Stability

- Antioxidative potential is the beer's ability to quench radical species of oxygen.
- Measurement is possible with fairly expensive lab instruments
 - ESR – electron spin resonance spectroscopy
 - EPR – electron paramagnetic resonance spectroscopy
- Can be used to determine the impact of process changes on the antiox potential of a beer.

Flavor Stability

- Antioxidative potential can be enhanced by following generally accepted good practices.
 - Avoiding oxygen ingress
 - Keeping grain beds flooded
 - Controlling trub carryover.
- Proper equipment design also helps
 - Stainless steel equipment
 - Vortex breakers
 - Gentle boiling

Flavor Stability

The AntiOx Battery



Quiet Filling
Pellet Hops
Caramel malts
Clear lauter worts
Last Worts > 1.5 P
Gentle Boiling



Vortexing
Heavy metals
Cloudy lauter worts
Excessive Trub Carryover
High Temp Boiling



At the end of fermentation, the battery is as charged as it will get.

Flavor Stability



You can't make beer bulletproof.
But you can give it some protection.

Summary

- Brewers need to balance throughput, yield and quality.
- Decisions should be based on data.
- Ultimately the brewer needs to prioritize what is important and tailor the process to meet the need.

Thank You.

- Questions?