WORLD BREWING CONGRESS
August 13–17, 2016 • Denver, Colorado, U.S.A.
#ElevateBeer

Improving Brewhouse Efficiency By Adjusting Mash Water, Lauter, and Sparge Volumes

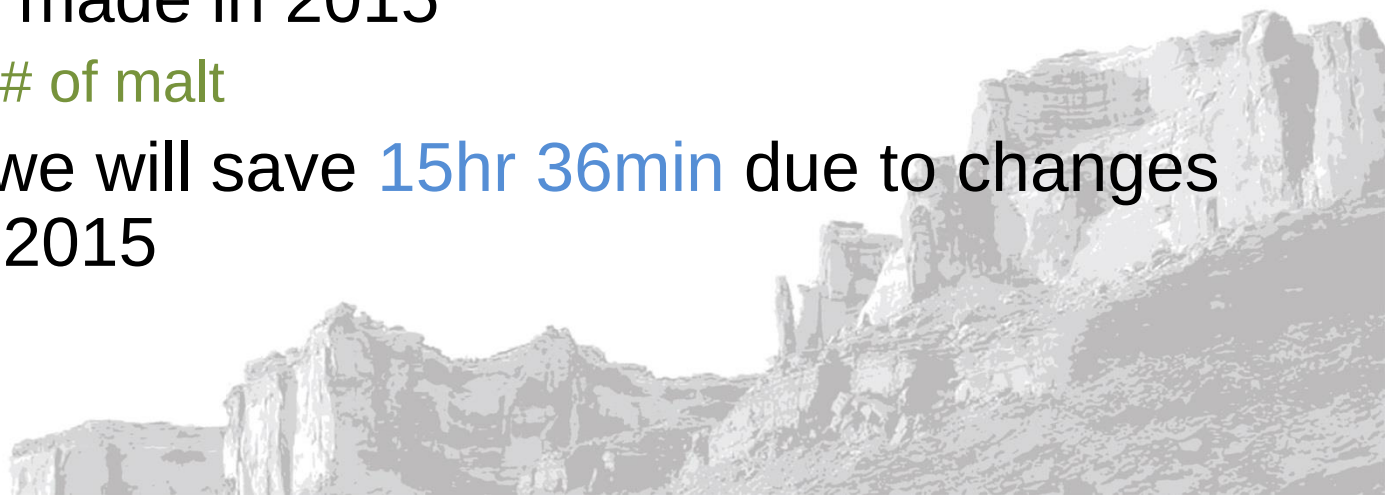
By: Eddie Gutierrez

2nd: Drew Russey, PhD

Spoiler Alert

- Why should a 20 year old brewing company continue to look into brewhouse optimization??

- Brewhouse Optimization Results
  - In 2016 we will save over $20,000 due to changes made in 2015
    - 45,800# of malt
  - In 2016 we will save 15hr 36min due to changes made in 2015



Brewhouse Efficiency

$$Brewhouse\ Efficiency = \frac{Total\ Extract}{Total\ Potential\ Extract}$$

- Total Extract=Amount of extract in the wort
- Total Potential Extract=Amount of extract available in each malt being used
  - Calculated using coarse as is % or other value
    - Available from malt suppliers

Benefits of Increased Efficiency

- Effective brewhouse optimization can save money and time:
  - Increasing brewhouse efficiency decreases malt usage and ultimately saves money.
  - Decreasing malt bill can create a more efficient mash volume, lessening the load on the lauter tun, resulting in quicker lautering and ultimately saving money.

Brewhouse Description

- 136bbl(160hl) Brewhouse
- Separate mash tun and lauter tun
- Automated mash in and mash rest program
- Mash tun agitator operates throughout the mash in and saccharification rest to ensure homogeneity

- Lauter tun rakes operate throughout the lauter and rake height is controlled by BrauKon BrauControl automation
- Flow rate is controlled by BrauKon BrauControl automation
- Sparge is separated into 3 sparge steps throughout the lauter

Scope of the Project

- Problem
  - Beers with target original gravity above 15° have high final runnings(>6°)
- Action
  - Use water more efficiently throughout the mash and lauter processes to extract more sugar
- Goals
  - Increase brewhouse efficiency-reduce malt usage
  - Must not increase lauter time
  - Must not negatively effect the finished product

Using Darcy's Law

$$Q = \frac{kA\Delta p}{\mu L}$$

- Darcy's Law describes the flow of a fluid through a porous medium
  - Q= Flow rate of wort
  - k= Permeability of grain bed
  - A= Area of lauter tun
  - Δp= Pressure Differential
  - μ= Viscosity of wort
  - L= Depth of grain bed

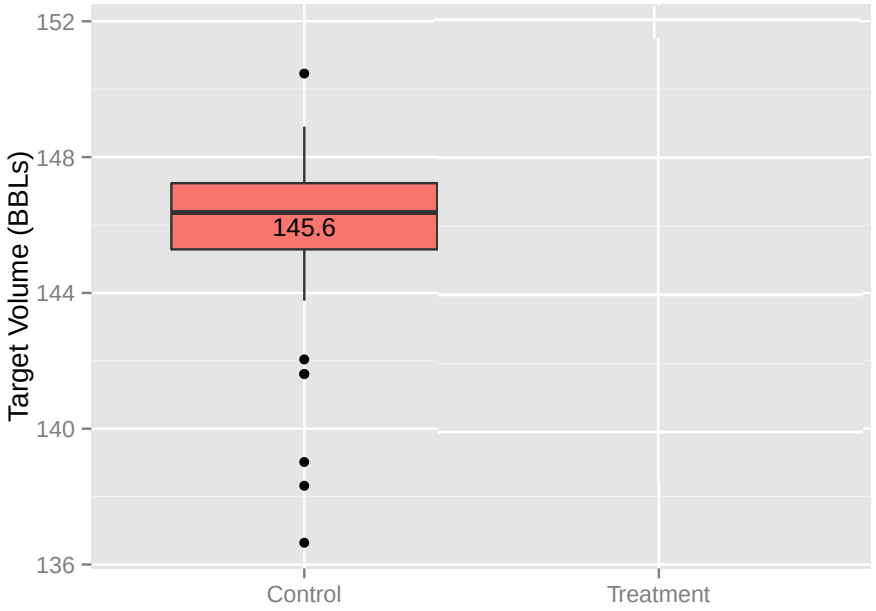
Measurables

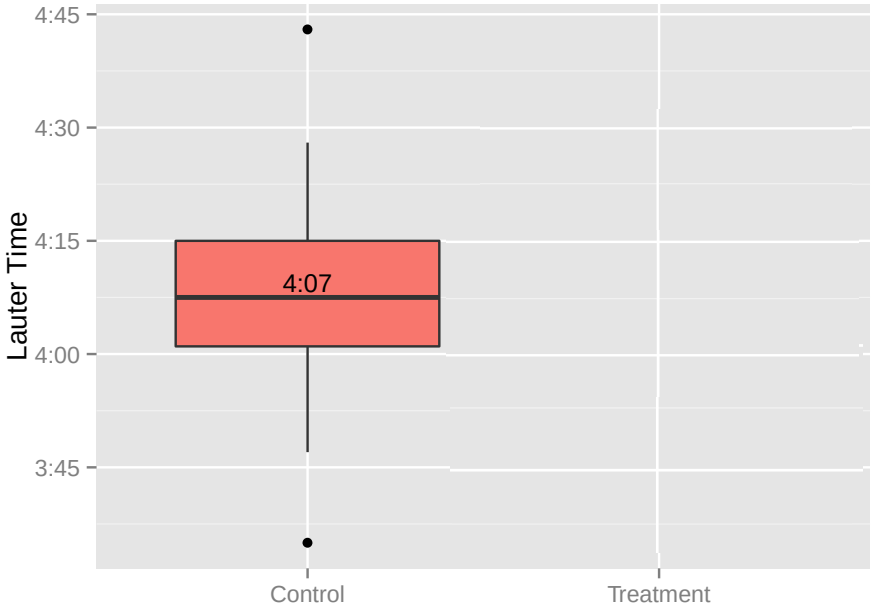
- Variables
  - Mash in liquor volume
  - Pre sparge wort lauter volume
  - Sparge liquor volume
  - Grain bill

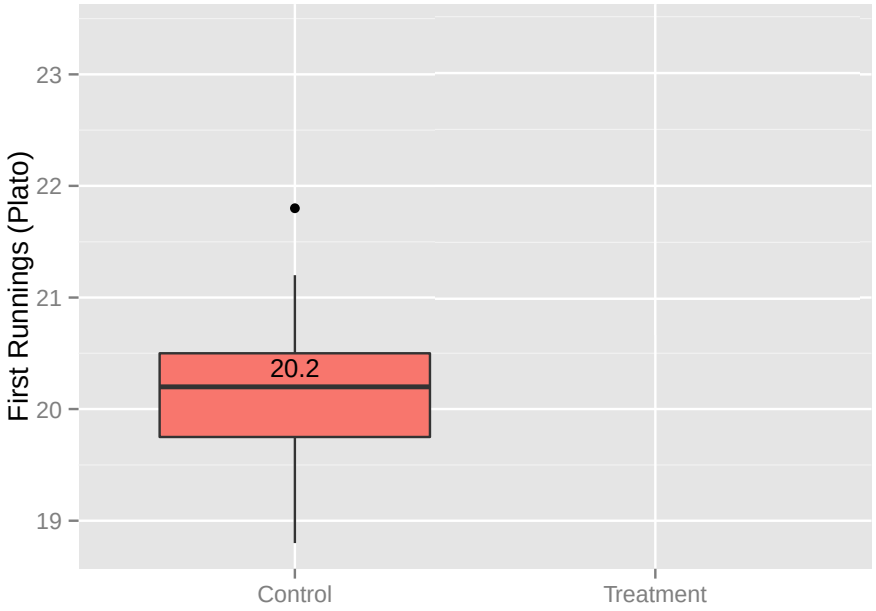
- Indicators of success
  - **Target volume** = $\frac{\textit{Start of boil gravity * Start of boil Vol.}}{\textit{Target original gravity}}$
  - **Lauter time** = *end time - start time*
  - **First runnings** = sample of wort runnings at beginning of lauter
  - **Final runnings** = sample of wort runnings at end of lauter
  - **Brewhouse efficiency** = $\frac{\textit{Total extract}}{\textit{Total potential extract}}$

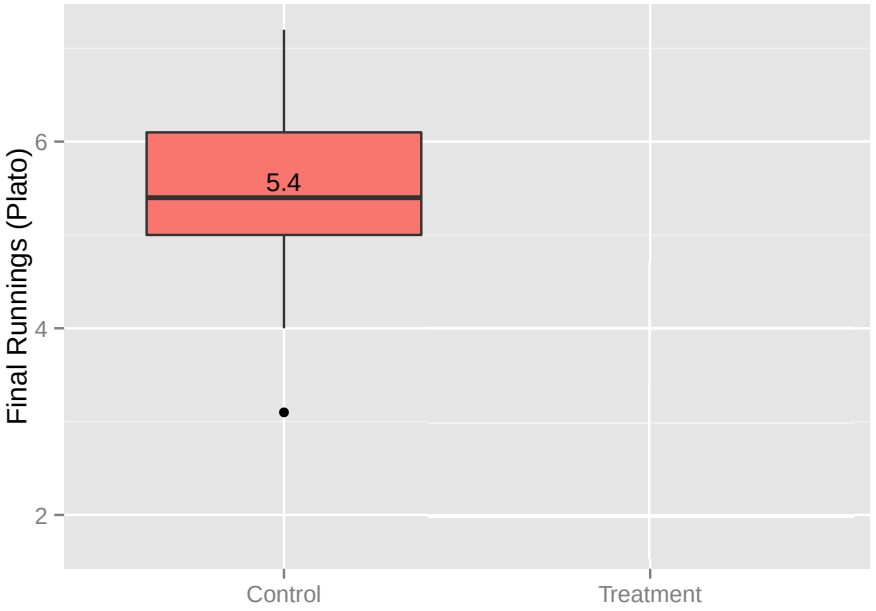
Case 1 Experiment Overview

- Case 1 – 15.4° Plato beer
  - ↓Mash in liquor volume
    - Increase grist to water ratio
  - ↑Pre sparge wort lauter volume
  - ↑Post sparge liquor volume
  - ↓Grain bill to keep batch size appropriate for FV

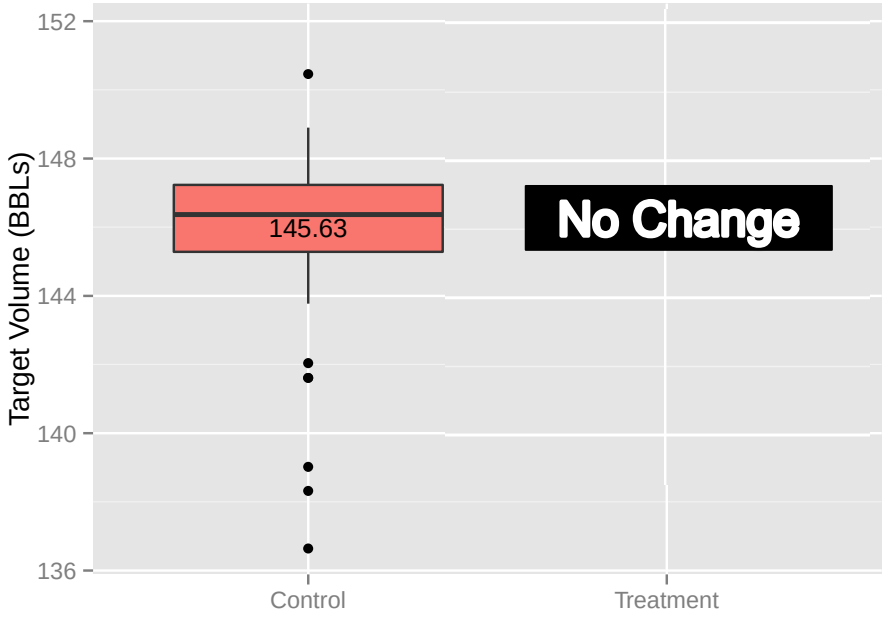

Target Volume (BBLs)
152
148
144
140
136
145.6
Control
Treatment

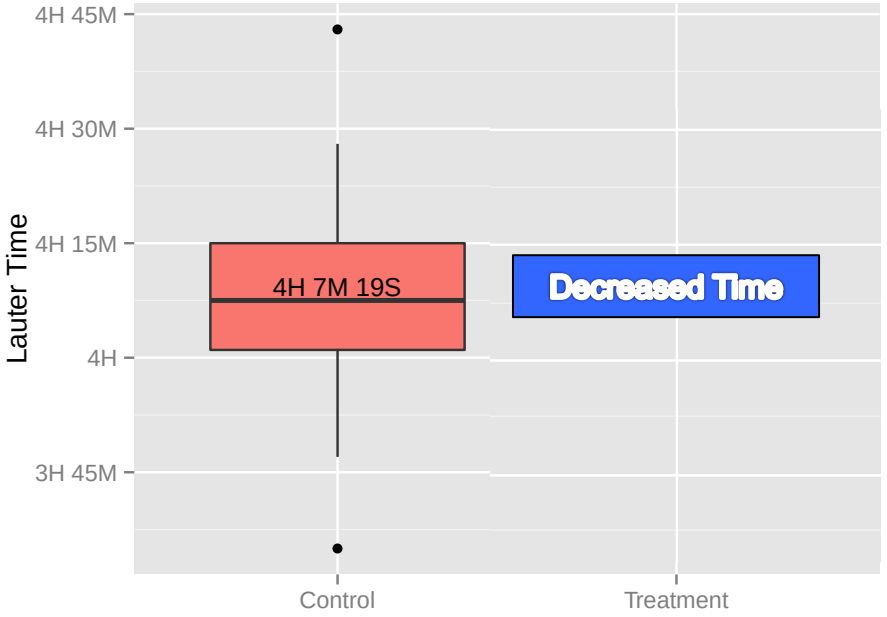

Lauter Time
4:45
4:30
4:15
4:00
3:45
4:07
Control
Treatment

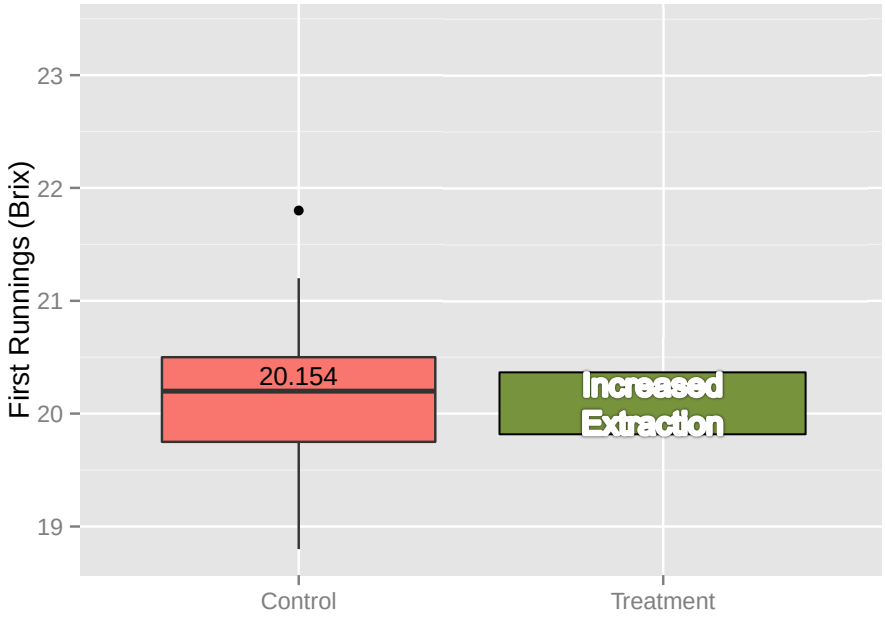

First Runnings (Plato)
23
22
21
20
19
20.2
Control
Treatment

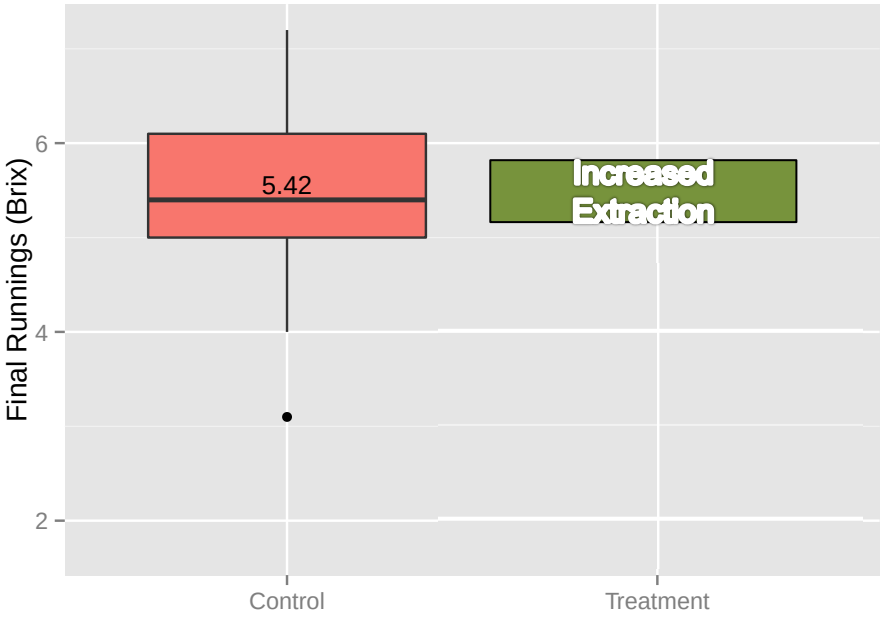

Final Runnings (Plato)
6
4
2
5.4
Control
Treatment

Control n = 46





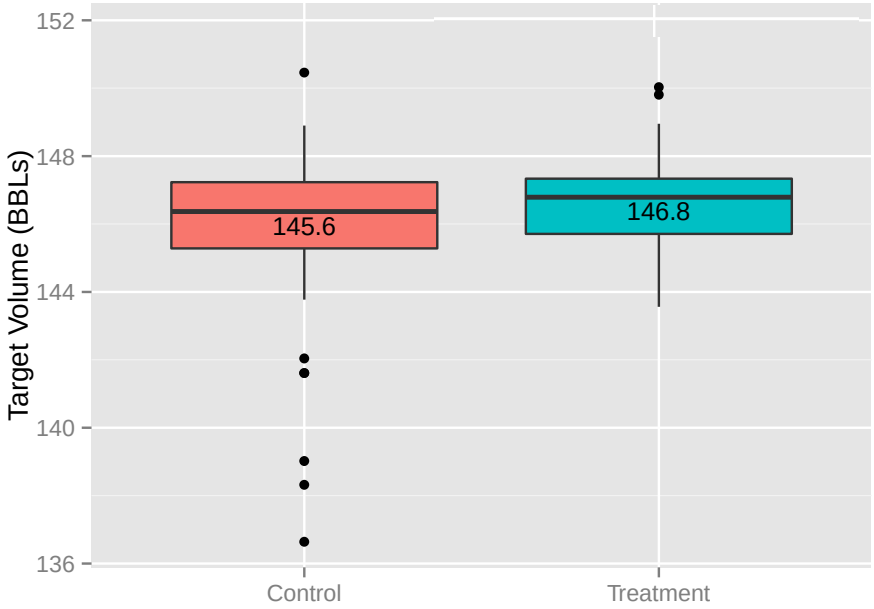


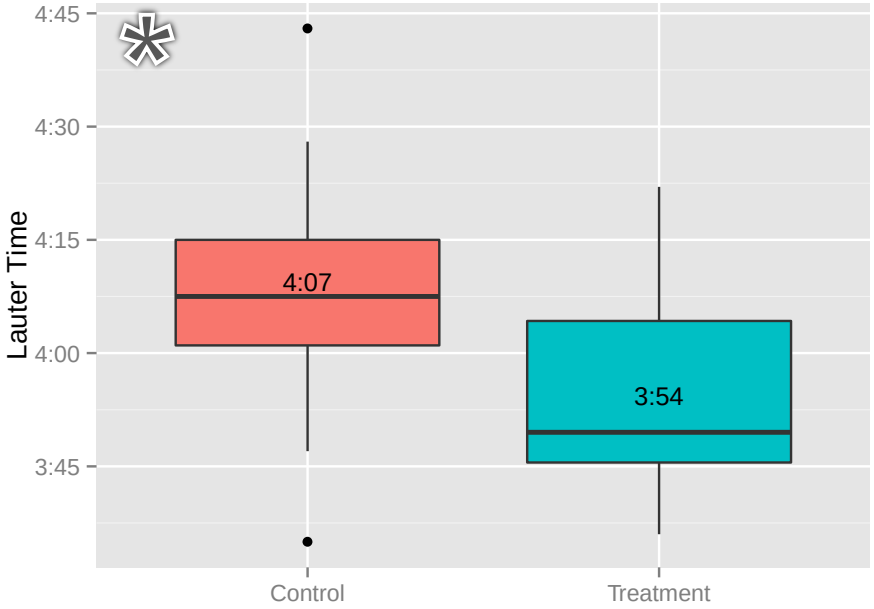


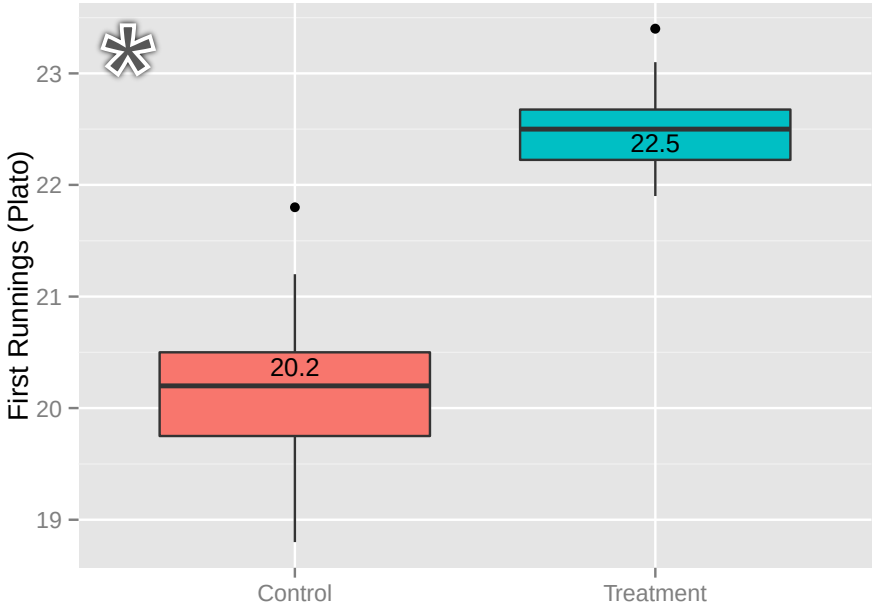
Predictions

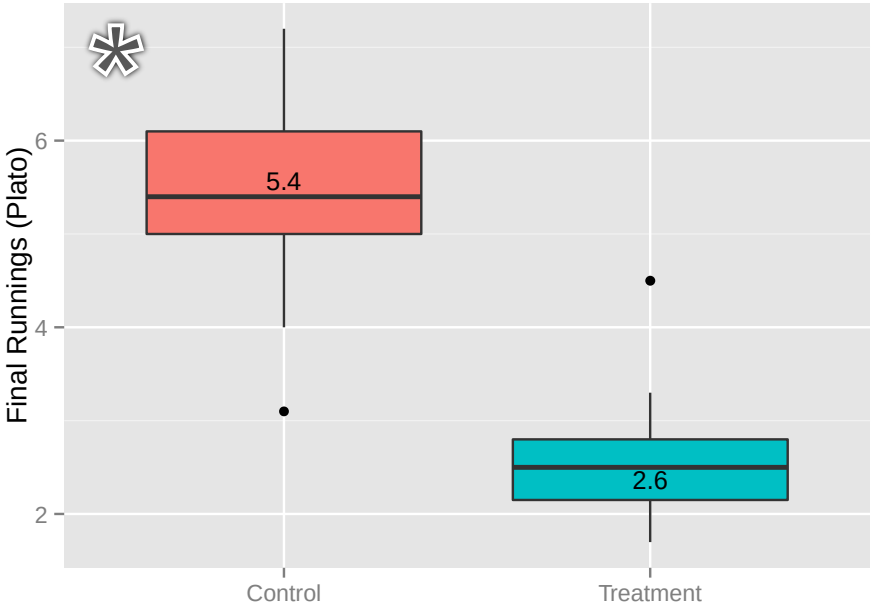
Control Treatment

n = 46







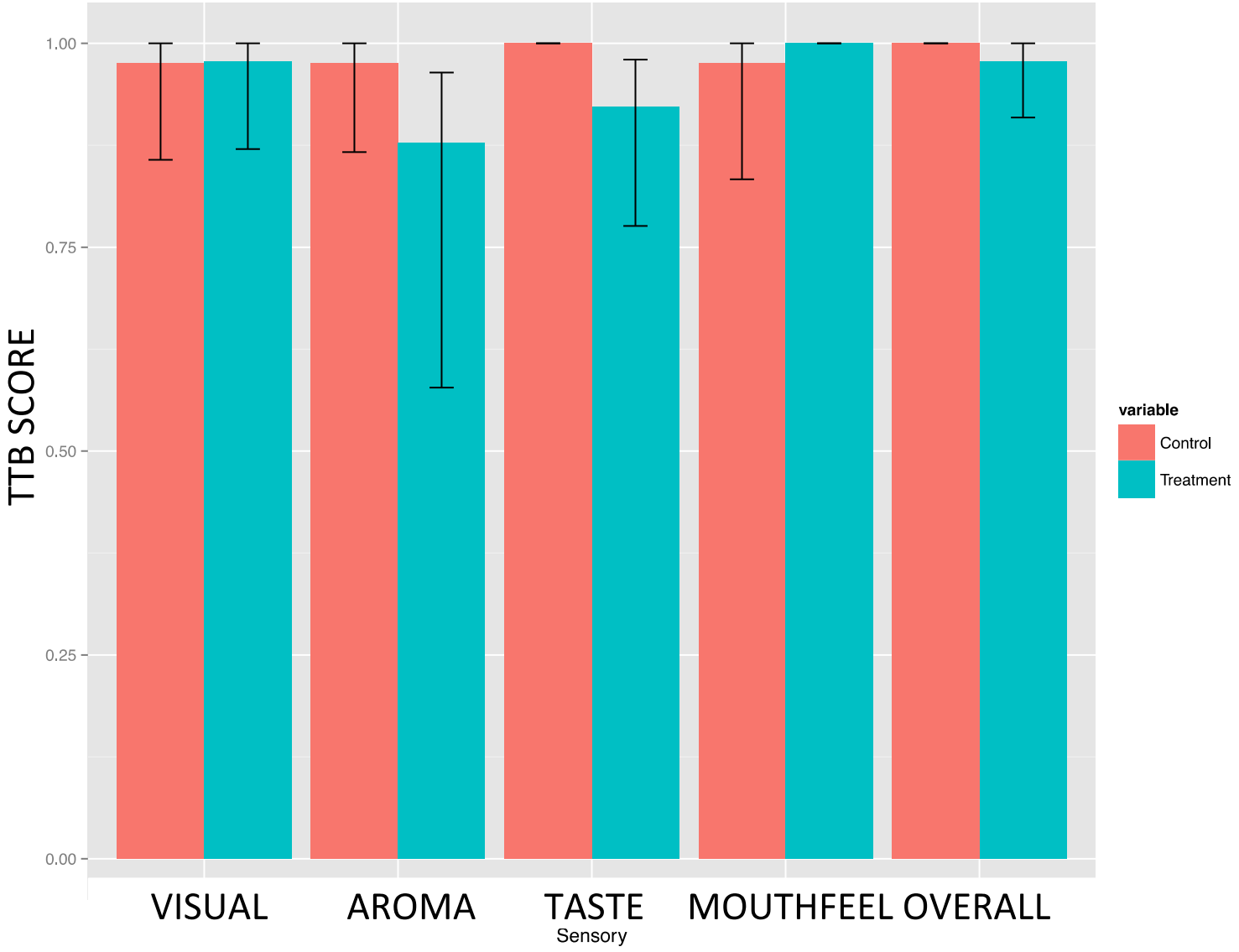


Control Treatment

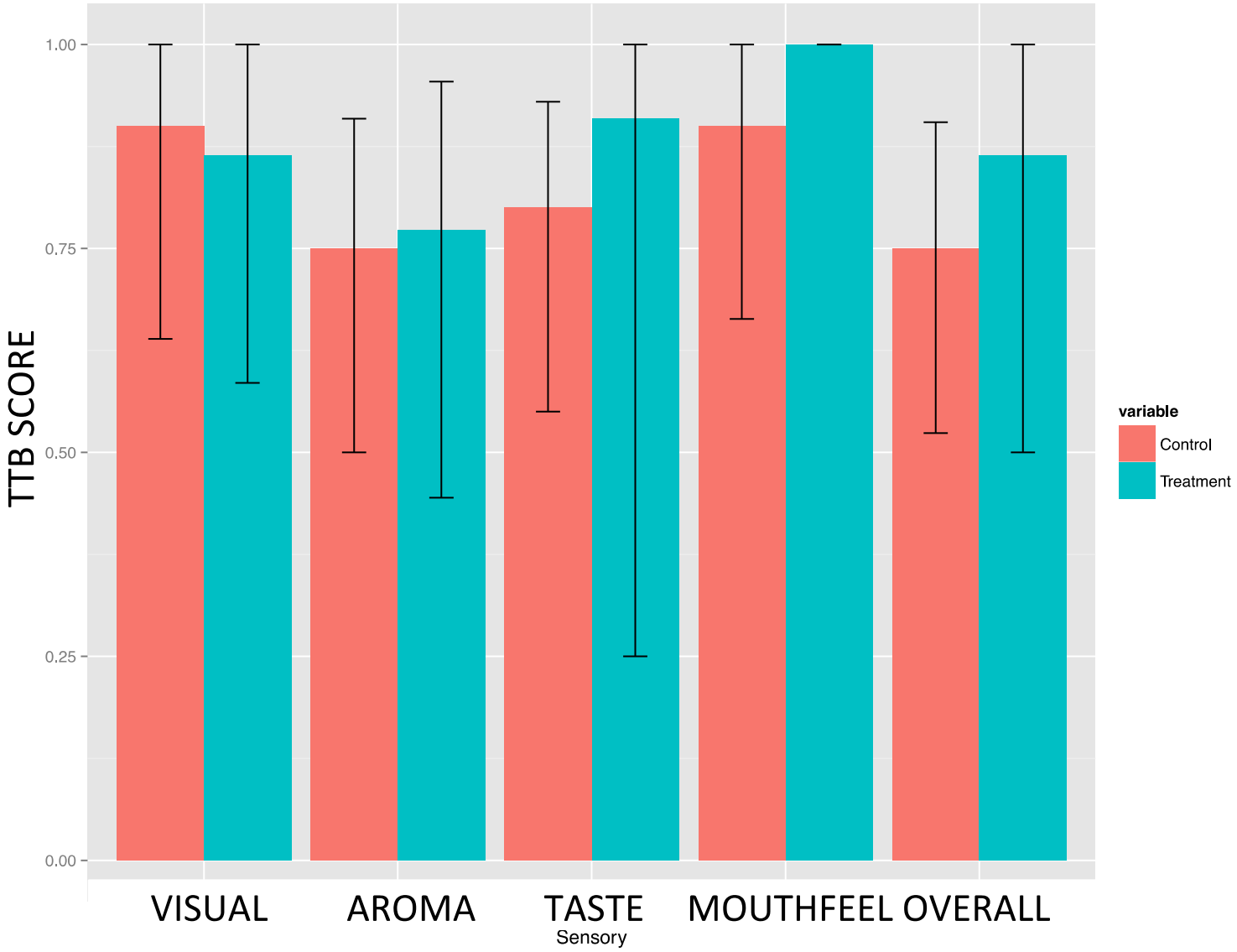
n = 52

= $p < 0.001$

Product Release

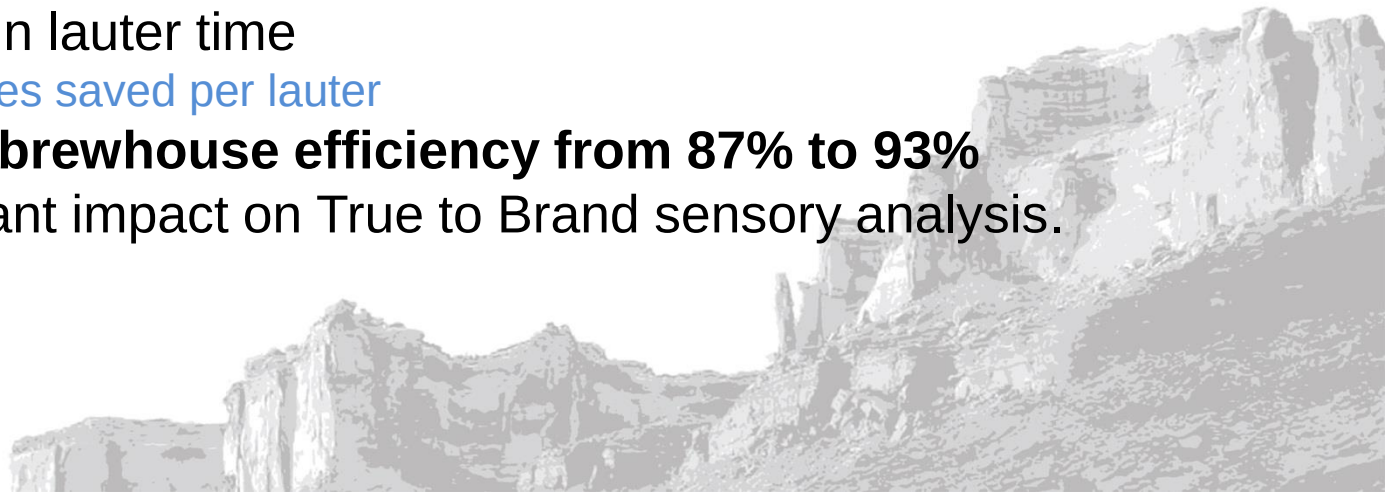


Force Aged

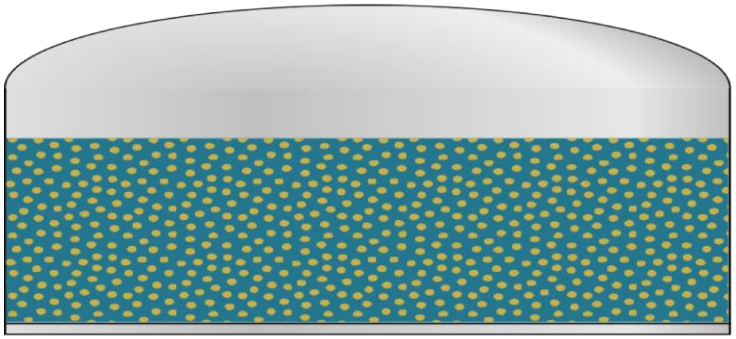

1.00
0.75
0.50
0.25
0.00
TTB SCORE
VISUAL
AROMA
TASTE
MOUTHFEEL
OVERALL
Sensory
variable
Control
Treatment

Case 1 Results

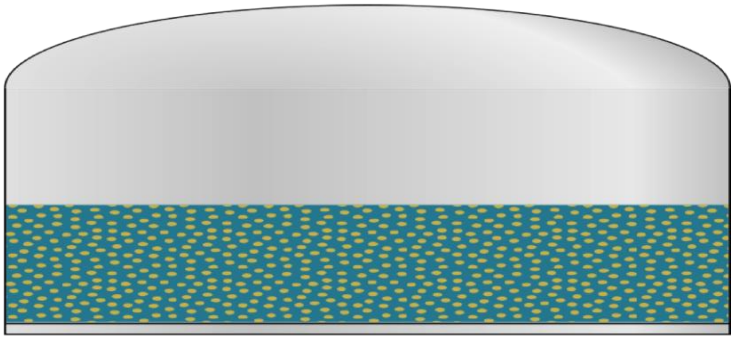
- Problem
  - Beer with target original gravity of 15.4° has high final runnings(~6°)
- Action
  - Use water more efficiently throughout the mash and lauter processes in order to extract more sugar
- Results
  - Better Extraction
    - First runnings increase and final running decrease
    - 5% Grain Reduction (425#)
  - Reduction in lauter time
    - 13 minutes saved per lauter
  - **Increases brewhouse efficiency from 87% to 93%**
  - No significant impact on True to Brand sensory analysis.



Case 2 Experiment Overview

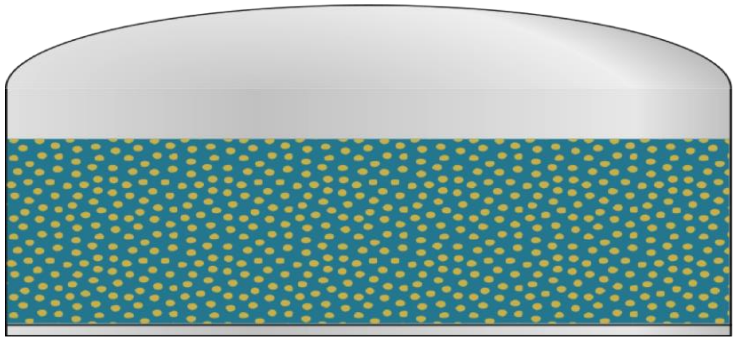


First Wort
Lauter
➔

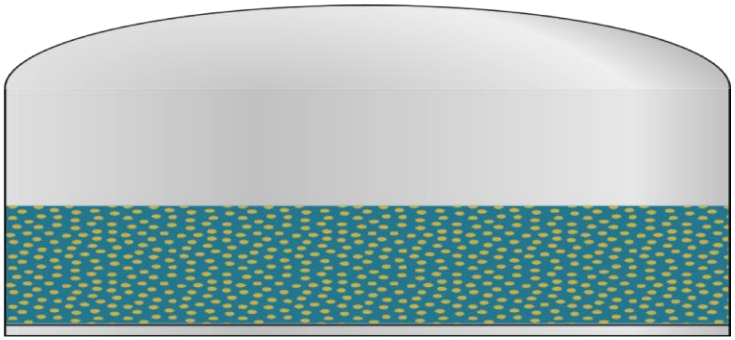


- Case 2 – 23.8° Plato beer double mash beer
  - Introduce minisparge to force out concentrated wort
    - ⬇Mash in liquor volume
      - Increase grist to water ratio
    - ⬇Pre sparge liquor volume
    - ⬇Grain bill in order to keep batch size appropriate for FV

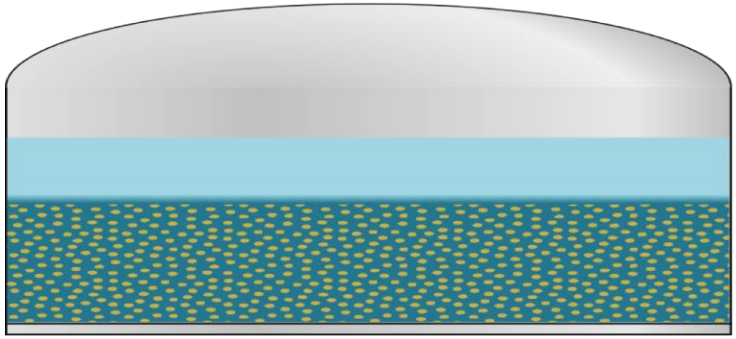
Case 2 Experiment Overview



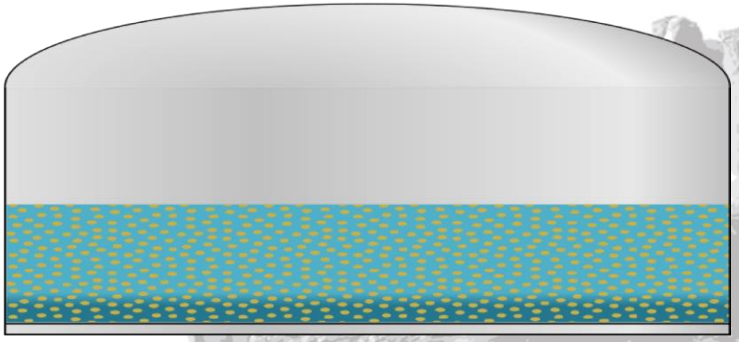
First Wort
Lauter
➔

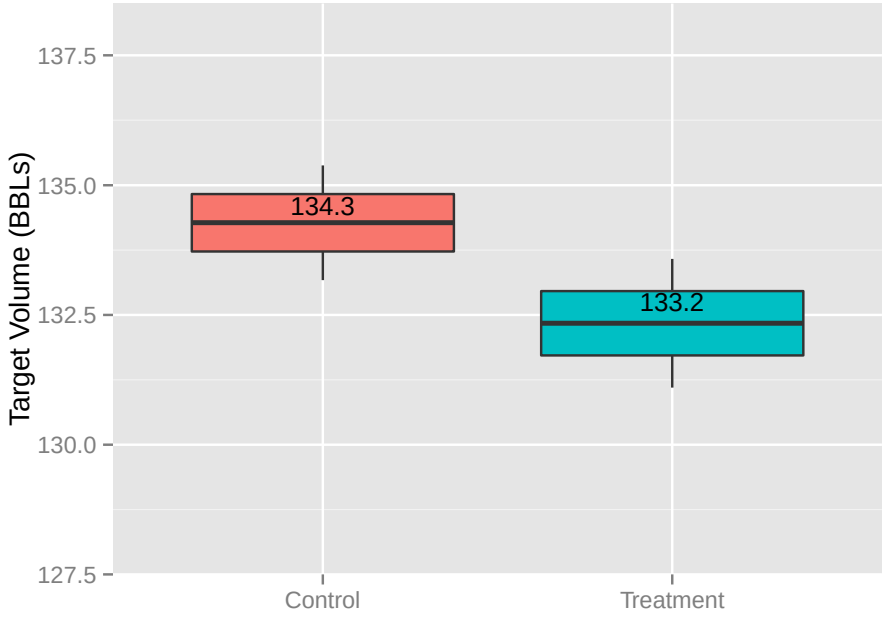


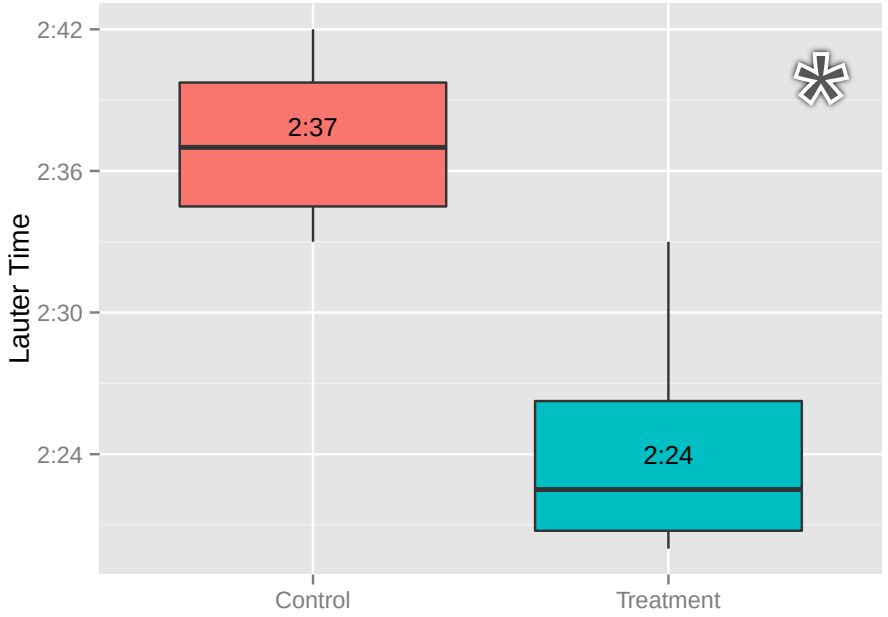
Minisparge
↙

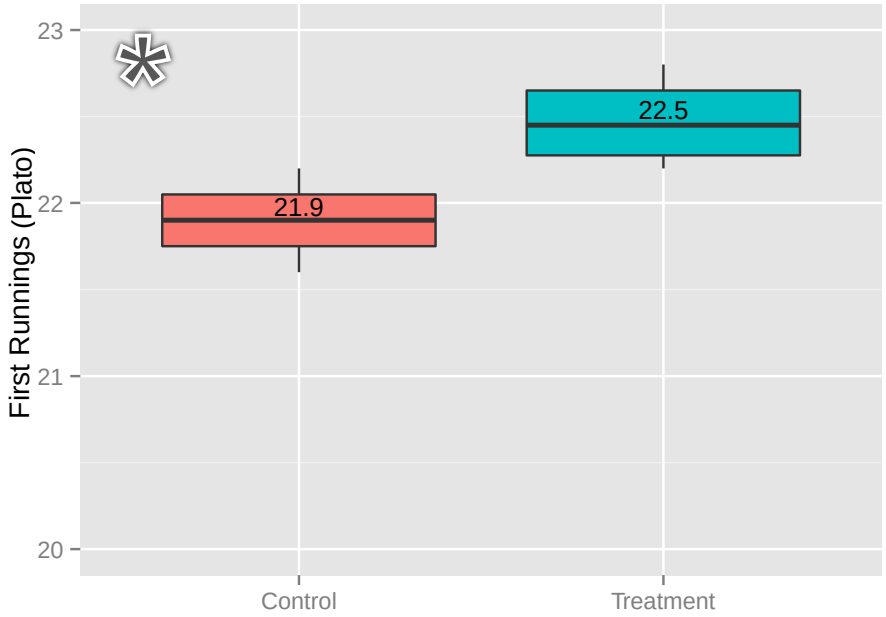


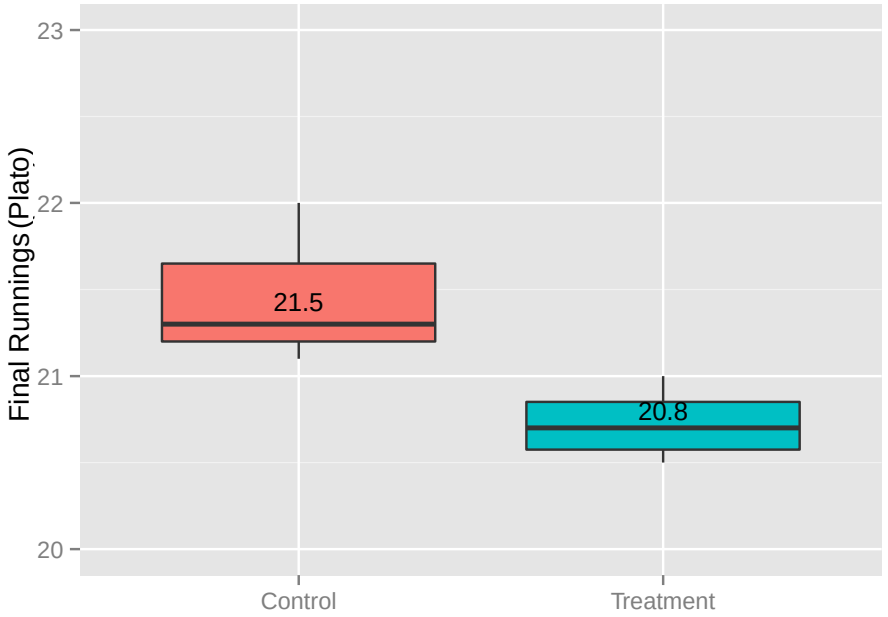
Lauter
➔











Results

Control Treatment

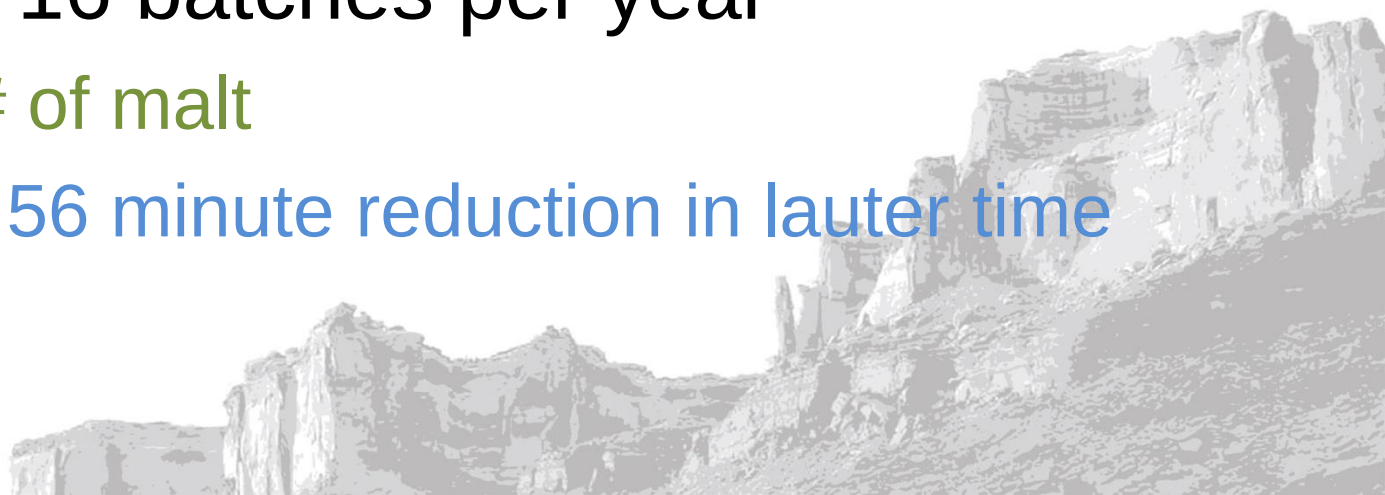
* = $p < 0.02$

Case 2 Results

- Problem
  - Beer with target original gravity of 23.8° has high final runnings(21.5°)
- Action
  - Use water more efficiently throughout the mash and lauter processes in order to extract more sugar
- Results
  - First runnings increase and final running decrease
  - 10% Grain Reduction (1800# per double mash)
  - 26 minute reduction in lauter time per double mash
  - **Increase brewhouse efficiency from 58% to 63%**

Results Summary

- Case 1 – 40 batches per year
  - 17,000# of malt
  - 8 hours 40 minute reduction in lauter time
  - No significant impact on True to Brand sensory analysis.
- Case 2 – 16 batches per year
  - 28,800# of malt
  - 6 hours 56 minute reduction in lauter time



Recommendations

- Do science
- Record as much data as possible and store it in a way that it can be analyzed easily
- Look for areas of inefficiency
- Single variable experimentation
- Analyze Results
- Repeat

Questions?

SAINT ARNOLD®
BREWING COMPANY

Eddie Gutierrez: eddie_gutierrez@saintarnold.com

Drew Russey: drew_russey@saintarnold.com

Statistics

- Case 1
  - Normality of control and treatment datasets assessed by Shapiro-Wilk test.
    - Only First Runnings met assumption of normality. Test with a t-test
    - All others tested with Wilcoxon signed-rank test (non-parametric)
- Case 2
  - Normality assessed by Shapiro-Wilk test
    - No groups violated assumption of normality
    - All tested with t-test.
- TTB error bars
  - Data was bootstrapped (resampled 1000x) to estimate 95% confidence interval since data is essentially binomial.
  - Force Age samples have larger error bars due to
    - nature of sampling (e.g. 3x for PR and 1x for FA).
    - More 0 ratings on FA beers.