Hop Utilization in the Whirlpool

VBA Craft Brewers Conference
Friday November 10, 2023
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Who we are

Julie Smith - Lawson’s Finest

- Certified Cicerone
- ASBC/MBAA Webinar Committee
- Pink Boots Volunteer Coordinator, VT Chapter Co-Leader
- Long Trail Brewing 2015-2018
- Lawson’s Finest Liquids 2018-current

Amy Todd - Bia Diagnostics

- BA Chemistry University of Vermont
- American Brewer's Guild 2009
- Magic Hat Brewing Co 2010-2013
- Siebel Institute of Chicago Sensory Panel Management and Brewing Microbiology
- Founded Zymology Labs 2016 (sold to Bia Diagnostics in 2022)
- Certified Cicerone and BJCP beer judge
- VBA DEI committee

Outline

- Questions and experiment design
- Equipment set-up and recipe
- Brew Day #1 : Data review and new questions
- Brew Day #2 :Data review and new questions
- Brew Day #3: Data review and new questions
- Remaining questions
- Takeaways and next steps
- Designing experiments in your brewery

Hop Utilization

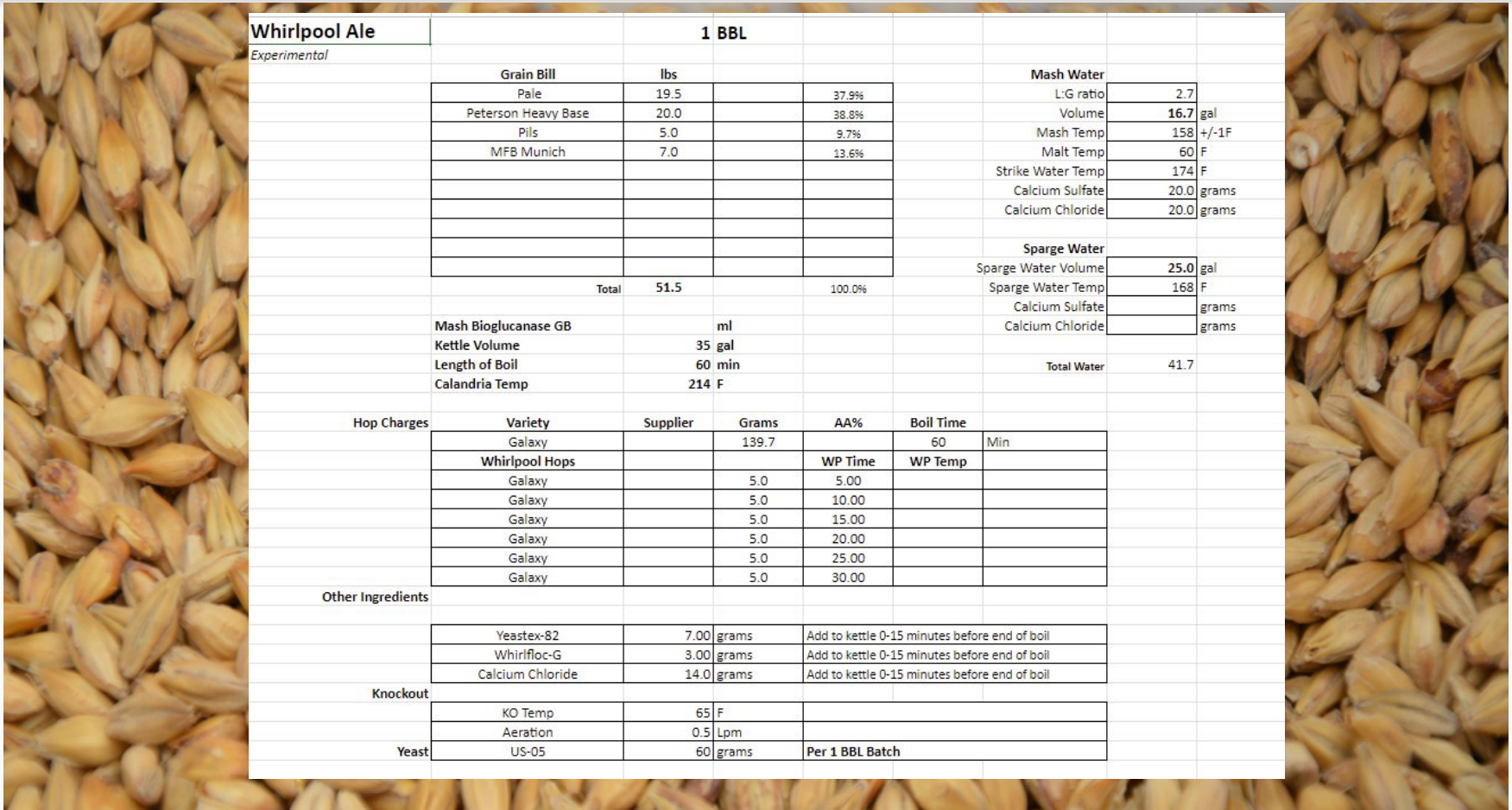
- Does adding hops in the whirlpool increase bitterness?
- Does a longer whirlpool extract more IBUs?
- At what temperature do IBUs stop being extracted?
- When does the wort becoming oversaturated with hops?

How to set up an experiment

- Observation
- Questions
- Hypothesis
- Independent and dependent variables
- Experimental design
- Data analysis

Equipment

Recipe Design



Whirlpool Ale — **1 BBL**

Experimental

Grain Bill	lbs		
Pale	19.5		37.9%
Peterson Heavy Base	20.0		38.8%
Pils	5.0		9.7%
MFB Munich	7.0		13.6%
Total	51.5		100.0%

Mash Bioglucanase GB		ml
Kettle Volume	35	gal
Length of Boil	60	min
Calandria Temp	214	F

Mash Water		
L:G ratio	2.7	
Volume	**16.7**	gal
Mash Temp	158	+/-1F
Malt Temp	60	F
Strike Water Temp	174	F
Calcium Sulfate	20.0	grams
Calcium Chloride	20.0	grams
Sparge Water		
Sparge Water Volume	**25.0**	gal
Sparge Water Temp	168	F
Calcium Sulfate		grams
Calcium Chloride		grams
Total Water	41.7	

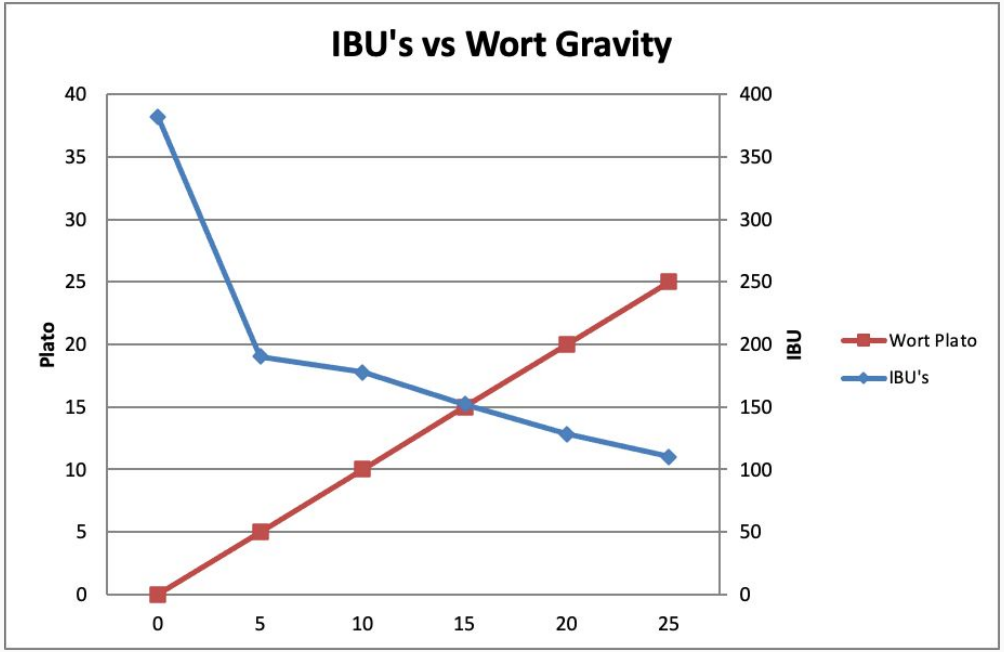
Hop Charges	Variety	Supplier	Grams	AA%	Boil Time	
	Galaxy		139.7		60	Min
	Whirlpool Hops			**WP Time**	**WP Temp**	
	Galaxy		5.0	5.00		
	Galaxy		5.0	10.00		
	Galaxy		5.0	15.00		
	Galaxy		5.0	20.00		
	Galaxy		5.0	25.00		
	Galaxy		5.0	30.00		

Other Ingredients				
	Yeastex-82	7.00	grams	Add to kettle 0-15 minutes before end of boil
	Whirlfloc-G	3.00	grams	Add to kettle 0-15 minutes before end of boil
	Calcium Chloride	14.0	grams	Add to kettle 0-15 minutes before end of boil
Knockout				
	KO Temp	65	F	
	Aeration	0.5	Lpm	
Yeast	US-05	60	grams	**Per 1 BBL Batch**

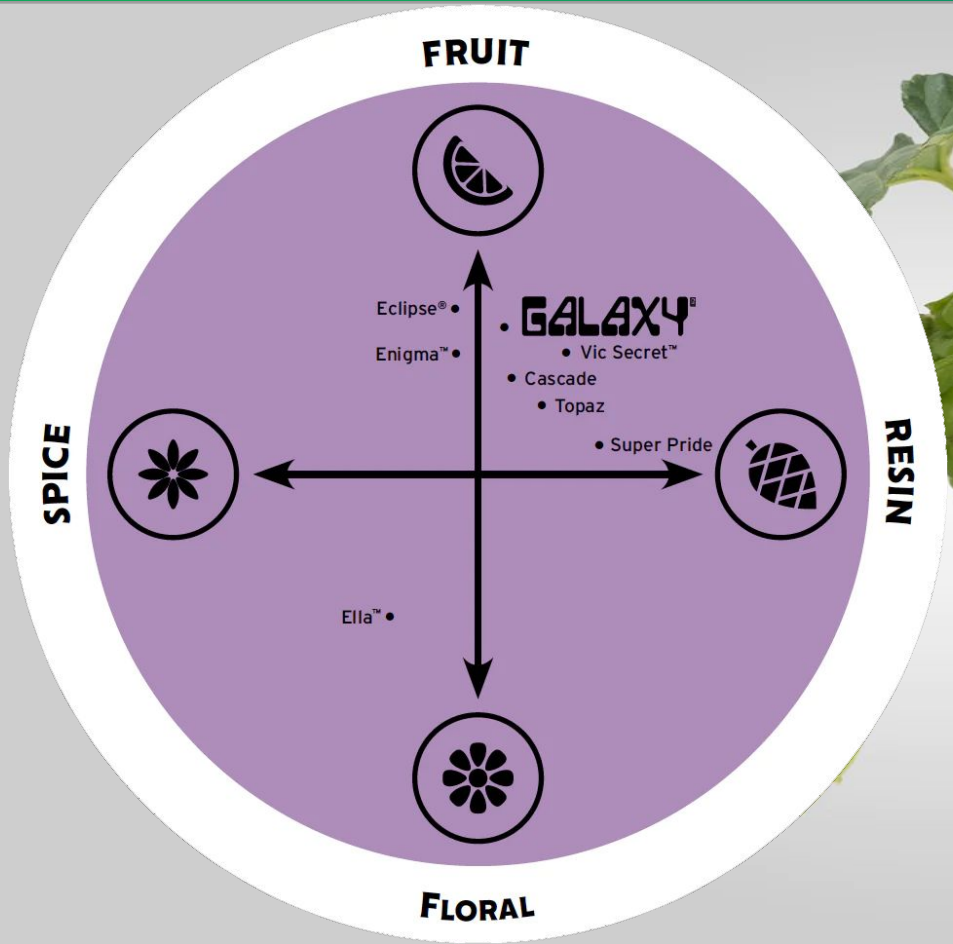
IBUs and Boil Hops

We used this chart from another brewer study to help inform our experiment design.

This graph shows that as degrees Plato increase in the wort, the overall utilization of IBUs in the boil goes down.



Galaxy Hop profile



FLAVOR KEY

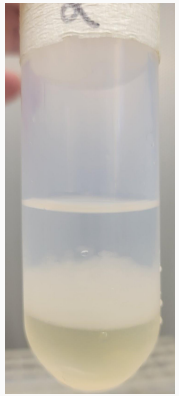
CITRUS

SWEET FRUIT

ALPHA ACIDS: 13.0-18.5%
BETA ACIDS: 6.1-11.6%
ALPHA/BETA RATIO: 1.3-2.7
COHUMULONE (%OF ALPHA ACIDS): 32-43
TOTAL OILS: 1.9-2.9 ML/100G

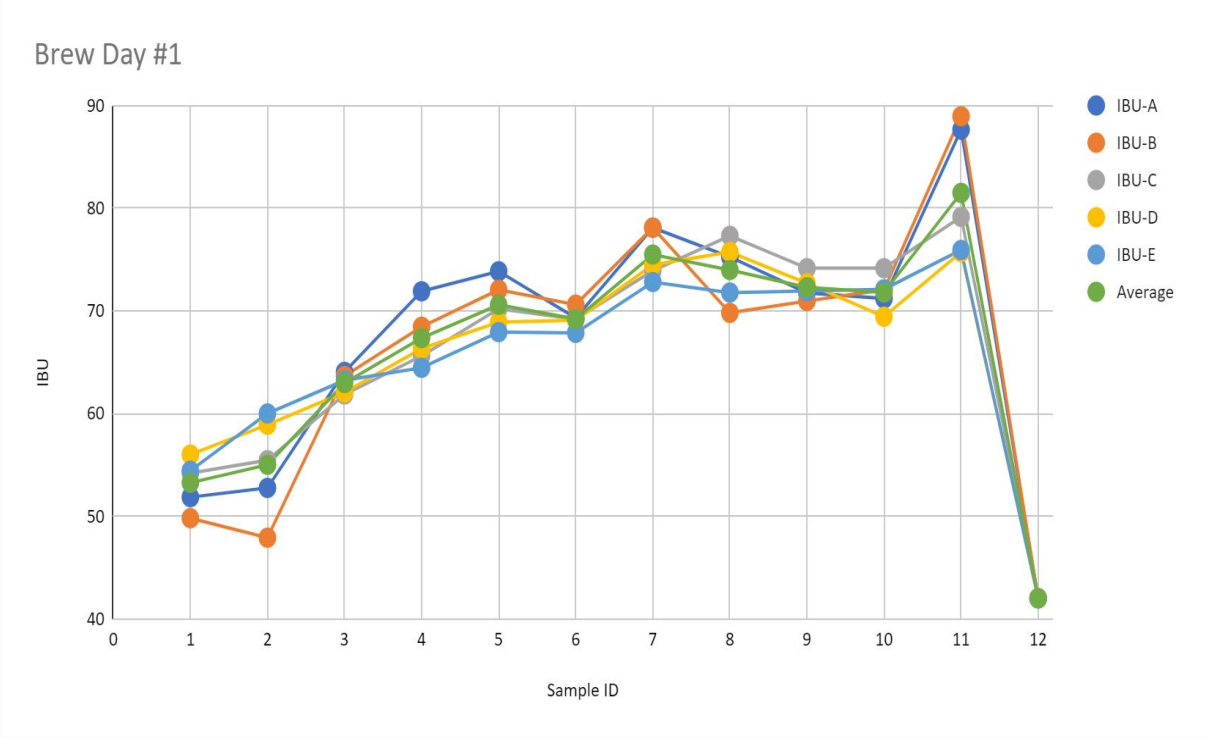
Data Collection

- ASBC Beer 23-A
- Limitations in testing method
- UV-Vis
- HPCL
- Sensory



Brew day #1

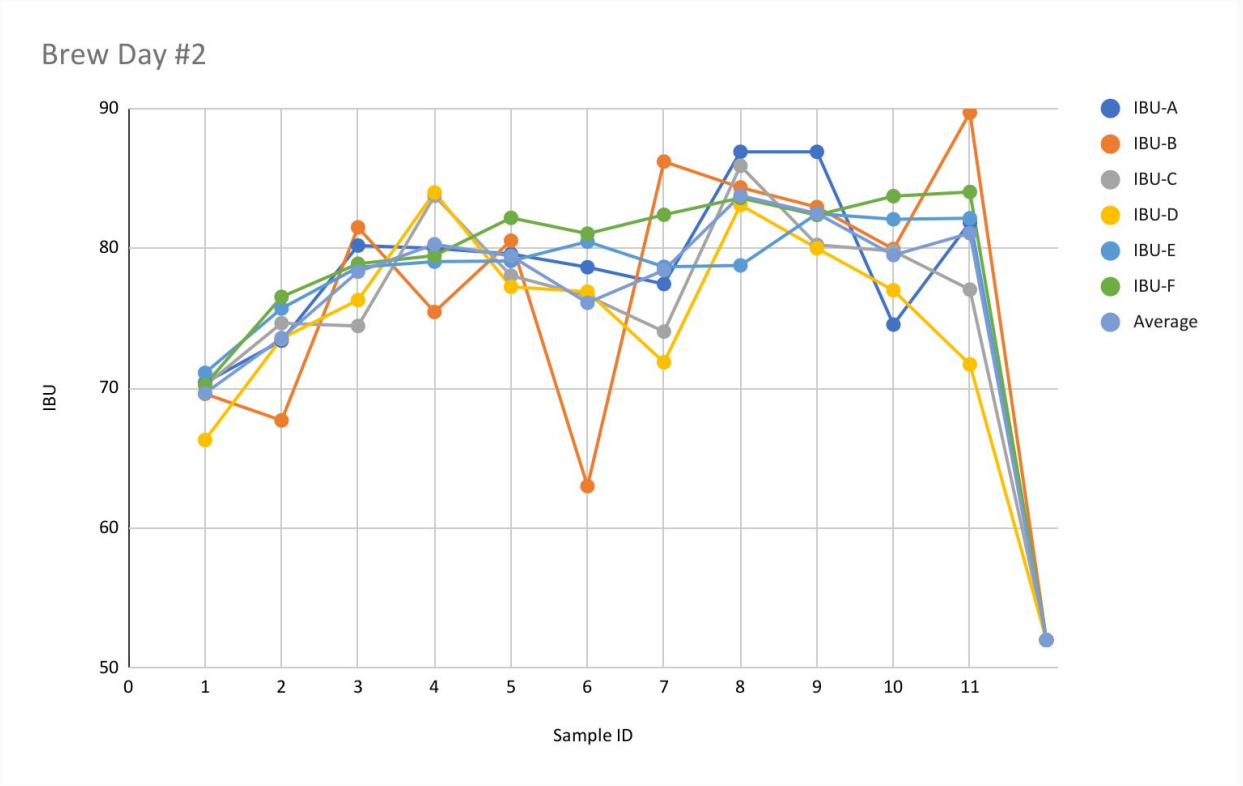
Sample ID	Project Interval (minutes)	WP Temp	Average IBU
1	0	207.1	53
2	5	202.6	55
3	10	198.6	63
4	15	194.8	67
5	20	191.2	71
6	25	187.9	69
7	30	184.7	75
8	35	181.7	74
9	40	179.5	72
10	45/End	176.7	72
11	FV full	68	81



Finished IBUs	42	Total Hops Added	169.7 grams

Brew day #2

Sample ID	Project Interval (minutes)	WP Temp	Average IBU
1	0	204	70
2	5	202.5	74
3	10	198.4	78
4	15	198.4	80
5	20	190.5	79
6	25	187	76
7	30	183.5	78
8	35	180.3	84
9	40	177.5	82
10	45/End	175	80
11	FV full	62.2	81



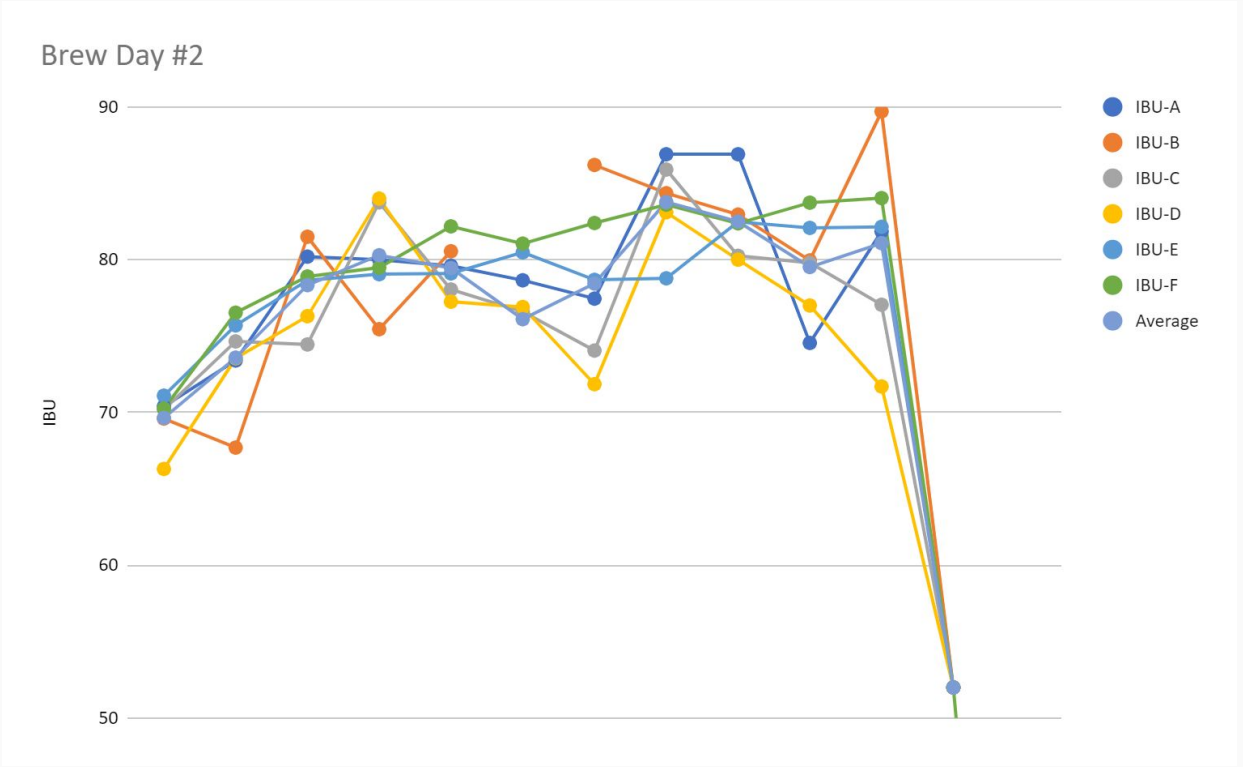
Finished IBUs	52	Total Hops Added	169.7 grams

Outlier Identification

- Arrange data smallest to largest
  - 63 77 77 79 80 81
- Find Q1 - 25% of the total number of data points (6)
  - .25 (6) = 1.5 rounded to 2
  - Second data point is 77
- Find Q3 - 75% of total number of data points
  - .75(6) = 4.5 rounded to 5. 5th data point is 80
- Find the interquartile range IQR Q3-Q1
  - 80-77 = 3
- Find the upper and lower boundary Q3 + 1.5(IQR) and Q1 - 1.5(IQR)
  - 80 + 1.5(3) = 84.5
  - 77 - 1.5(3) = 75.5
- Identify outliers - anything above or below boundaries

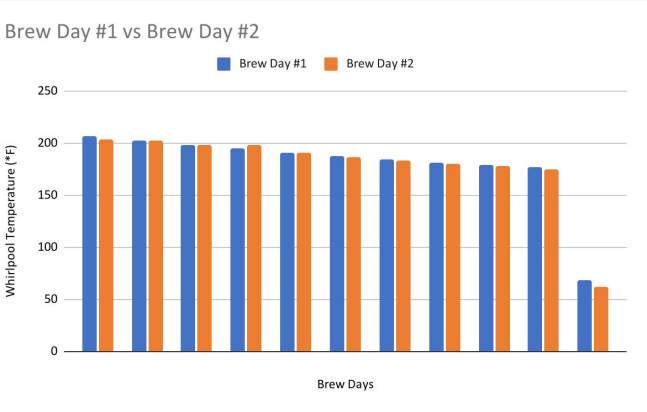
Brew day #2 without Outlier

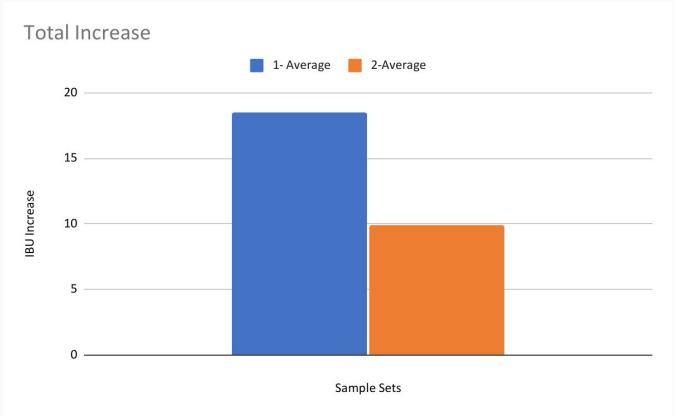
Sample ID	Project Interval	WP Temp	Average IBU
1	0	204	70
2	5	202.5	74
3	10	198.4	78
4	15	198.4	80
5	20	190.5	79
6	25	187	79
7	30	183.5	78
8	35	180.3	84
9	40	177.5	82
10	45/End	175	80
11	FV full	62.2	81

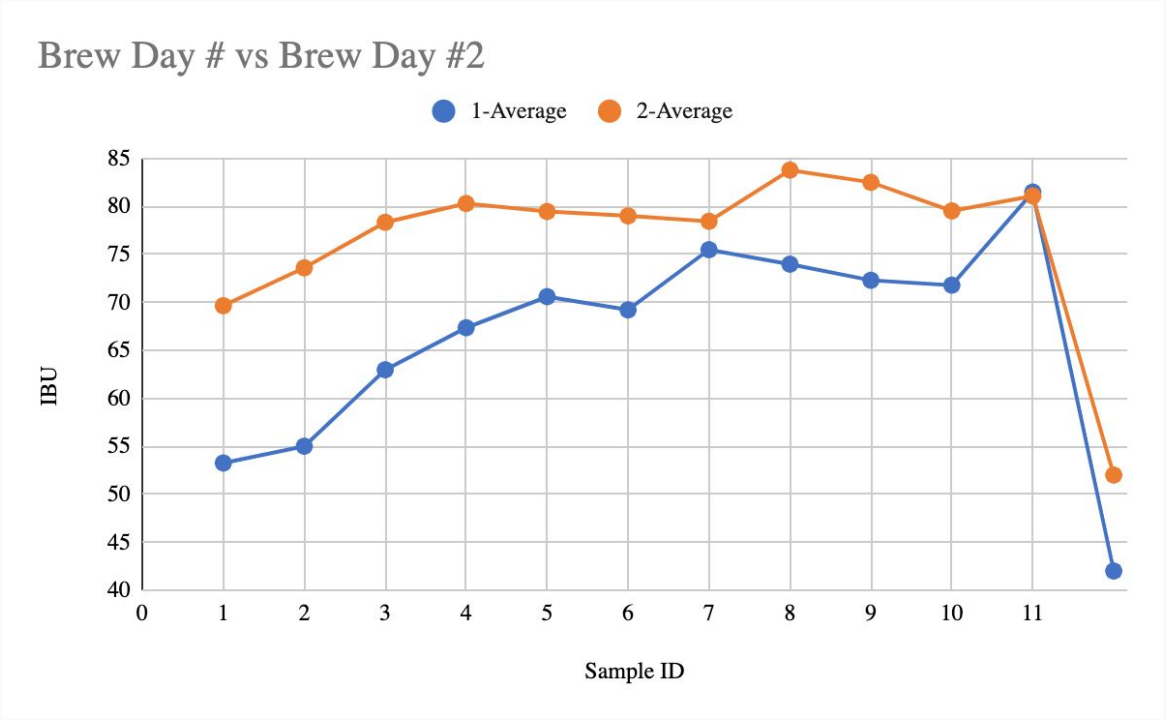


Finished IBUs	52	Total Hops Added	169.7 grams

Comparing Brew Days 1 & 2

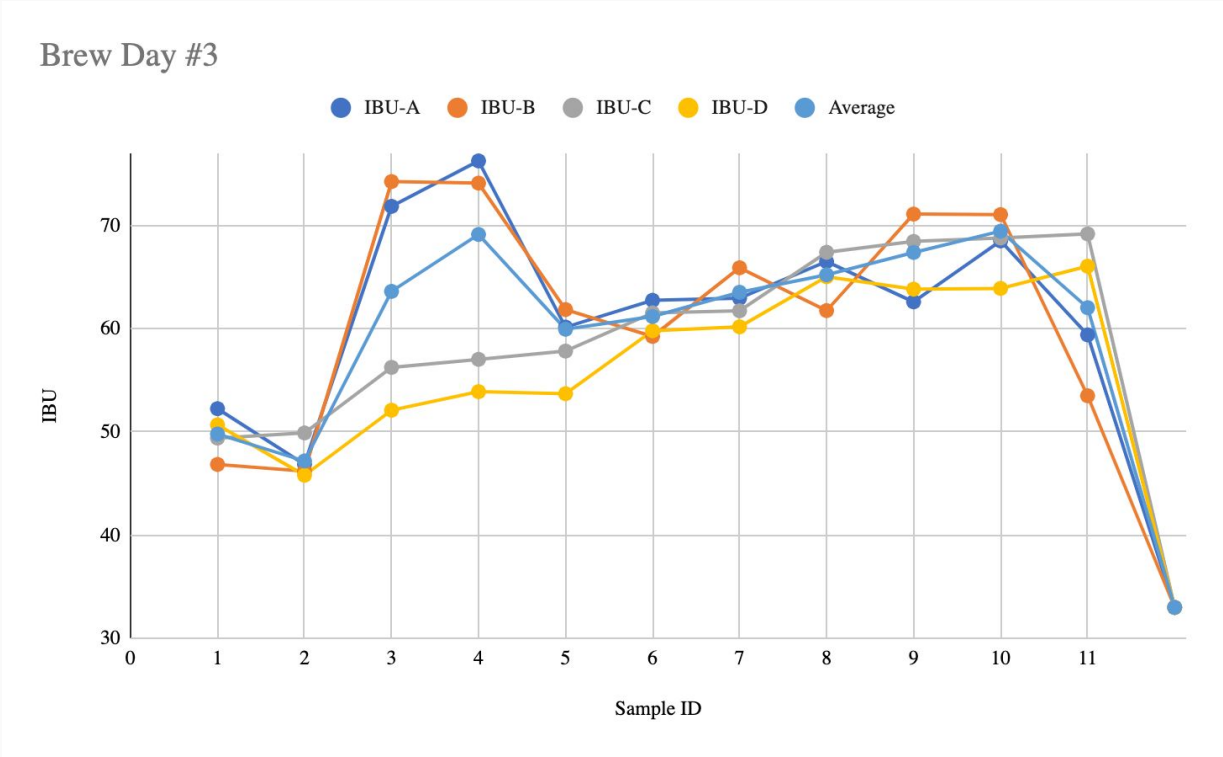






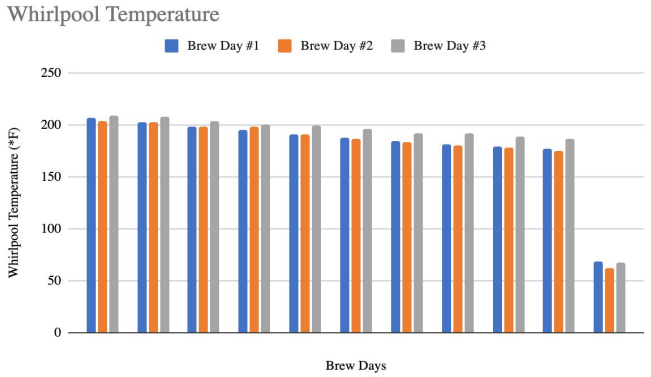
Brew day #3

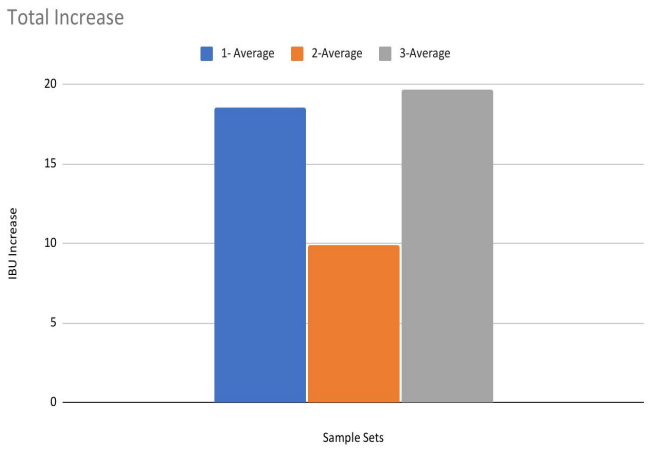
Sample ID	Total WP time	WP Temp	Average IBU
1	0	208.8	50
2	0	207.8	47
3	5	203.8	64
4	10	199.9	69
5	10	199.4	60
6	15	195.8	61
7	20	192.2	64
8	20	191.6	65
9	25	189	67
10	30	186	69
11	-	67	62

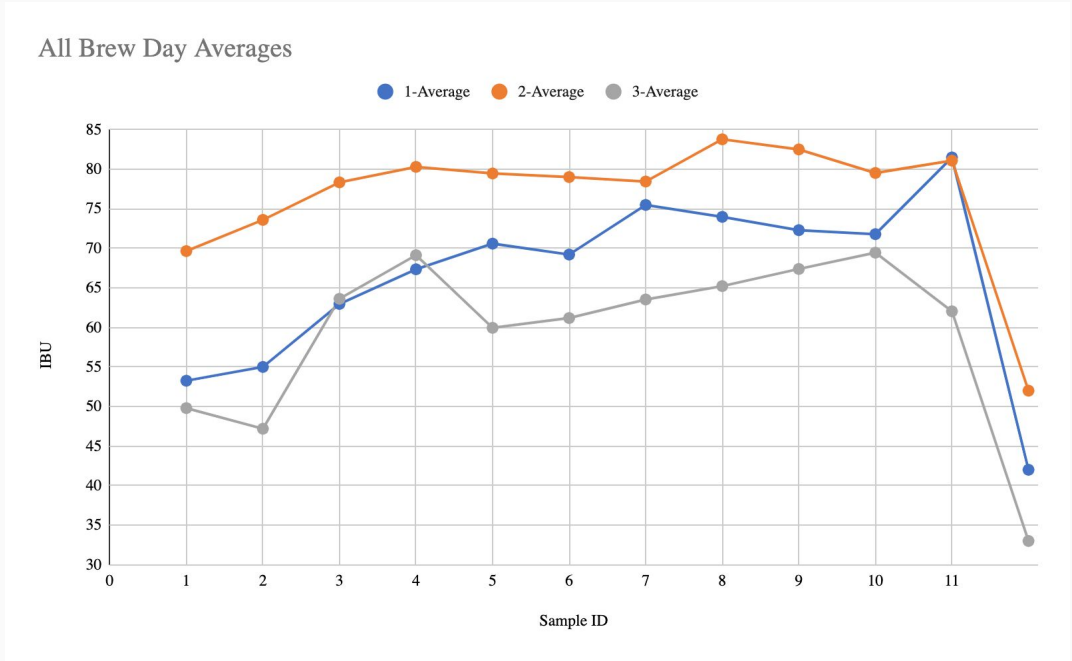


Finished IBUs	33	Total Hops Added	229.7 grams

A Look at All Brew Days

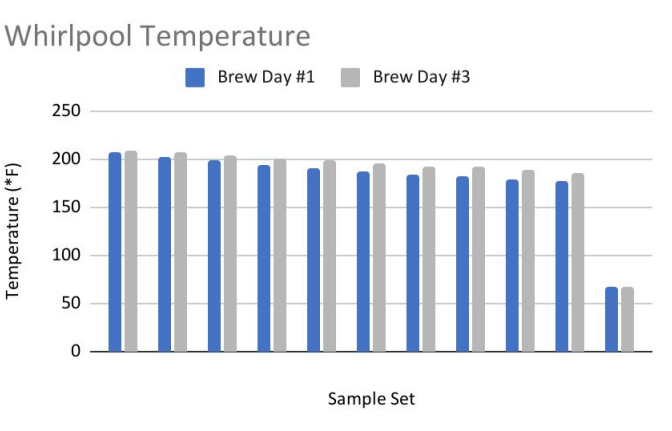


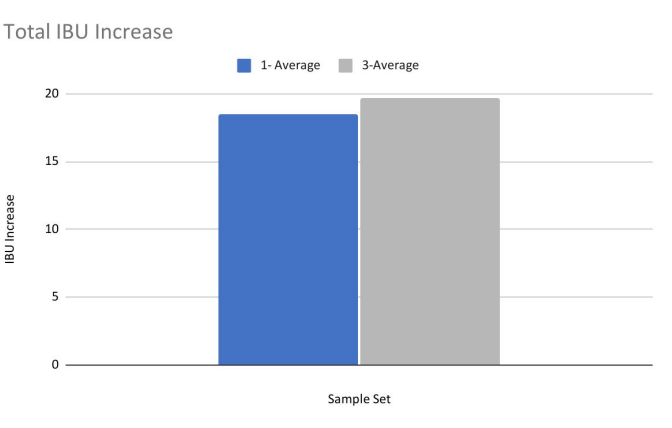


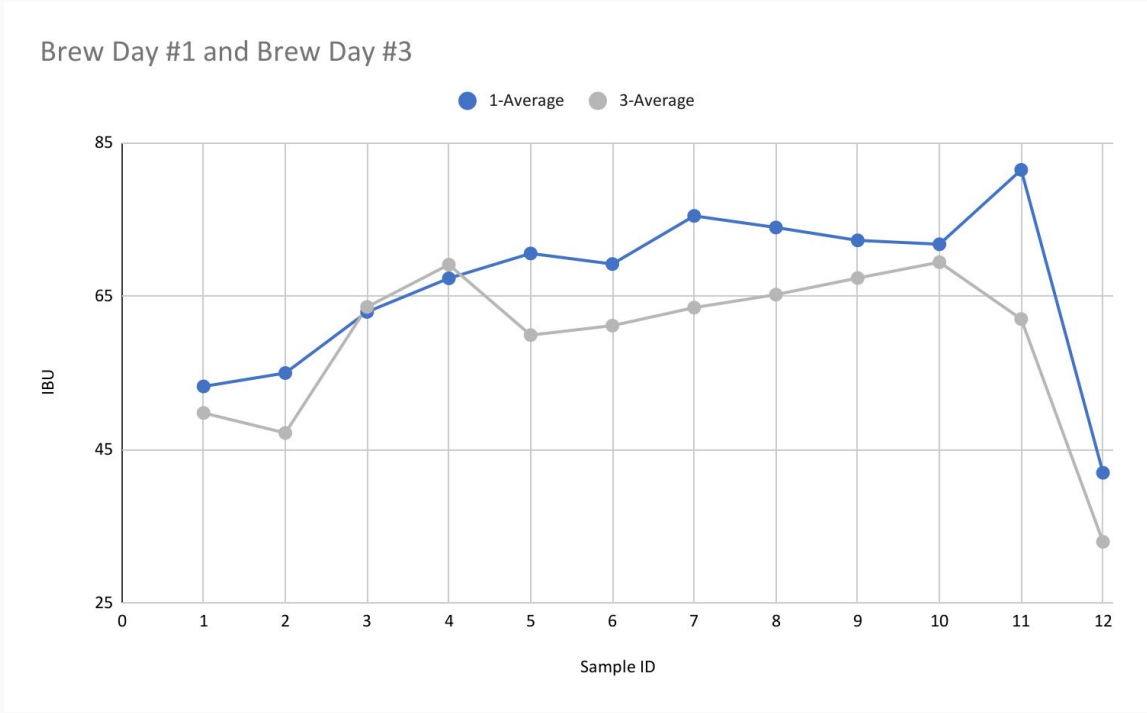


Brew Day #1	Finished IBUs	42	Total Hops Added	169.7 grams
Brew Day #2	Finished IBUs	52	Total Hops Added	169.7 grams
Brew Day #3	Finished IBUs	33	Total Hops Added	229.7 grams

Brew Days #1 and #3





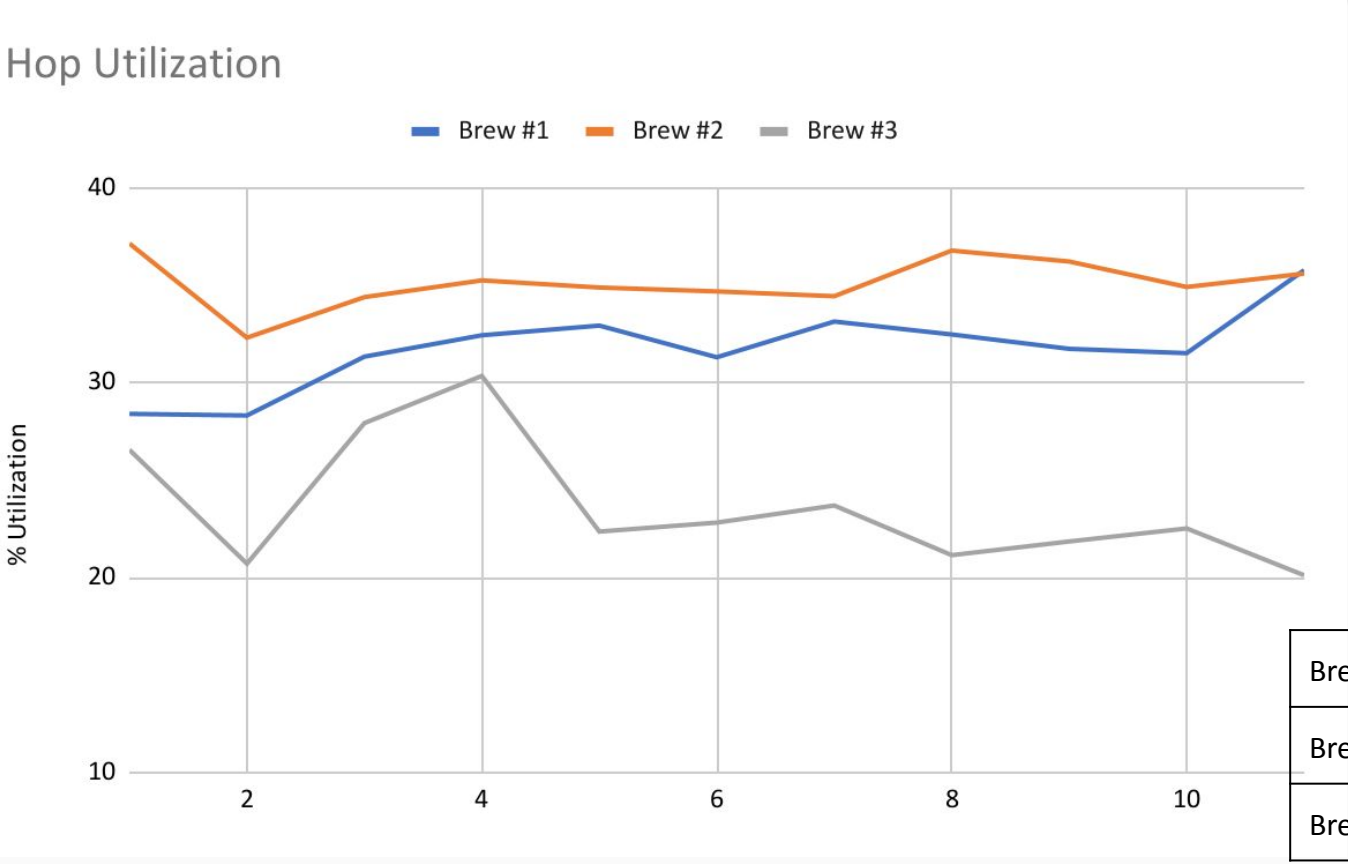


Hop Utilization calculation

$$IBU_{max}\ (mg/L) = \frac{(W)(AA)}{V} \qquad \frac{(139.7g)(.1575)}{1bbl} \times \frac{1bbl}{117.34L} \times \frac{1000mg}{g} = 187.5mg/L$$

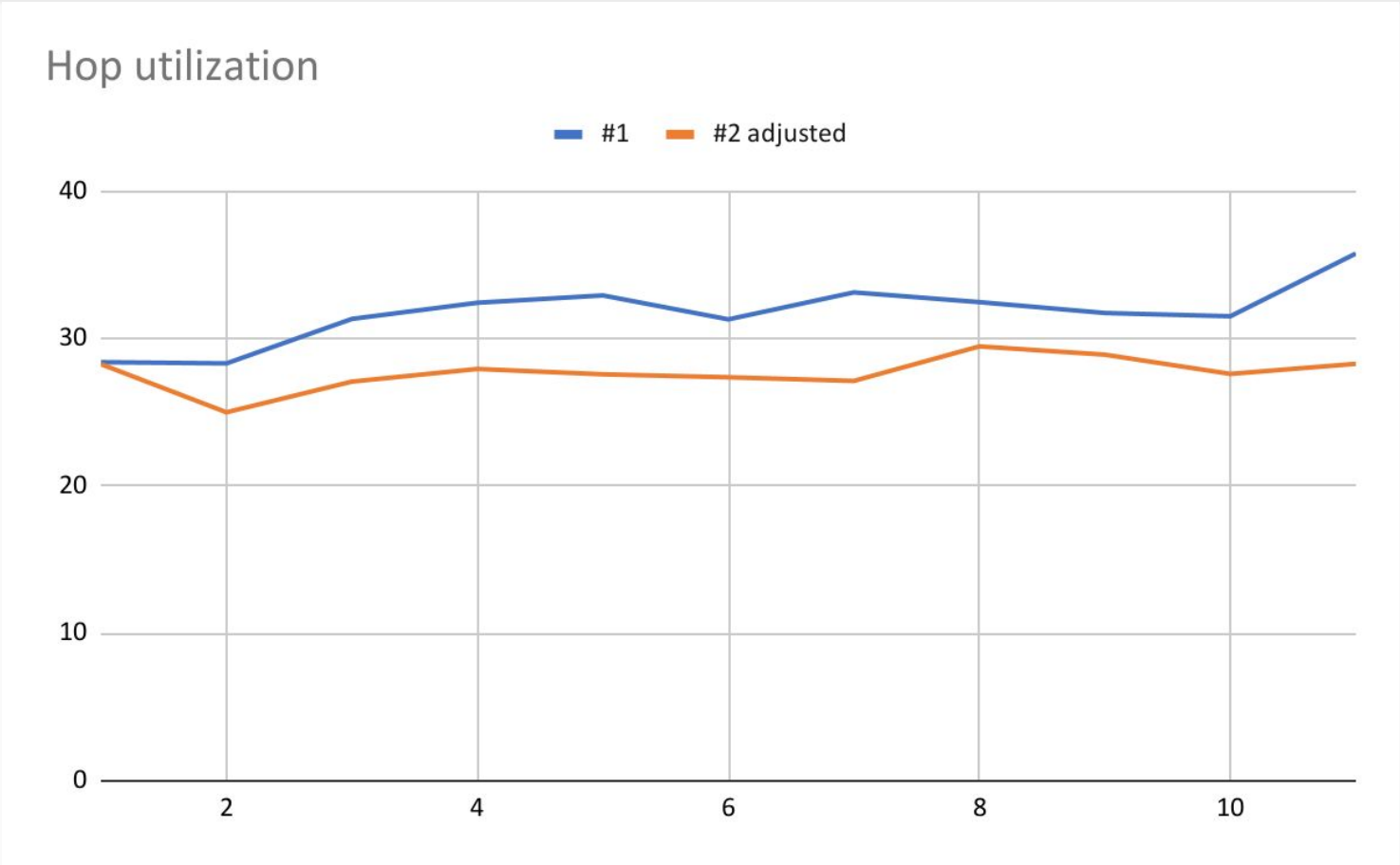
$$\text{Utilization} = \frac{IBU}{IBU_{max}} \qquad \frac{53}{187.5} = 28.35\%$$

Hop Utilization all Brew Days



Brew Day #1	Utilization %	18
Brew Day #2	Utilization %	23
Brew Day #3	Utilization %	11

Brew #1 vs #2 adjusted



Questions we still have

- Why did batch two start with higher IBUs?
- Why did batch 3 have the lowest final IBUs when we used the most hops?
- Would a different hop have similar results?
- What caused the jumps and dips in IBUs? What in our testing/results is significant and what is due to natural variation in testing?
- Why was there the biggest IBU increase in the 1st experiment?
- What parameters were out of our control?
- What could we test next to keep learning from the experiment?
- What else affects IBU utilization?
- How does this correlate to sensory experience?

Designing experiments in your brewery

References

- Wort IBU utilization chart, Scott Shirley
- ASBC Estimated IAA calculator
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- The Effect of pH on Utilization and IBUs https://alchemyoverlord.wordpress.com/2018/09/08/the-effect-of-ph-on-utilization-and-ibus/

Thank You!

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