CRAFT BREWERS CONFERENCE & BrewExpo America

Hidden Secrets of The New England IPA a.k.a. Hazy IPA, Juicy IPA

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Outline of Presentation

How to Brew a New England IPA

12 Commercial NEIPA Were Analyzed by High Performance Liquid Chromatography (HPLC) for various hop compounds and were compared to West Coast style IPAs.

Haze Testing:
Turbidity, Yeast Count, Hop Acid contribution to haze, Centrifuge testing, GC Headspace Analysis, Haze Analysis, Haze Stability

Other Testing: IBU & Foam

Conclusion

How to Brew a New England IPA

Brewing Ingredients

Water: 150 – 200 ppm Chloride (mouthfeel/softness)
75 – 100 ppm Sulfate (hop character)

Grist: 10 – 50% high protein adjuncts like:
flaked oats (16% protein of which 10% is prolamins)
flaked wheat (13% protein of which 80% is prolamins)
prolamins are proline rich haze active proteins
2-Row Pale Malt

Hops: Fruit Forward & Citrus Varieties, Dry Hop > 3 lbs/bbl
High in geraniol? (Bravo, Brewers Gold, Cascade, Centennial, Chinook, Galaxy, etc.)

Yeast: medium to low attenuating yeast, med-low flocculating,
high ester strains like London Ale III, Dry English Ale, Conan, S-33.

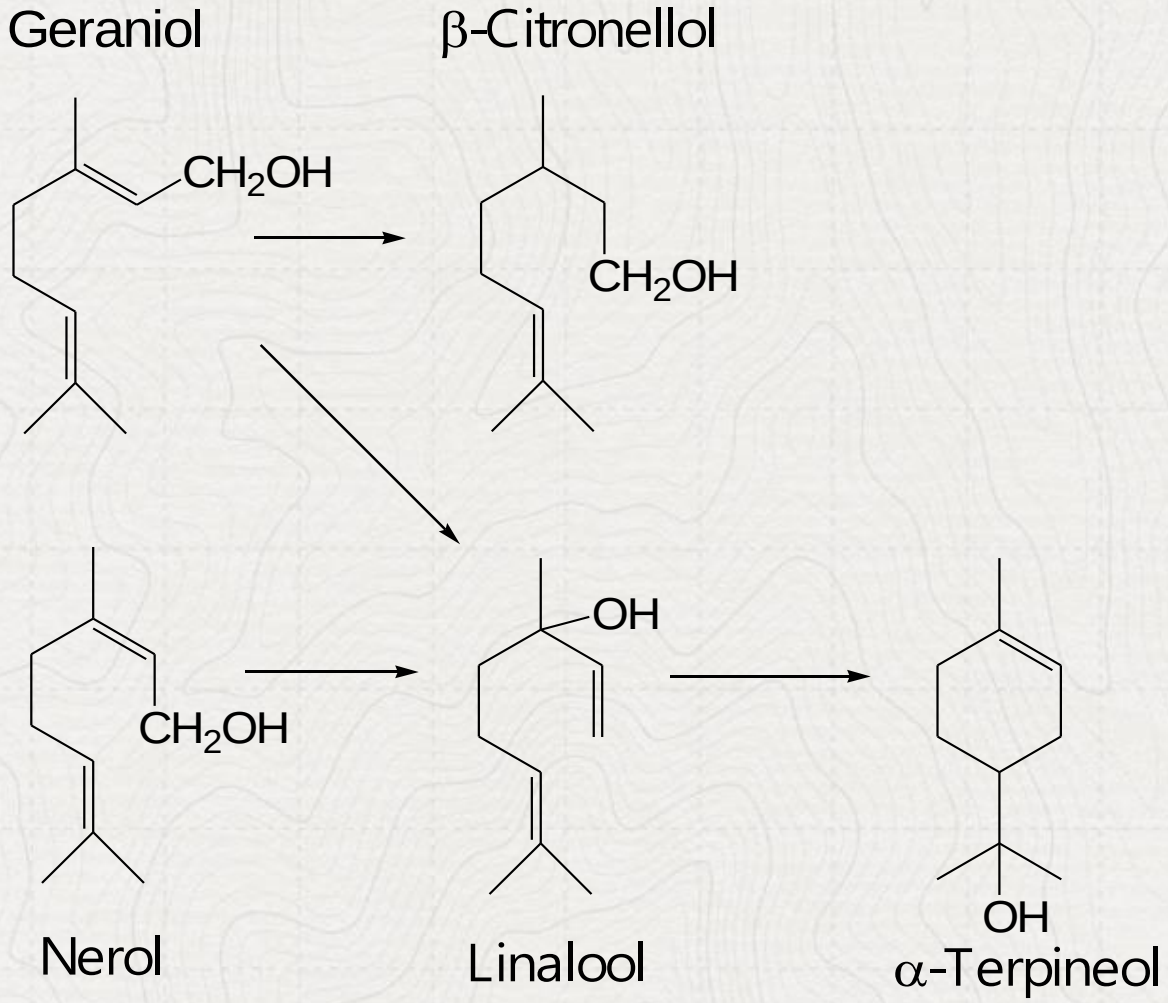
How to Brew a New England IPA

Hopping Regime

Little to no hops added to the kettle
30 – 50% added to whirlpool, multiple additions, at reduced whirlpool temp of <180ºF

Dry Hop during primary fermentation
Multiple hop additions starting
24- 48 hour after the yeast is pitched

Yeast biotransformation of oxygenated hop oils



Tokoi, K.; Itoga, Y.; Takayanagi, J.; Kosugi, T.; 2014 Screening of Geranoil-rich flavor hop and interesting behavior of B-citronellol during fermentations under various hop-addition timings J. Am. Soc. Brew. Chem. 72(1) 22-29.

New England IPA Beer Specification*

Beer

OG: ~ 1.06 – 1.07 (14 – 17 ^{o}P) FG: ~ 1.010 – 1.016 (2 – 4 ^{o}P)

IBU: 50 – 70 (we measured 41 – 108)

ABV: 6.3% – 7.5%

Color: 4-7 SRM (8-14 EBC)

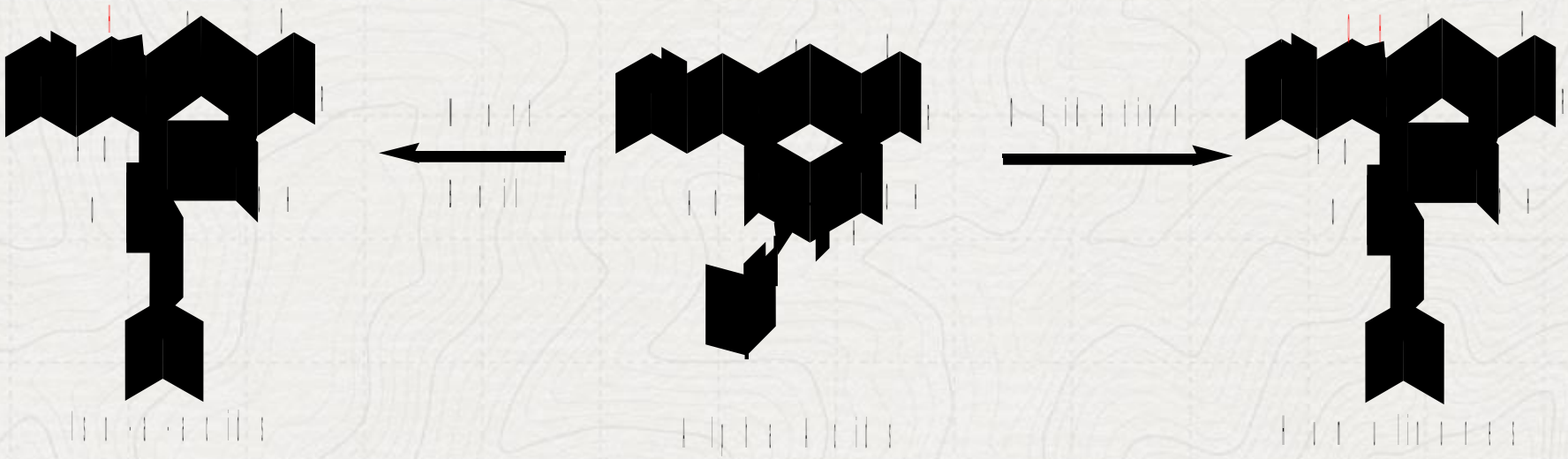
*Brewers Association

*

Beer Analysis – Hop Compounds Tested by HPLC

Bitter Compounds: Isoalpha Acids, Humulinone, and Alpha Acids

Non-bitter Compounds: Beta Acids, Myrcene (hop oil) & Xanthohumol (polyphenol)



1 ppm ~ 1 IBU

1 ppm ~ 0.1 IBU

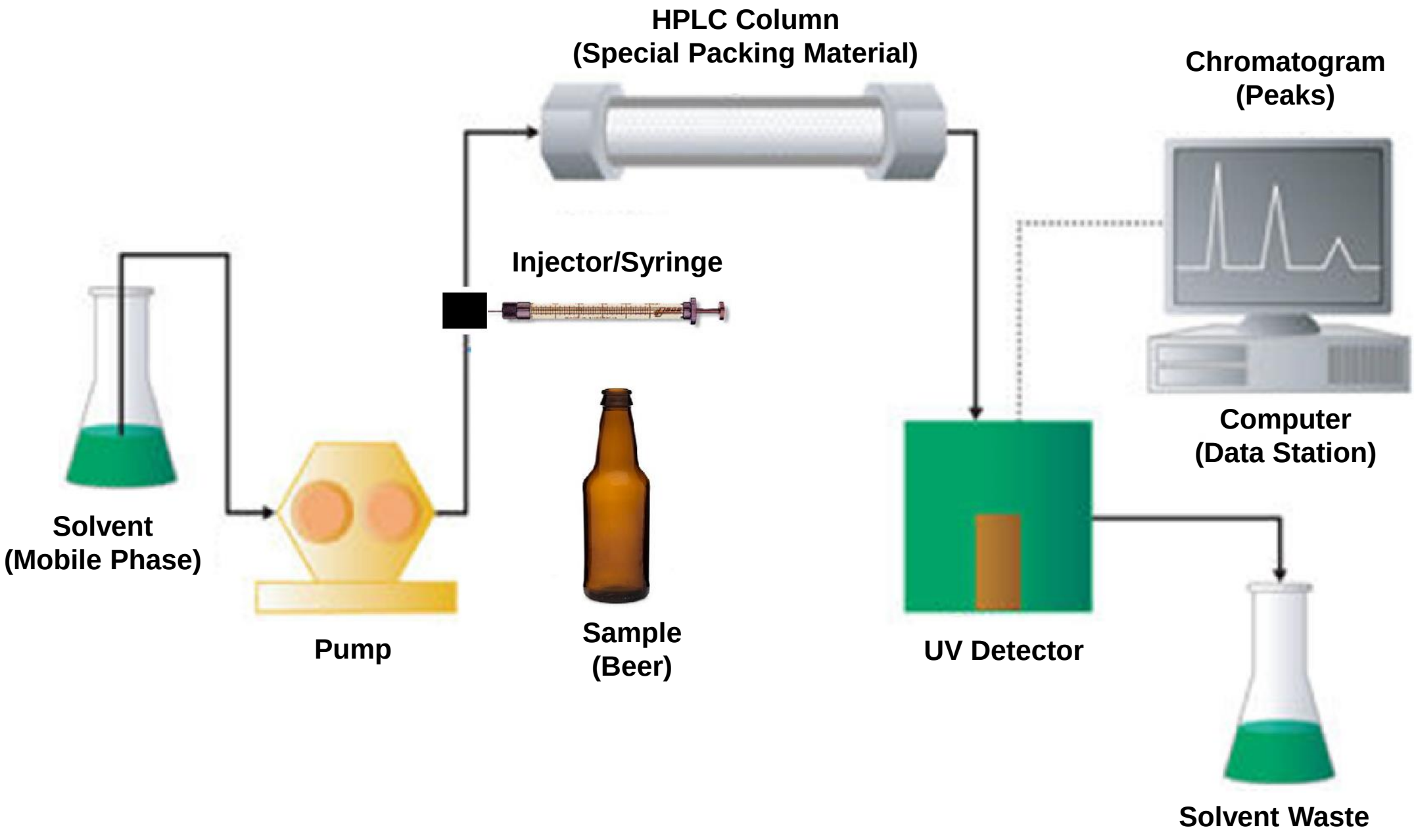
1 ppm ~ 0.66 IBU

(0.25% - 0.35% in hops)

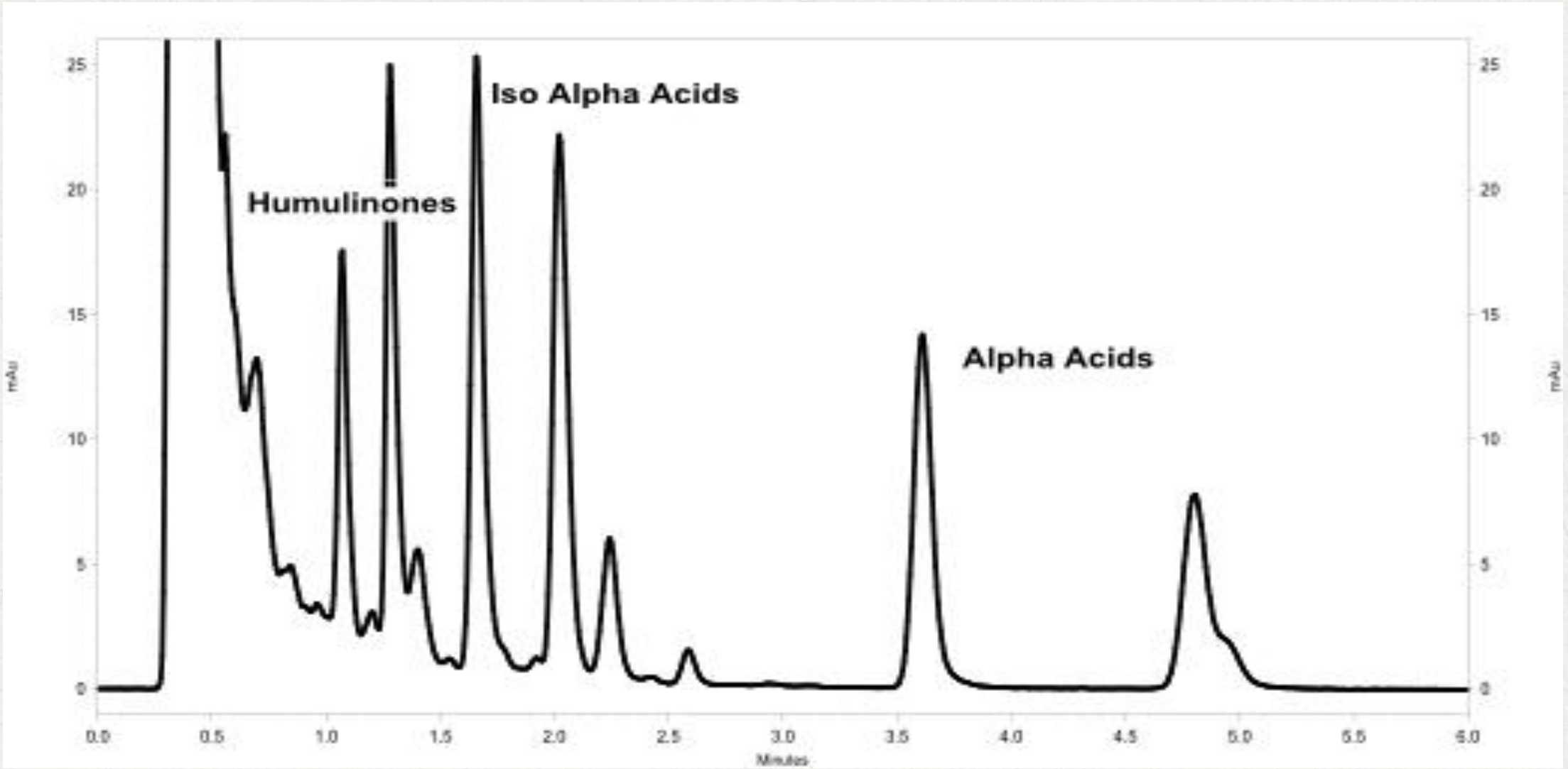
High Performance Liquid Chromatography (HPLC)

A mixture of hop compounds in beer can be separated and measured very accurately using High Performance Liquid Chromatography

HPLC Works by Separating, Identifying, & Quantifying



HPLC Chromatogram of Hop Acids In Beer

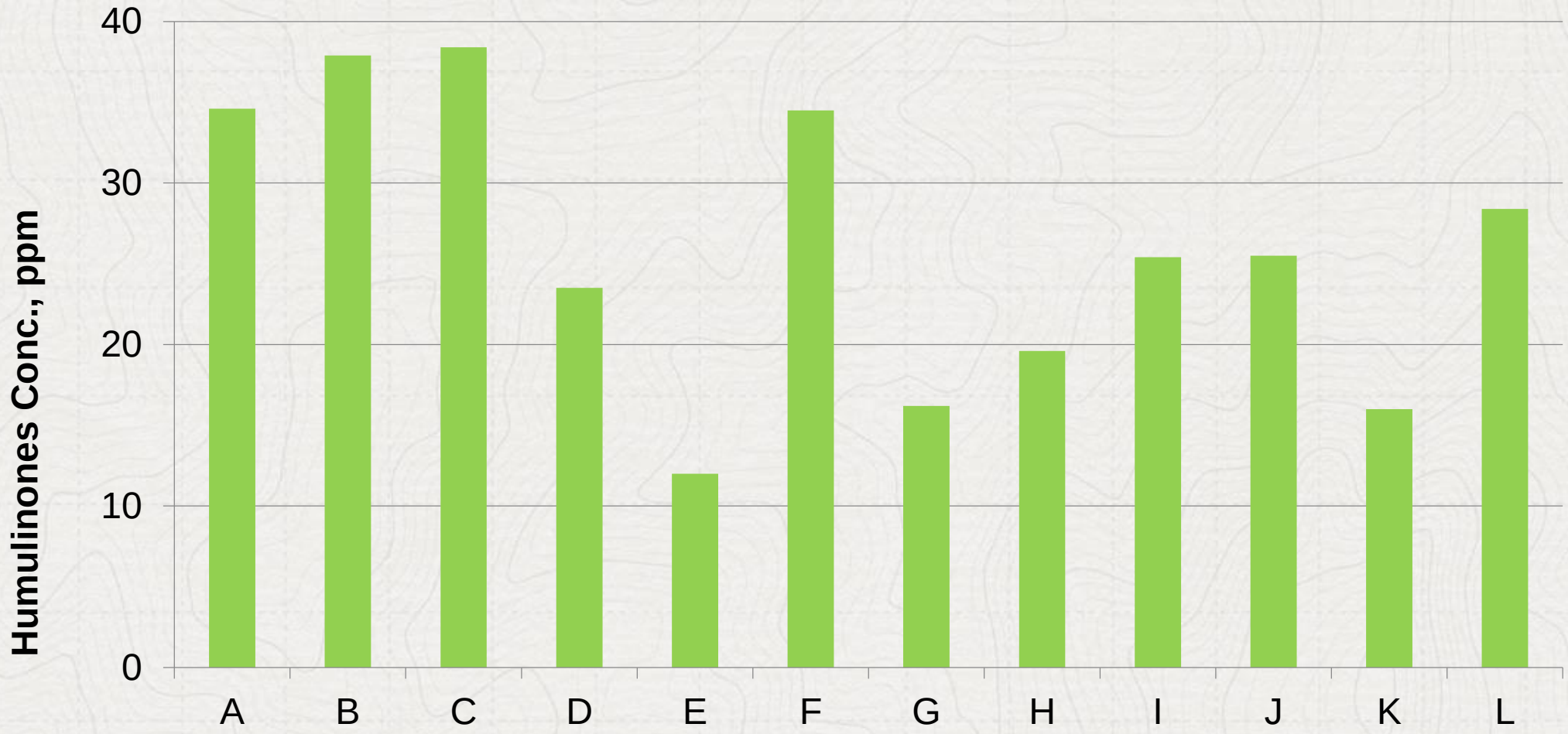


Isoalpha Acid Concentration of New England IPAs

Range: 5 ppm – 32 ppm Average: 20 ppm (vs 48 ppm West Coast IPA)

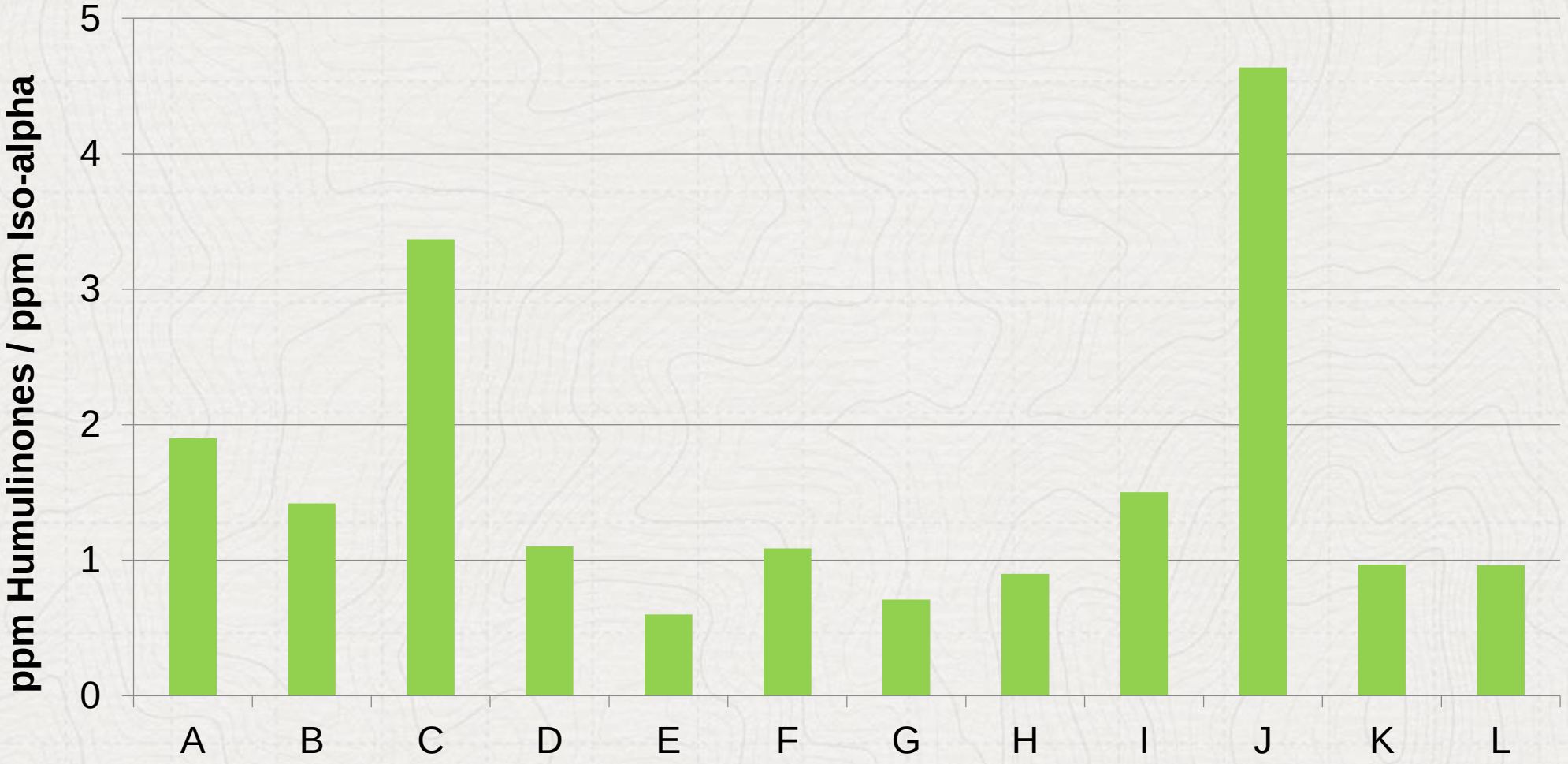
Humulinones Concentration in New England IPAs

Range: 12 ppm – 38 ppm Average: 26 ppm (vs 11 ppm West Coast IPA)



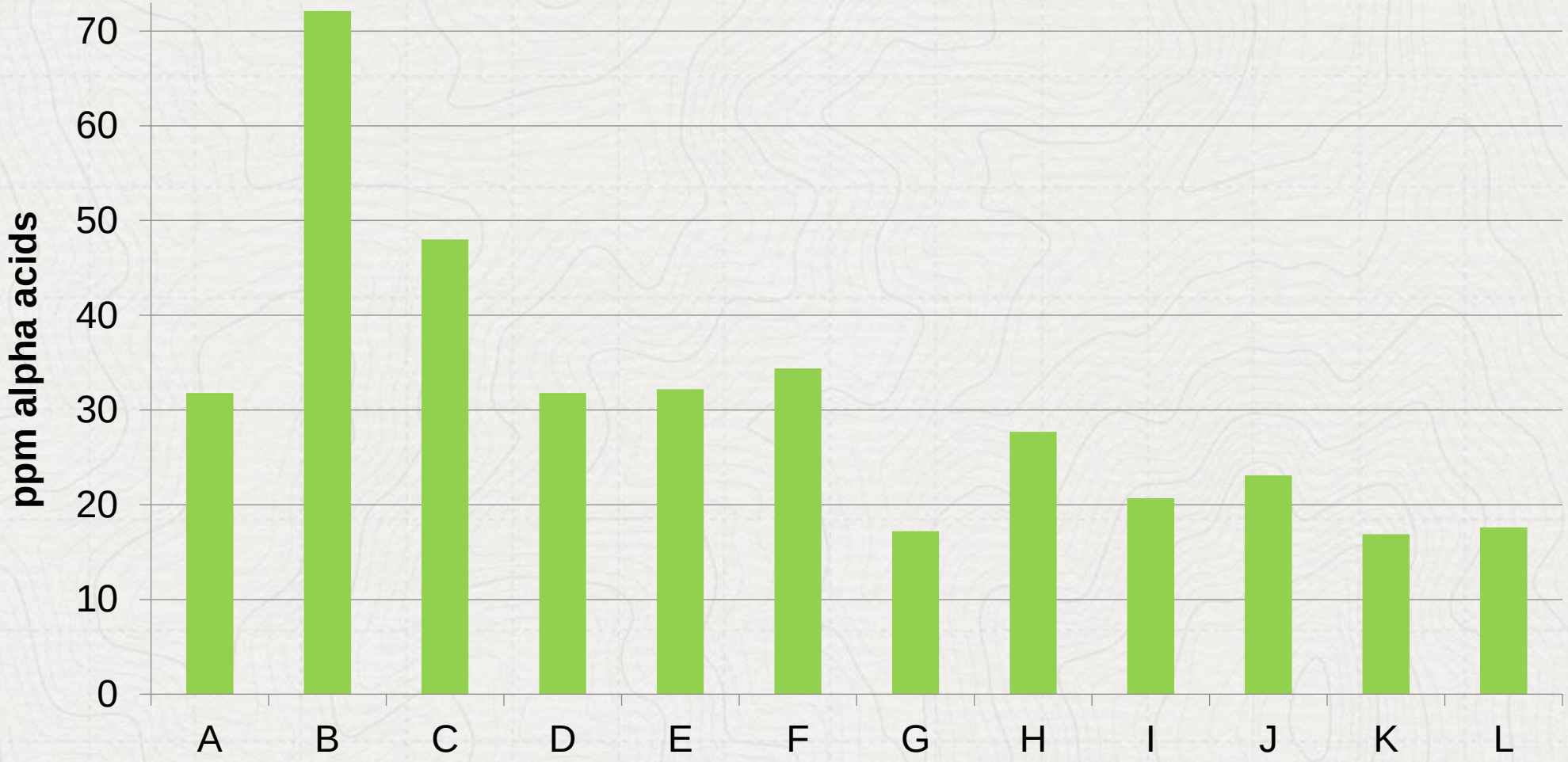
Ratio of Humulinone : Isoalpha Acid vs Bitterness

Range: 0.5 – 4.6 Average: 1.3 (vs 0.3 West Coast IPA)
Humulinone contribute ~ 50% of the NEIPA's bitterness



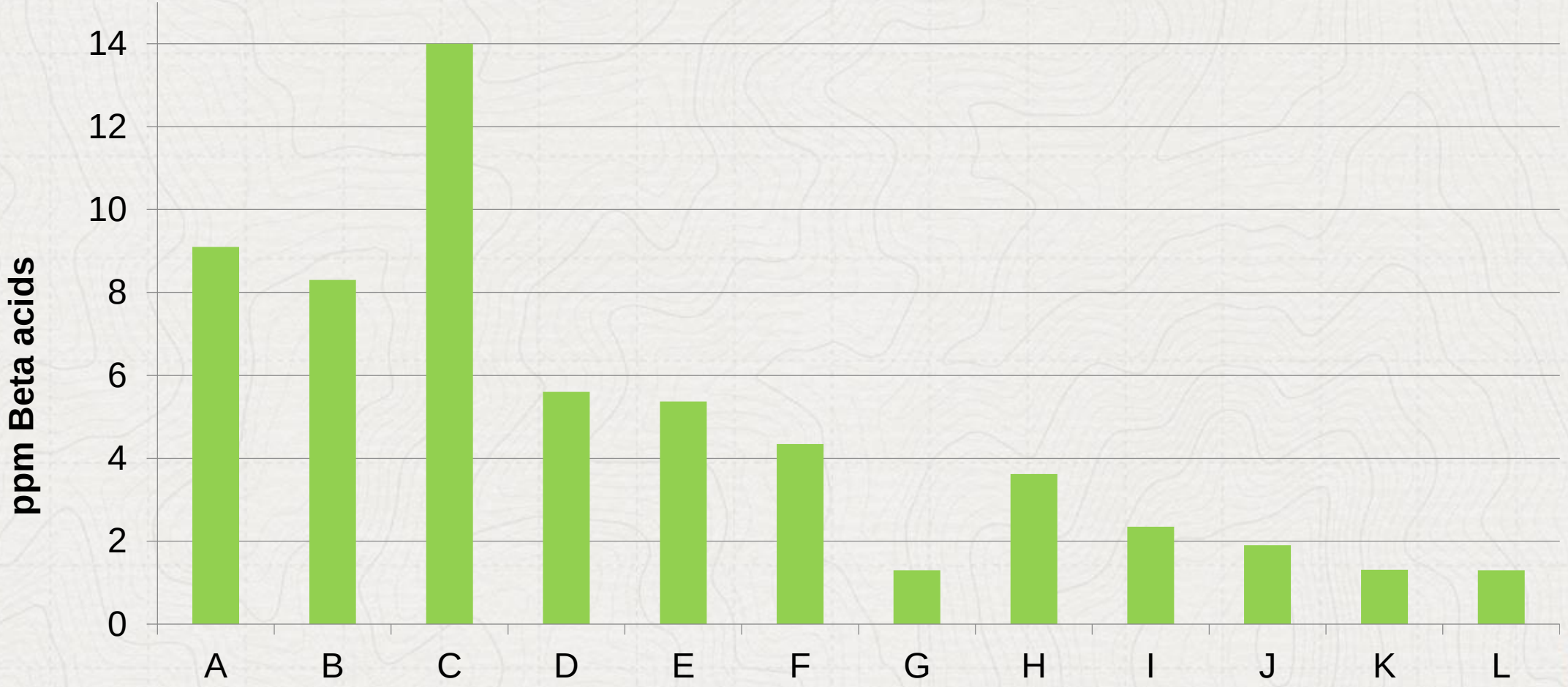
Alpha Acid Concentration in NEIPAs

Range: 17 ppm – 72 ppm Average: 31 ppm (vs 13 ppm for West Coast IPA)



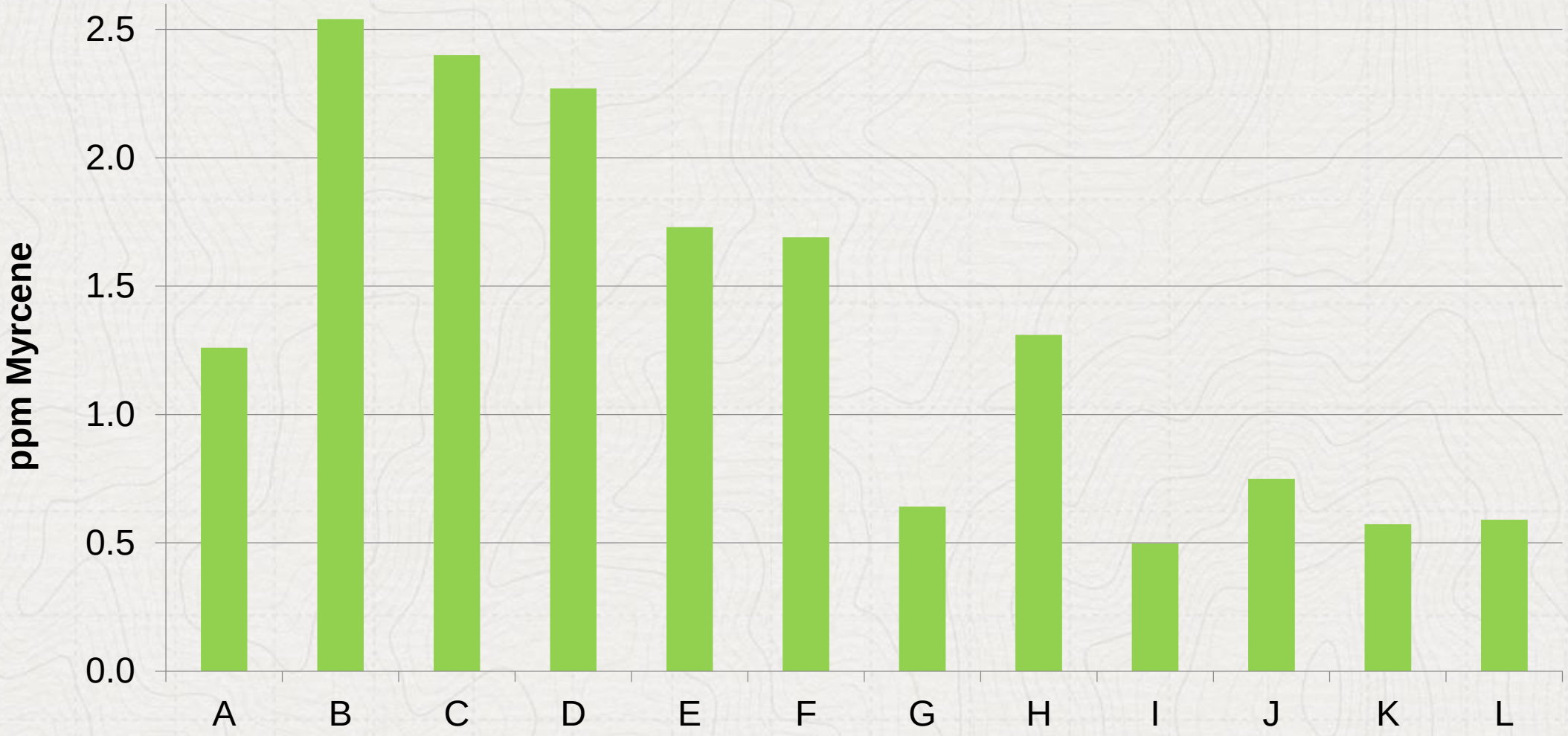
Beta Acid Concentration in New England IPAs

Range: 1 ppm – 14 ppm Average: 5 ppm (vs 0 ppm West Coast IPA)



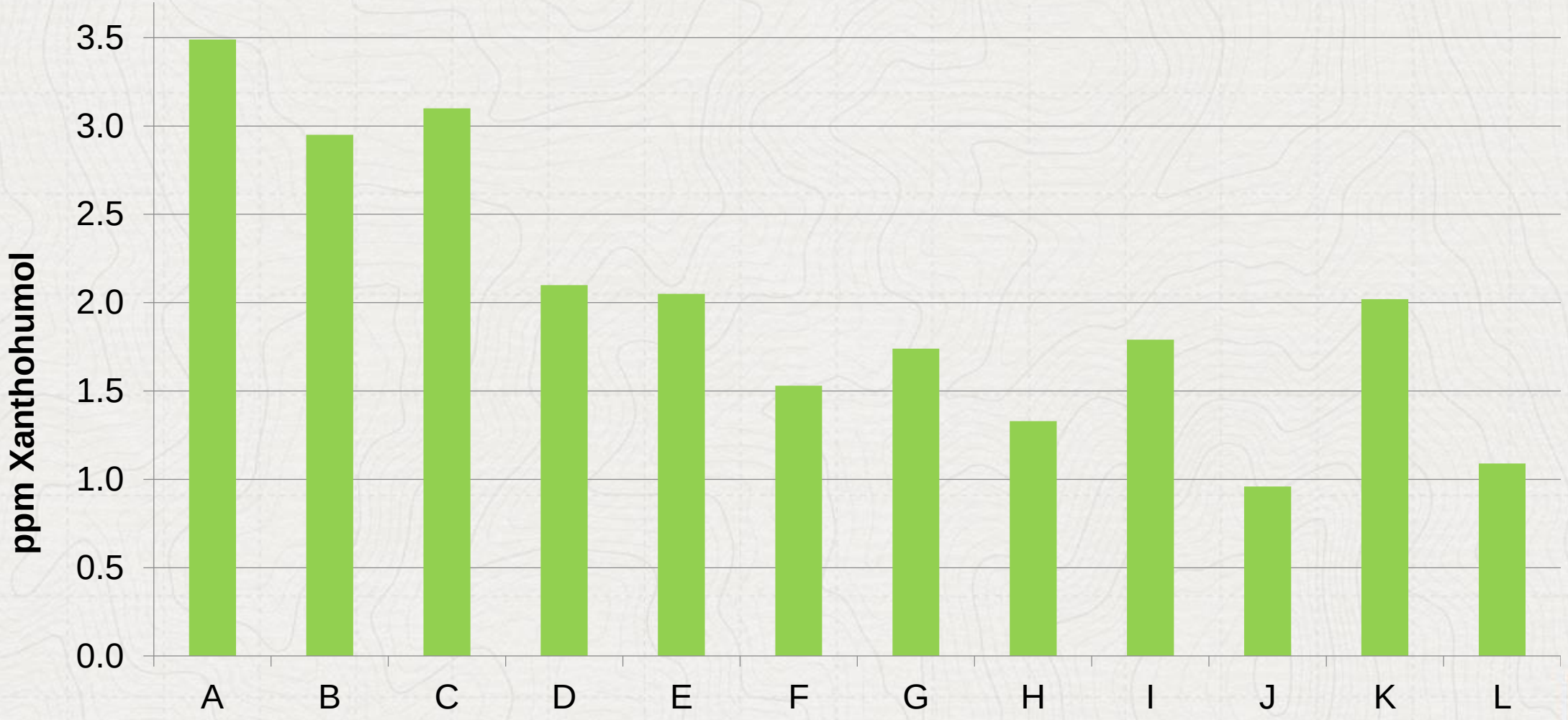
Myrcene Concentration in New England IPAs

Range: 0.5 ppm – 2.5 ppm Average: 1.4 ppm (vs <0.3 ppm West Coast IPA)



Xanthohumol Concentration in New England IPAs

Range 0.9 ppm – 3.5 ppm Ave: 2 ppm (vs 0.7 ppm in West Coast IPA)



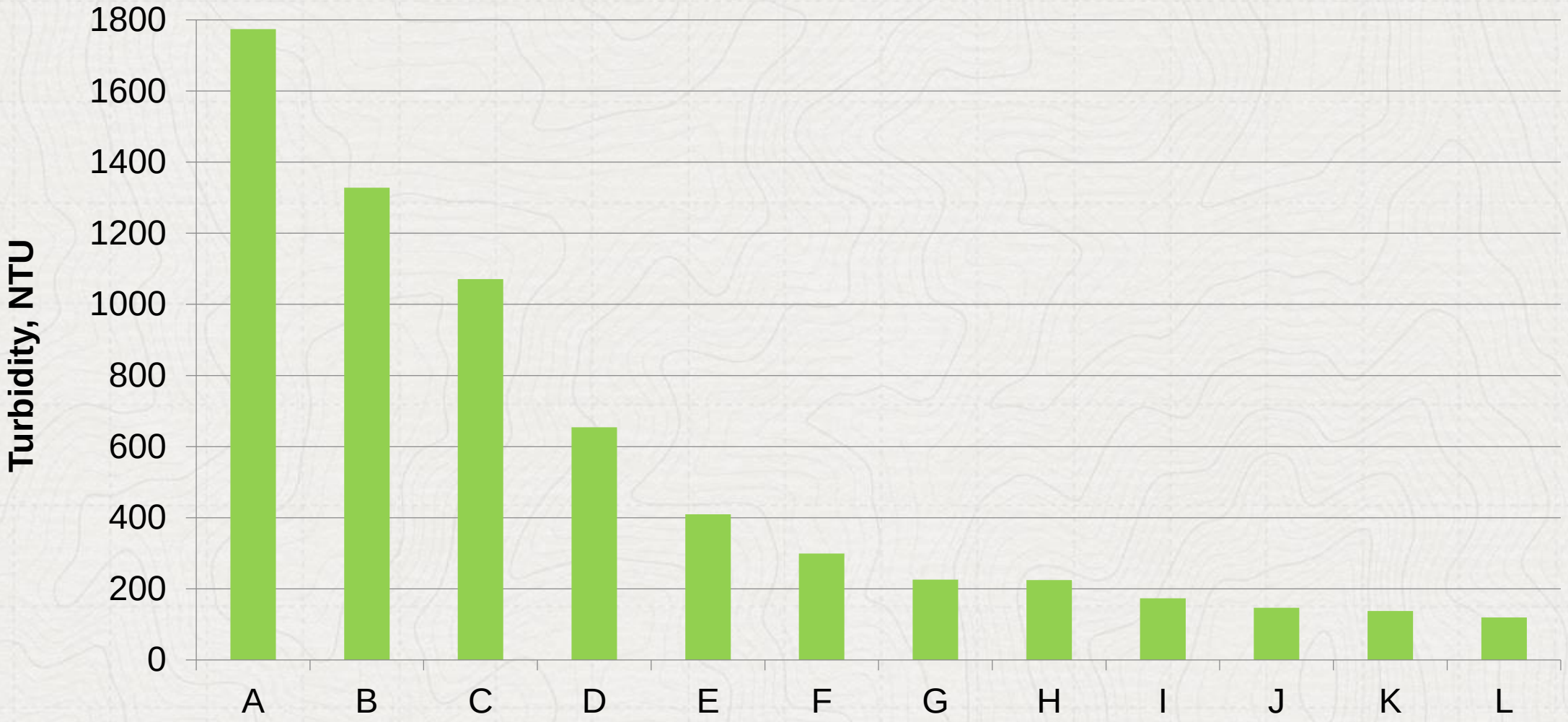
Haze Testing

Haze can be measured using a turbidity meter

5 NTU 50 NTU 500 NTU

Turbidity Measurements

Range: 119 – 1770 NTU Average: 547 (West Coast IPA less than 30)



Yeast is Generally NOT a Contributor to Haze

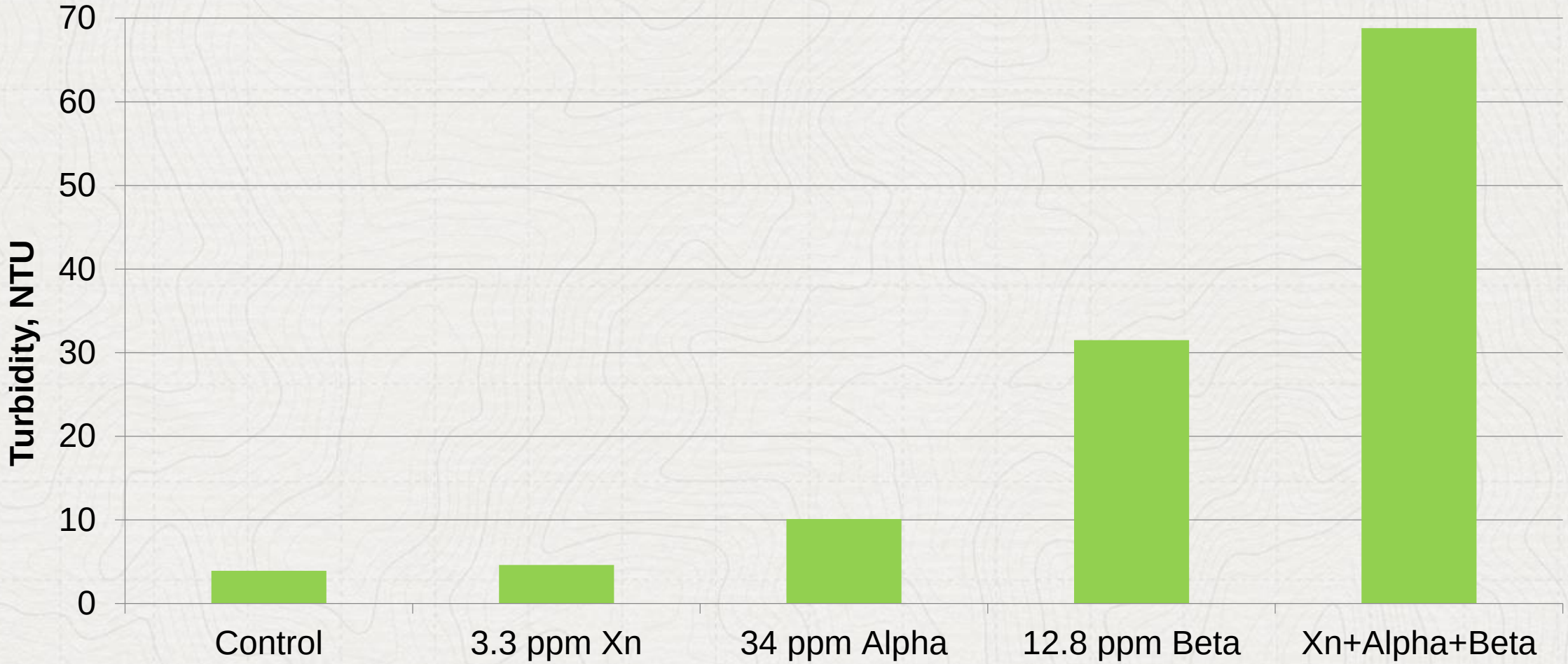
A yeast count of 1 million cells/mL contributes 8.5 NTU of Haze

Yeast Counts of New England IPA Beers

Beer	Initial turbidity, NTU	Yeast Count Million cells / mL	Contribution of Yeast to Turbidity
B	1328	<1	<1%
E	410	0.1-0.2	<1%
F	299	0.2	<1%
H	224	<1	<4%
J	147	5	29%
L	119	0.2	<2%

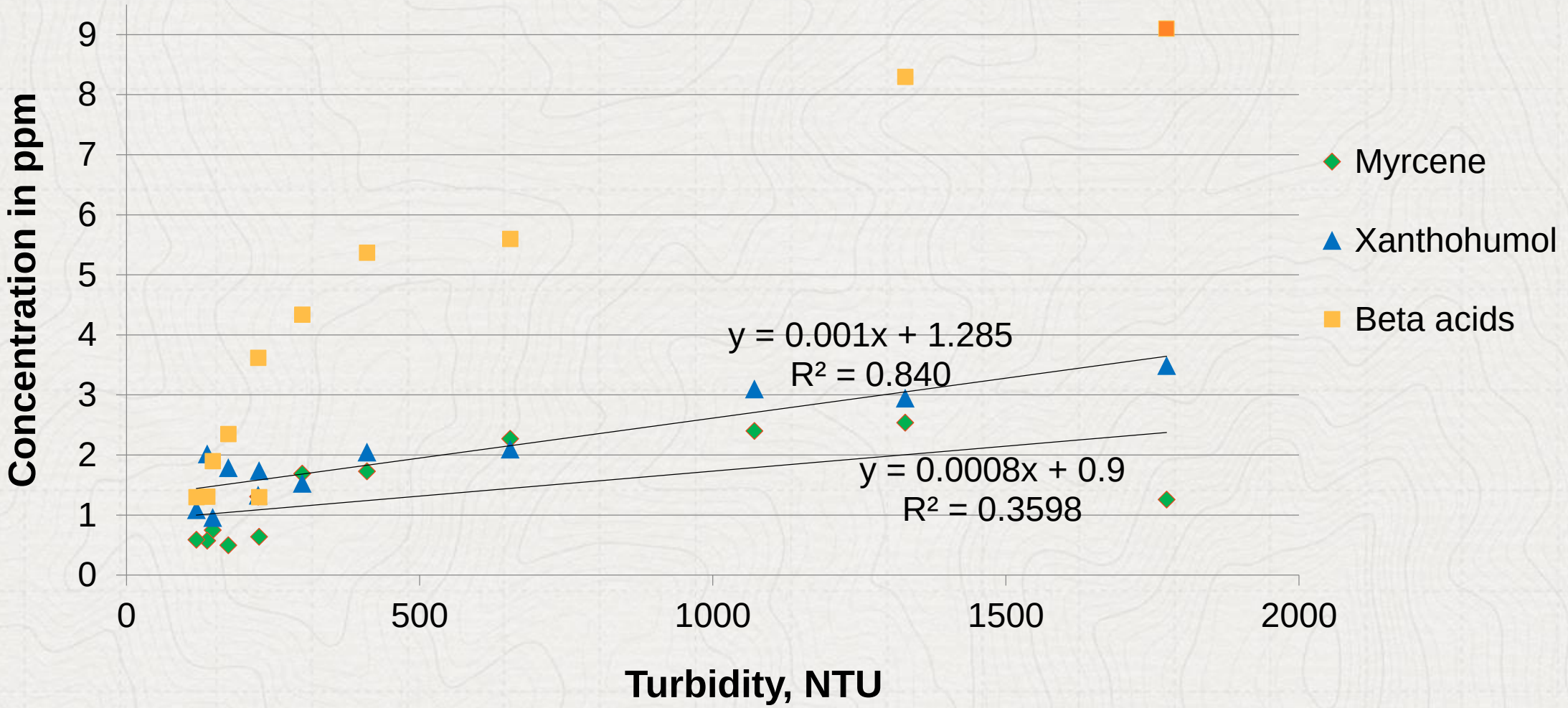
Effect of Hop Compounds on Haze

With an average turbidity 547 NTU, hop acids contributed ~ 10% of turbidity



Relationship Between Turbidity & Hop Compound Concentration

NEIPAs with higher turbidity had higher concentrations of the non-polar hop compounds



The Haze Acts Like A Carrier for Non-polar Hop Compounds

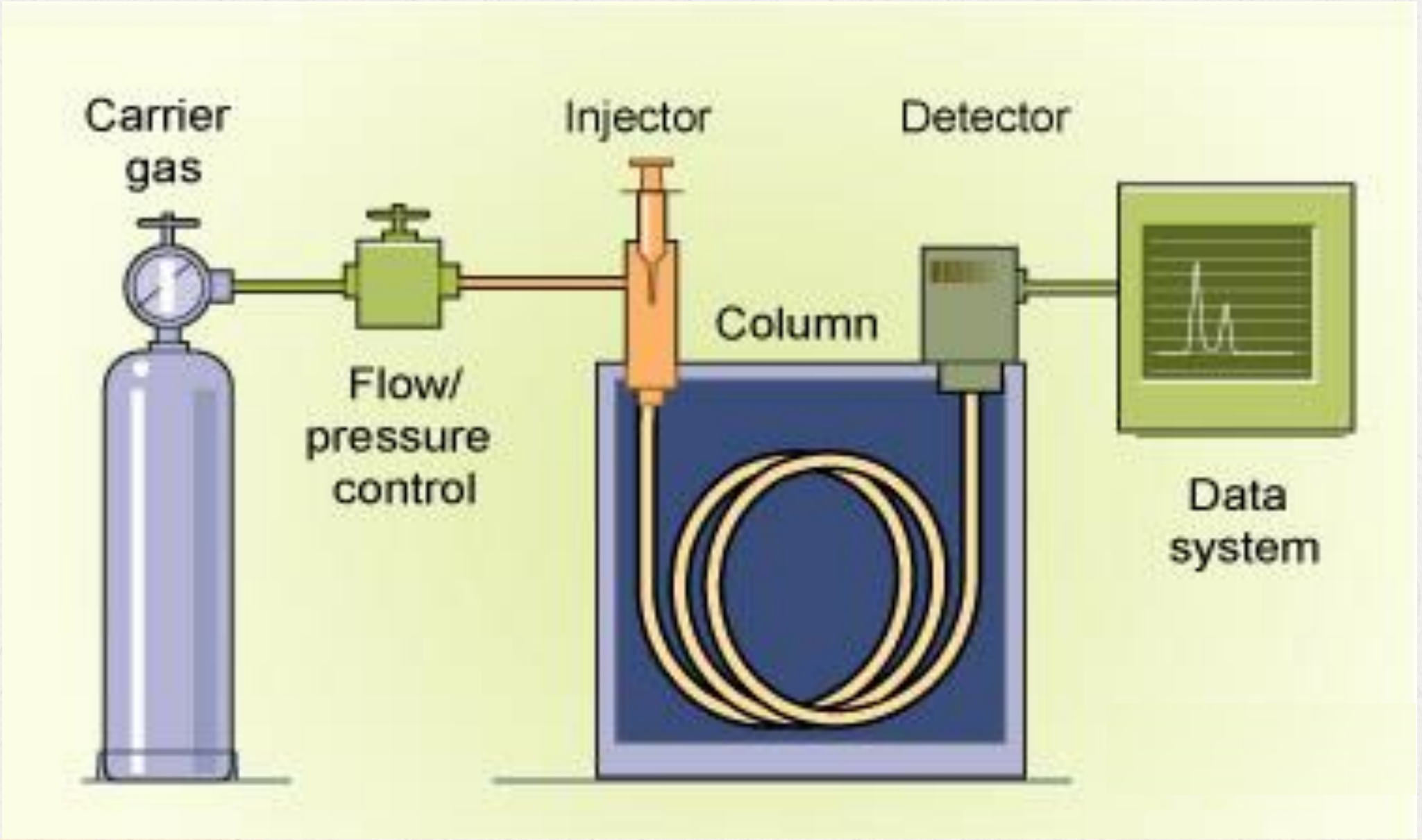
HPLC Analysis of NEIPA Before & After Centrifuge

Beer	NTU Turbidity	ppm Humulinone	ppm iso-alpha acids	ppm alpha acids	ppm myrcene	ppm Xantho-humol	ppm Beta acids
1 H	1071	38	11.4	48	2.4	3.1	14
1 C	295	37.9	10.7	26.2	1.1	1.5	2
2 H	1774	34.6	18.2	51.8	1.3	3.5	9.1
2 C	889	33.8	17.5	35.1	0.8	2.1	4.3

H = Hazy Beer; C = Centrifuged Beer

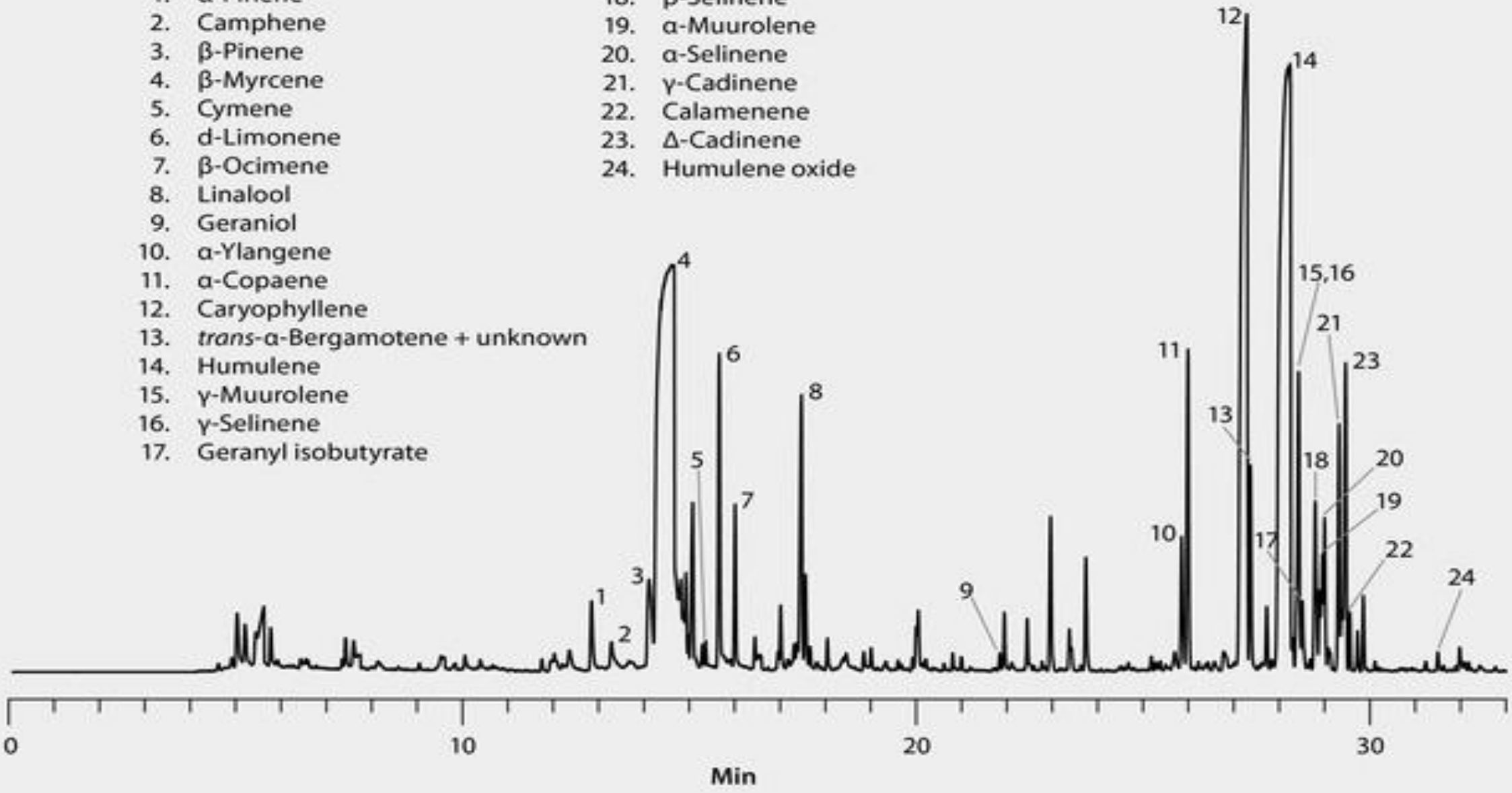
Hop Oil Analysis via Gas Chromatography Head Space Analysis

Gas Chromatography (GC) Separates, Identifies, & Quantifies Hop Essential Oils



GC Chromatogram of Hop Oil

1. α-Pinene
2. Camphene
3. β-Pinene
4. β-Myrcene
5. Cymene
6. d-Limonene
7. β-Ocimene
8. Linalool
9. Geraniol
10. α-Ylangene
11. α-Copaene
12. Caryophyllene
13. *trans*-α-Bergamotene + unknown
14. Humulene
15. γ-Muurolene
16. γ-Selinene
17. Geranyl isobutyrate
18. β-Selinene
19. α-Muurolene
20. α-Selinene
21. γ-Cadinene
22. Calamenene
23. Δ-Cadinene
24. Humulene oxide



GC Headspace Analysis of Aroma Compounds in NEIPA Before & After Centrifuge

	NEIPA Hazy	NEIPA After Centrifuge	Change in Concentration After Centrifuge
	µg/L		
Ethyl-2-methylbutanoate	23.4	18.3	-22%
Isobutyl isobutanoate	146.9	109.9	-25%
Myrcene	**7107**	**1584**	**-78%**
beta-Limonene	**73.8**	**27.7**	**-62%**
3-Methylbutyl isobutyrate	183.5	127.4	-30%
2-Methylbutyl isobutyrate	520.5	369.3	-29%
2-Nonanone	19.5	18.3	-6%
Linalool	615	592	-4%
2-Decanone	7.5	7.5	0%
Methyl nonanoate	n.d.	n.d.	
Terpineol	60.4	55.8	-8%
Citronellol	86.8	87.1	0.3%
Geraniol	469.8	436.7	-7%
2-Undecanone	21.4	16.1	-25%
beta-Caryophyllene	**188.2**	**50.0**	**-73%**
Farnesene	n.d.	n.d.	
2-Dodecanone	n.d.	n.d.	
Humulene	**206.0**	**52.3**	**-75%**
Thiols	ng/L		
4-Mercapto-4-methylpentan-2-one	106.6	93.2	-12%
3-Mercapto-1-hexanol	37.3	33.5	-10%
3-Mercaptohexyl acetate	<5	<5	
	<5 = LOQ in ng/L	n.d. = not detectable	

Detailed Analysis of New England IPA Haze

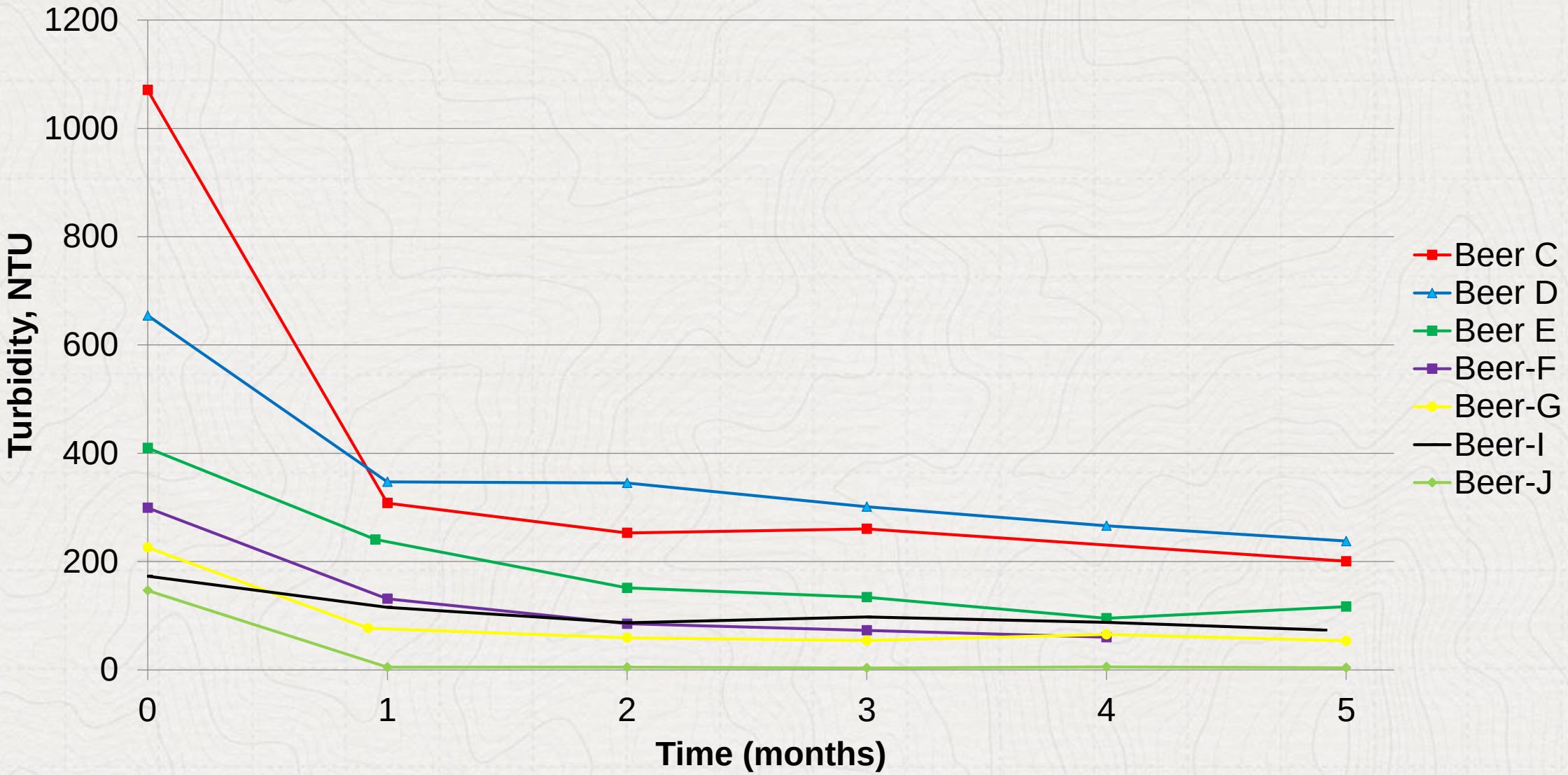
Haze precipitation from a NEIPA was freeze dried & analyzed

Protein	Poly-phenols	Fatty Acids	% Linolenic acid	% Linoleic acid	% Oleic acid	Starch
35.7%	3.4%	0.9%	0.22	0.52	0.19	10%

Hop Compound	Myrcene mL/100g	% Alpha Acids	%Beta Acids	% Xantho-humol	%Iso-Alpha acids	% Humul-inones
Freeze-dried	0.1	8	3	0.3	0.3	0.2

Prolamins are Proline-rich proteins and haze active proteins. Prolamins can hydrogen-bond to polyphenols (monomer, dimer, trimer of proanthocyanidins) to form haze. The ratio of protein to polyphenol is important to haze.

Haze Stability of NEIPA vs Time Stored at 3 ºC



International Bitterness Units Test - IBU

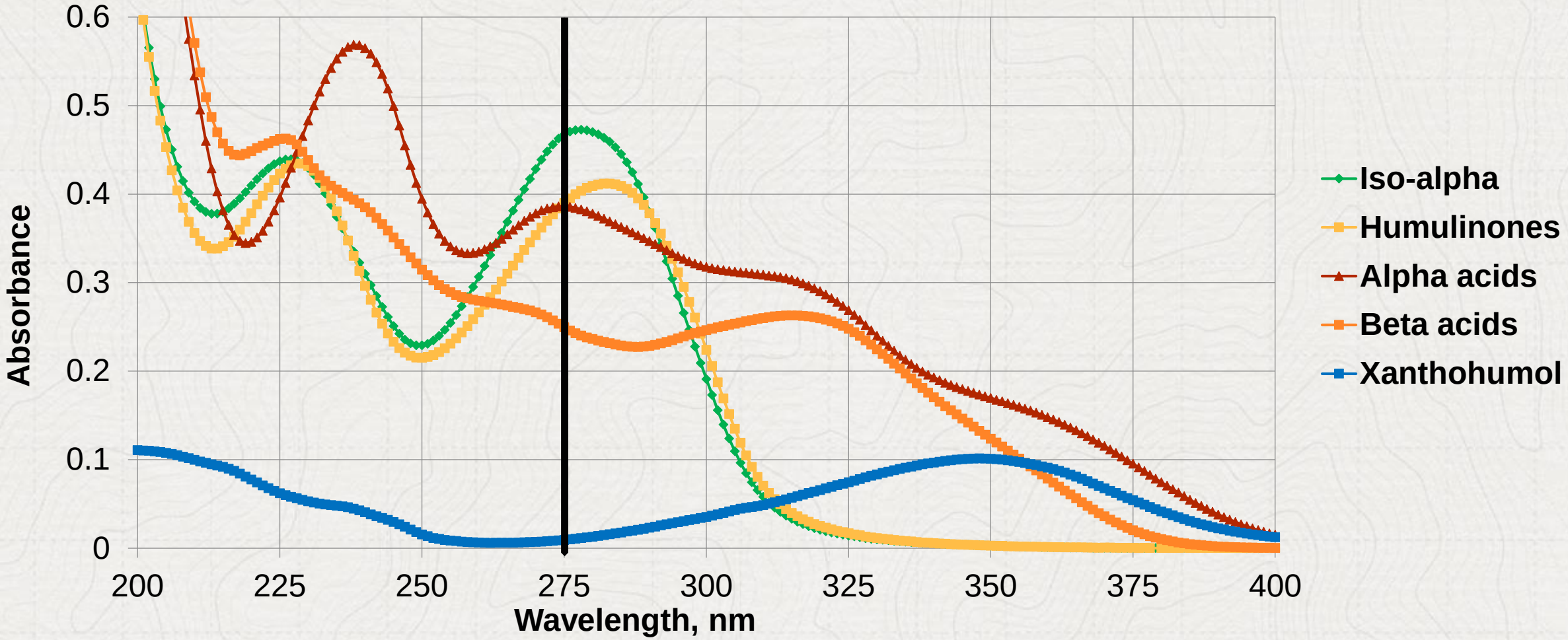
The IBU Test Method Was Developed to Measure Only Isoalpha Acids In Beer & 1 ppm of isoalpha acids ~ 1 IBU.

The Method:
Add 10 mL beer + 20 mL isooctane + 1 drop Octyl alcohol + 1 mL 3N HCl to 50 mL centrifuge tube, shake 15 minutes, centrifuge, transfer upper clear isooctane layer to cuvette, measure absorbance at 275 nm in a UV Spectrometer.

$BU = absorbance_{275} \times 50$

Note: In addition to isoalpha acids, isooctane will also extracts humulinones, alpha acids, beta acids, Xanthohumol & other compounds and these compounds can and do absorb at 275 nm

Absorbance Spectra of 30 ppm of Hop Compounds in Iso-Octane

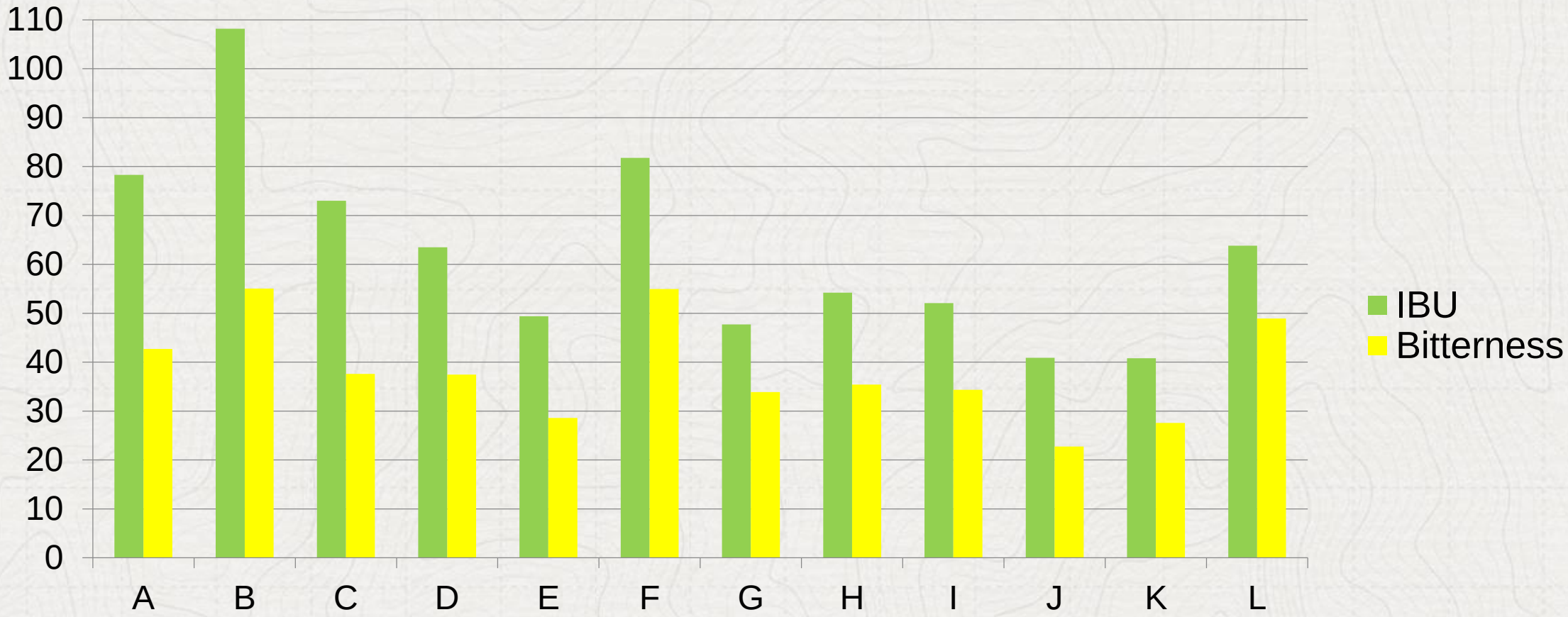


Response Factors:

Iso-α-acids: 0.7; Humulinone: 0.6; Alpha Acids: 0.6; Beta Acids: 0.4; Xanthohumol: 0.07

New England IPA IBU vs Calculated Bitterness

IBU Range: 41 – 108 Ave IBU: 63 Ave Calculated Bitterness: 37



Calculated Bitterness = ppm IAA + (0.66 x ppm Hum) + (0.1 x ppm AA)

The IBU Does Not Work For Dry Hopped Beers

The Isoalpha acids, Humulinones, Alpha Acids & Beta Acids in dry hopped beers get extracted into the isooctane layer and absorb light at 275 nm & at different intensities, thus interfering with the IBU test. Each hop acid has a different bitterness therefore you cannot correlate the IBU test to sensory bitterness.

	IBU Response Factor	Relative Bitterness to Iso-Alpha Acids
1 ppm Iso-alpha Acids	**0.7 IBU**	**1**
1 ppm of Humulinone	**0.6 IBU**	**0.66**
1 ppm of Alpha Acids	**0.6 IBU**	**0.1**
1 ppm of Beta Acids	**0.4 IBU**	**0.05**
1 ppm of Xanthohumol	**0.07 IBU**	**Not Bitter**

HPLC can accurately measure the concentration of isoalpha acids, humulinones, & alpha acids in beer allows one to calculate the bitterness of NEIPAs.

Nibem Foam Stability Tester

Beer is transferred from a bottle or can to a glass. A flasher will fill the glass with highly reproducible foam. The beer foam collapse is measured over 30 mm and the results are reported in seconds.

Nibem Foam Stability Test Results for New England IPA

Conclusion

The smooth bitterness that many people experience drinking NEIPAs is due to the high concentrations of humulinone in these beers and the relatively low concentration of isoalpha acids.

Like West Coast IPAs the sensory bitterness of NEIPA's is a little more than half of what the IBU test result would indicate. This is due to the fact that in addition to isoalpha acids, humulinones, alpha acids, & beta acids get extracted into the isooctane layer & absorb & interfere with the IBU test yet are only 2/3, 1/10 & 1/20 as bitter as isoalpha acids.

The foam quality of NEIPA are very good and this is due to the high protein and high alpha acid concentrations in these beers.

The haze stability of NEIPA isn't very good with most beers dropping to less than 400 NTU within one to two months after packaging.

Conclusion

Analysis of the haze shows it to contain ~36% protein, ~ 3% polyphenols, 0.9% fatty acids ~ 10% carbohydrate and 12% hop compounds. The use of high protein adjuncts such as wheat & oats rich in prolamines (haze proteins) are known to combine with polyphenols to form haze. Hops acids can also add to haze but it's small and due to the very low yeast count in most of these beers, yeast is generally not a contributor to haze but can be at higher concentrations.

The big secret here is that the haze in New England style IPAs is very important because it can act as a carrier and increase the concentration of non-polar compounds like alpha acids, xanthohumol, beta acids and non-polar aroma compounds and most likely other non-polar flavor compounds which contribute to the unique flavors this style of beer has to offer.

Acknowledgements

Bob Smith

New England Breweries

Hopsteiner

Thank You For Your Kind Attention