

Recent developments in IPA brewing

It's Still All About The Hop

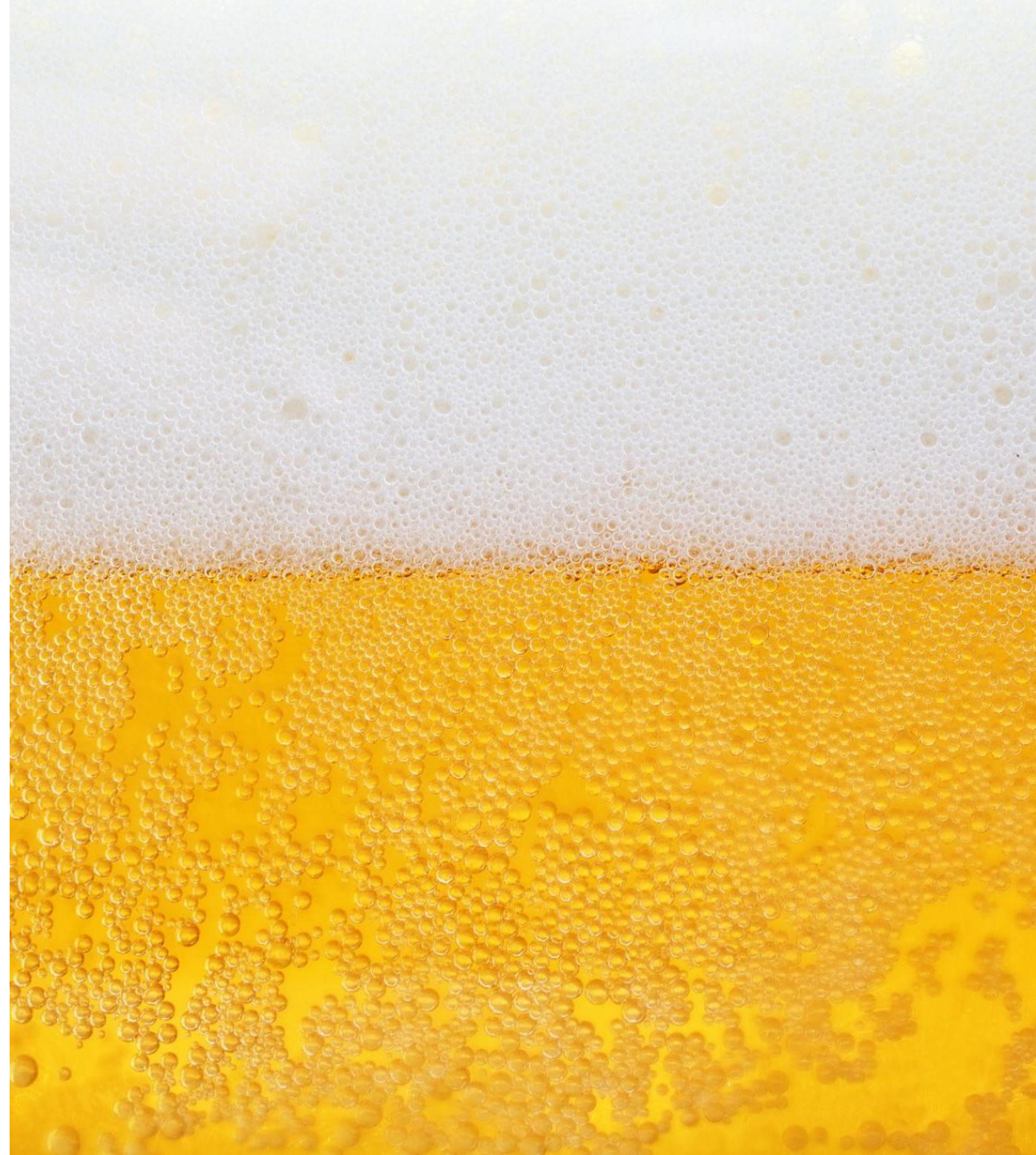


Today's IPA

- ▶ Close to 50% of craft beer dollars, over 40% of craft beer volume
- ▶ Craft Brewers focusing on:
 - ▶ Building exciting new brands with unique hop flavors
 - ▶ Maintaining consistency in core brands (analytically, haze, clarity and flavor)
 - ▶ Consumer interest in more tropical flavors
 - ▶ Reducing hop burn, grittiness and excessive bitterness
 - ▶ Cost savings in formulations and increasing efficiencies
 - ▶ Higher abv versions and NA/LA versions
 - ▶ Brand loyalty >>>Brand extensions
 - ▶ Diversifying hop strategies-new varieties, hop products, more varieties in recipe

Agenda

- ▶ Current IPA brewing processes and recent developments
 - ▶ New West Coast IPA
 - ▶ Double IPA
 - ▶ Hazy IPA
 - ▶ Hoppy Lagers
 - ▶ NA IPA and other newer styles
- ▶ Yeast developments
- ▶ Biotransformation, Terpenes, Thiols and thiol release
- ▶ Hop creep
- ▶ Hop products
- ▶ Wet Hops/Fresh Hops
- ▶ New Hop Varieties



New West Coast IPA

▶ Malts:

- ▶ Pale as possible.
- ▶ 100% pilsner malt or pilsner malt/2 row malt blend are common
- ▶ Some brewers are using adjunct use up to 10% (flaked rice)
- ▶ Some wheat malt OK

▶ Yeast

- ▶ Cal Ale yeast still popular, and dry yeast is much better than it used to be
- ▶ Neutral English yeast with good attenuation and flocculation
- ▶ Lager yeast, specifically Swiss Lager or 3470 (3470 can be fermented warmer with little increase in sulfur production)
- ▶ Kviek Lutra yeast-very neutral, ferment at 80°F and adds a nice pineapple ester. Don't go too high on temp

▶ Water: still want higher sulfate than chloride: 2.5:1 ratio Ca++ 85-110 ppm

New West Coast IPA

▶ Hops

- ▶ Target lower IBU: 40-60 IBU with clean bitterness
- ▶ Classic WC IPA hops still work-Resurgence of Cascade, Simcoe and Centennial along with **Mosaic**, Citra, Amarillo, CTZ
- ▶ Lots of New Zealand hops
- ▶ Hop Salad in dry-hop
- ▶ Newer hop varieties (see following slides)
- ▶ Hop products (see following slides)
 - ▶ Pourable extract in kettle and whirlpool
 - ▶ Cryohops
 - ▶ Liquid hop extracts
- ▶ Other flavor additions
 - ▶ Terpenes

New West Coast IPA

▶ Brewing Techniques

- ▶ Adjunct inclusion? (sugars, rice)
- ▶ Mash hopping (biotransformation?)
- ▶ Cold whirlpool hops (adds no bitterness, and keeps more volatile oils)
- ▶ Multiple dry hops
 - ▶ 2 additions post fermentation T90 pellets
 - ▶ One T90 addition at 3-4 days into fermentation, then one smaller one post fermentation-minimizes hop creep
 - ▶ Cryo hop or liquid hop addition as 2nd
 - ▶ Bright beer hop or terpene derived flavor addition
 - ▶ Don 't add hop extracts to bright, add them during conditioning

New West Coast IPA vs “Old”

▶ Old

- ▶ 90-95% 2row malt
- ▶ 5-10% light crystal or Munich
- ▶ 6-7.5% abv
- ▶ 65-80 IBU
- ▶ TG 3° P/ 1.012
- ▶ Heavy whirlpool hopping
- ▶ One dry hop. 1.5-2#+/bbl + in Dry Hop
- ▶ Cal Ale yeast or neutral English strain

▶ New

- ▶ 100% Pilsner malt or blend of Pilsner malt and 2R malt
- ▶ No specialty malts, maybe a touch of Munich or English Pale Malt
- ▶ Optional adjunct up to 10%
- ▶ 6-7% abv
- ▶ Lower IBU target ~50-60, cleaner bitterness
- ▶ TG 1-2° P/ 1.004-1.008
- ▶ Pilsner/lager yeast optional

New Double IPA- Popular convenience store brands are VERY different

▶ WC Double IPA

- ▶ Mostly 2 Row malt
- ▶ Sugar adjunct up to 10%
- ▶ 80+ IBU
- ▶ 8-9% abv
- ▶ Clean, neutral ale yeast strain
- ▶ 2.5-3.5° Plato TG/ 1.010-1.014
- ▶ Dry hop 2-4 lbs/bbl
- ▶ Clear golden color

▶ C-Store Double IPA

- ▶ Can be clear or hazy
- ▶ Up to 30% wheat in mash
- ▶ 9.0-10% abv 9.5% normal
- ▶ Brewed with amylase enzyme to get terminal gravity very low
 - ▶ 1-2°P/ 1.0025-1.005 TG
 - ▶ Add enzyme to mash with long, low temp conversion 148°F 90+ minutes
- ▶ Low IBU 25-30 is common
- ▶ Dry hop about 1 lb/bbl
- ▶ Fruit and/or flavors often added in bright tank

Hazy Juicy IPA developments

- ▶ Mid fermentation dry hopping being delayed til toward end of ferment, or eliminated altogether
 - ▶ Results in better yeast haze
 - ▶ Allows hop creep to occur before diacetyl rest
- ▶ Lactose not being used much anymore
- ▶ Reducing oats as a cost cutting option
- ▶ Reducing post ferment dry hop to avoid “hop burn” or using combination of pellets and pourable hop products
- ▶ Kviek yeast can increase fruitiness and provide haze
- ▶ Hop products that result in haze

Emerging IPA Styles

- ▶ Hybrid styles: Blend between New England and West Coast
 - ▶ Clear but juicy
 - ▶ West Coast hazy
 - ▶ Mid level IBU 40-60
- ▶ Low abv/Session IPAs
 - ▶ Add malt complexity, not necessarily sweetness using grains and light specialty malts
 - ▶ Keep pH low and final runnings high to avoid tannin extraction or harsh bitterness
 - ▶ 1.5-2°P TG /1.006-1.008

NA/LA IPA Techniques with maltose negative yeast strains

- ▶ High temperature/short time mash (160-165 for 5 minutes) with mash off raise
- ▶ Normal boil and whirlpool
- ▶ Consider liquid hops in whirlpool-Spectrum, Salvo, etc
- ▶ No yeast aeration. Stop ferment by crashing after 24 hours or gravity drop close to 1°P
- ▶ No T90 pellet dry hop. Use liquids and flavors. This prevents hop creep
- ▶ Preservatives required
- ▶ Force carb
- ▶ No draft
- ▶ Targets:
 - ▶ 6°P/1.024 OG, 5°P/1.020 TG
 - ▶ <30 IBU

IPA Styles

SUMMARY OF IPA BREWING PARAMETERS

	Historical Burton IPA	Scottish IPA	Early 1900s English IPA	Contemporary English IPA	West Coast IPA 2000-2020/American IPA	West Coast IPA Modern	Double IPA	Black IPA	New England Hazy/Juicy IPA	Brut IPA	
Grains	Pale malt %	100% Extra Pale	100%	85-95%	85-100%	85-97%	100% . Blend of Pilsner and 2R	95-100%	88-95%	50-70%, may include wheat malt	70-100%
	Crystal malts?	no	no	no	15-40°L	10-60°L	no	10-20°L	10-20°L	10-40°L	no
	Typical crystal %	0	0	0	0-10%	3-15%	0	0-5%	3-10%	0-10%	0
	Adjuncts %s	none	none	Maize, sugar	Maize, sugar	none	none	Sugar	not typical	Flaked oats, flaked wheat	corn, rice or sugar
	Roasted malts	none	none	none	Munich	Munich	none	none	Dehusked black malt, Black malt extract	none	none
	Typical %s	0	0	0	0-10%	0-10%	0	none	3-7%	0	0
Mashing	Mash conversion temperature °F	148-150	150-154	152-154	150-155°F	148-153°F	148-153°F	148-150°F	148-153°F	154-157°F	148-150°F
	Conversion time	120	120-180 minutes	90 minutes	15-30 minutes	15-60 minutes	15-60 minutes	60-120 minutes	15-120 minutes	20-60 minutes	30-120 minutes
	OG°P (SG)	15-18.75 (avg 16-17) (1.060-1.075)	14-17.5 (1.056-1.070)	12.5-15 (1.050-1.060)	12.5-18.75 (1.050-1.075)	12.5-18.75	12.5-18.75	18.75-22.5 (1.075-1.090)	14-18 (1.056-1.072)	14-17°P (1.056-1.068)	12-14°P (1.048-1.056)
	Fermentability	High	High	High	70-80%	75-82%	75-82%	80-86%	75-82%	65-80%	90%
	Target TG °P (SG)	0.75-3 (1.003-1.012)	0.75-3 (1.003-1.012)	2.5-4 (1.010-1.016)	3-4.5 (1.012-1.018)	2.5-4 (1.010-1.016)	2.5-4 (1.010-1.016)	1.75-3.75 (1.007-1.090)	2.5-4.5 (1.010-1.018)	3-6 (1.012-1.018)	<0
ABV target%	6-7%	5-7%	4-6.5%	5-7%	6.3-7.5%	6.3-7.5%	7.5-10%	6-7.5%	6-7%	5-7%	
Hopping	Overall Hop rates (lbs/bbl)	5 to 6	1.25-3	1.0-2.0	.75-2.5	.75-2	.75-2	3.5-8	1.5-4	2.0-8	1-4.0
	Recommended varieties	East Kent Goldings	East Kent Goldings, others	East Kent Goldings, Fuggles, US Fuggle, Cluster	East Kent Goldings, Fuggle, Target, Sovereign, Styrian	C hops, newer American hops	C hops, newer American hops	Any highly flavored hop	Any highly flavored hop	Tropical, high geraniol hops	Avoid C Hops. Use tropical, European, or grape-y hops
	Dry Hop Pounds /bbl	1	1.25-3	.25-0.5	1	0.4-2	1.5-3	.75-4	1.0-3.0	3.0-6.0	1-2.5
	Multiple Dry Hops?	Yes in casks	not typical	not typical	not typical	not typical	not typical	varies	Not typical	fermentation and post fermentation	not typical
	IBU target	~70	~70	~50	40-60	50-80	45-60	70-100+	50-80	35-50	25-40
Other Comments	Long, low intensity boil, 2-3 hours to minimize color development	Ferment cool	Most gravities dropped to 10-12°P after WWI, below 10°P after WWII	Based on GABF guidelines. Real examples are highly varied	Regional differences with TG/Body, IBU and hop varieties	Lower IBU and crisper than earlier version			2-3:1 Chloride to sulfate ratio in water	Amylase enzyme in mash	
	Age 12 months or more								High whirlpool hopping. Cold whirlpool?		

Hoppy Lager Styles-West Coast Pils

- ▶ West Coast Pils: Essentially a Pilsner dry hopped like an IPA
 - ▶ ~30 IBU
 - ▶ ~5% abv
 - ▶ All malt, Pilsner malt, maybe some Munich or Vienna
 - ▶ Pilsner in the brewhouse ops
 - ▶ Noble hops in brewhouse? Combine with Am hops in whirlpool?
 - ▶ Ferment with lager yeast
 - ▶ Dry Hop like an IPA with floral or fruity hops

Hoppy Lager Styles-Cold IPA

- ▶ Crisp, dry hopped adjunct lager with intense hop aromatics
- ▶ Typically brewed with 20-40% corn grits or flaked rice. Some brewers use AMG enzyme in an all malt recipe for crispness and dryness
- ▶ Substantial IBUs, 50-75
- ▶ Lager yeast fermentation-low sulfur producing yeast. Slightly elevated fermentation temperatures, eg 50-60°F
- ▶ IPA dry hop
- ▶ Southern Hemisphere hops were initially popular. Elegant fruitiness and floral character

Hoppy Lager Styles-Italian Pils

- ▶ Traditional European Pilsner with a dry hop
- ▶ Origination: Birrifificio Italiano's Tipopils--Agostino Arioli
- ▶ Italian Pilsner malt
- ▶ Noble hops in the brewhouse for an elegant bitterness
- ▶ Medium dry hop with noble hops
- ▶ Light haze/unfiltered

Hoppy Lagers

HOPPY LAGER STYLES					
	Imperial pilsner	India Pale Lager (IPL)	Cold IPA	Italian Pils	West Coast Pils
Brief Description	Big pilsner	IPA brewed as a lager	Hop forward dry lager with intense hops, solid bitterness and Pilsner crispness	German pilsner dry hopped with European hops	German pilsner dry hopped American IPA style. 50/50 blend of two styles
ABV	6.5-9%	6.5-7.9%	6.5-7.5%	4.5-5.5%	4.5-5.5%
IBU range	30-60	50-75	50-75	25-40	25-40
Typical Grains	Pilsner malt, some European specialty malts	2R or Pilsner malt base. Small % of specialty malts	American Pilsner malt or 2Row malt with high diastatic power, 20-40% adjunct (corn or rice), or use AMG enzyme to accentuate crispness	European pilsner malt, Italian pilsner malt	Pilsner malt, American 2R malt (blended) with small % specialty malts, typically no adjuncts
Hot Side Hops	Lager/Noble hops, floral and light fruity character, spicy	IPA hops	C Hops, new European hops, or Southern Hemisphere hops	Noble hops	Typically lager/ noble hops in brewhouse, with heavy whirlpool hopping. Some brewers are using American hops
Yeast	Traditional Pilsner strain, standard cold ferment and lagering protocol	Traditional pilsner or lager strain, ferment cool, 50-55°F with standard lagering protocol	Traditional Pilsner or lager strain that produces low sulfur and low esters, ferment warmer than normal, but not ale temps (eg 55-65°F), shorter aging period	Traditional pilsner strain and fermentation profile	Traditional pilsner or lager strain, sometimes fermented at higher than normal temperatures
Cold Side Hops/Dry Hops	None to a small amount of noble or new European/ American lager hops	IPA dry hops	Dry hop at end of fermentation, use new American or European hop varieties, C-hops or Southern hemisphere hops	Post fermentation dry hops with noble hops, low-medium addition rates	IPA hops

Newer brewhouse processes

▶ Mash hopping

- ▶ We now know that bound thiols in both malt and hops can survive the brewhouse and be released by thiol active yeast
- ▶ Adds a soft bitterness component

▶ Whirlpool hopping

- ▶ Use all whirlpool hopping for bitterness. Results in softer bitterness. Popular technique with Hazy IPA
- ▶ Whirlcool hopping: Running wort through chiller to below 185°F, then add hops. No bitterness conversion, more flavor and aroma are retained

Terpenes

- ▶ Major component of hop oils
- ▶ Hydrocarbons
- ▶ Hop Terpenes
 - ▶ Myrcene: Minty, woody, leafy
 - ▶ Caryophellene: Spicy, peppery
 - ▶ Limonene: Citrus
 - ▶ Linalool: Floral, lavender, light citrus
 - ▶ Geraniol: Floral and Citrus
 - ▶ Citranellol: Rose and Citrus



Biotransformation and mid-ferm dry hop

- ▶ Refers to enzymatic change of terpenes and thiols by yeast. Gene edited yeast increase thiol release
- ▶ Still used in many New England IPAs. B glucosidase release terpenes and can convert terpenes if used in mid ferm or late ferm dry hop
- ▶ Hop strain dependent: Centennial, Chinook, Cascade, El Dorado, Idaho 7 and Azacca all are good
- ▶ Very yeast strain dependent-London Ale III, Conan/Vermont, Kviek, Kolsch
- ▶ Flavors go from citrus, pine and floral to juicy citrus/orange juice 24 hours after adding dry hops

Thiols

- ▶ Sulfur containing organic compounds with -S-H end
- ▶ Found in small concentrations in hops, but highly aromatic
- ▶ Tends to bind with other compounds-like sugars (glycosides)
- ▶ Can be enzymatically released by yeast, especially gene-edited strains
 - ▶ Results in huge tropical fruit release during fermentation
- ▶ Hop thiol positive
 - ▶ Cascade, Calypso and Saaz have high bound thiol contents
 - ▶ Nelson Sauvignon, Citra and Simcoe have high free thiol content
 - ▶ Pale malts have high bound thiol contents. Wheat and colored malts are very low
- ▶ Phantasm powder (Sauvignon Blanc grapes)
- ▶ 3MH-Tropical Fruit, Grapefruit
- ▶ 4MMP-Black Currant

Gene edited yeast

- ▶ CRISPR-Cas9 gene editing process-allows formation of enzymes by yeast that break down bound thiols and release them
- ▶ Omega Yeast Labs and Berkeley Yeast pioneers
- ▶ Enzymatic action in mashing helps free up bound thiols from both malt and hops (if mash hopping), allowing gene edited yeast activity
- ▶ The yeast strain is important-they produce different intensities of tropical flavor
- ▶ Passionfruit and tropical flavors emerge strongly after day 1 of fermentation
- ▶ Some times the tropical intensity is too much
 - ▶ Dry hop post ferment with citrusy/piney hops
 - ▶ Blend with standard yeast ferment

Hop Creep

- ▶ A secondary fermentation that happens after dry hopping
- ▶ Enzymes in unboiled hops can break down dextrins, and live yeast can re-start the fermentation. This can result in:
 - ▶ Excess carbonation in packaged product
 - ▶ Higher abv
 - ▶ Diacetyl formation (yeast in secondary not healthy enough to re-consume). Oxygen ingress during dry hopping makes the problem worse
- ▶ Prevention:
 - ▶ Dry hop earlier, at warmer temperatures and build the hop creep and diacetyl reduction into your recipe
 - ▶ Some hops are more prone to hop creep
 - ▶ Use ALDC-diacetyl producing enzyme
 - ▶ Use gene edited yeast that don't produce diacetyl

New Hop Products

- ▶ YCH Cryo-Hops/Haas Lupomax/Crosby CGX: Frozen and concentrated resins in pellet form. ~50% less mass than T90 pellets
- ▶ Brewhouse pourable hop extracts: Haas Flex and Incognito, Steiner Salvo, Hopflow
- ▶ Liquid and powder hop products for dry hopping: Haas Spectrum, Steiner Salvoplus, CGX Nuvo powder
- ▶ Frozen fresh hops
- ▶ Other products: Steiner LLZ, Haas Euphorics, Abstrax Quantum and Omni, Abstrax Skyfarm and BrewGas

Wet Hop/Fresh Hop Beers

- ▶ Fresh hops, not kilned, baled or pelletized
- ▶ Because of moisture content, need to use 5-6x amounts to get same result
- ▶ Some hop suppliers are now freezing fresh hops so they can be used year-round

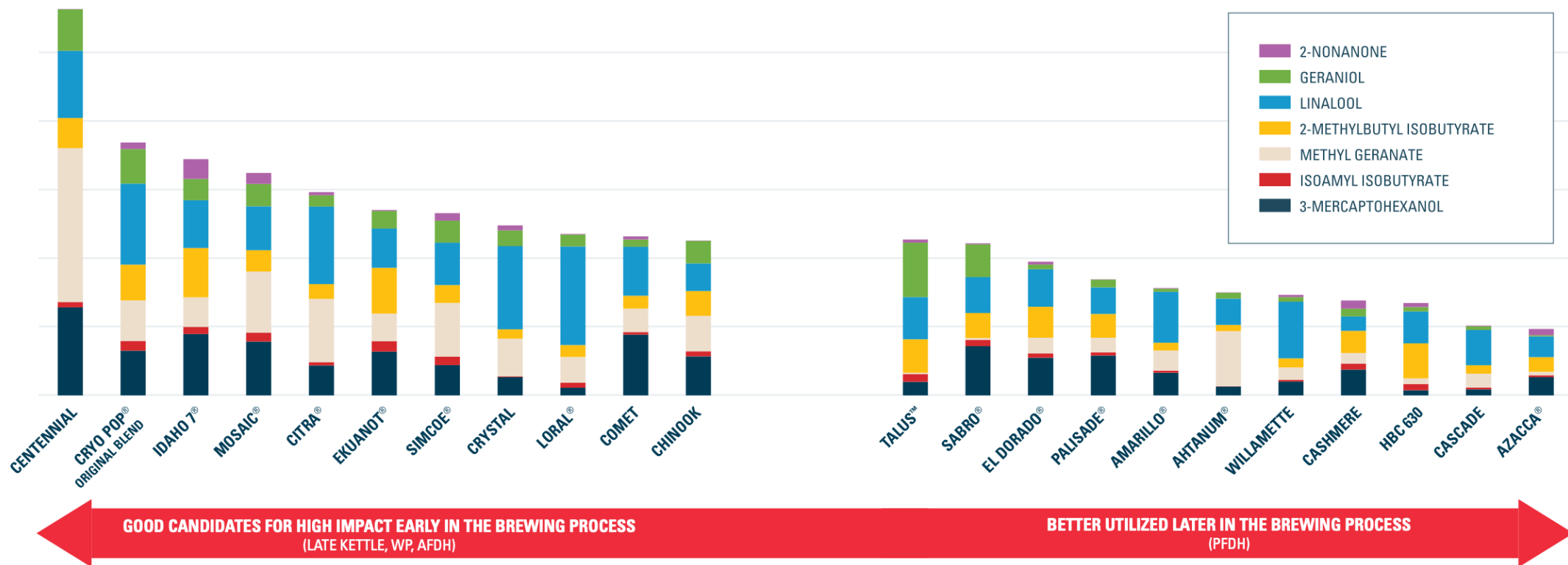
Hop Survivability from YCH Hops

THE SURVIVABLES GRAPH

GC-QTOF and GC-SCD technology is useful for research purposes, as well as in the development of practical tools which help brewers make more informed decisions about when and how to use hops.

ANSWERS SUCH QUESTIONS AS:

- What variety should I use?
- Where in the process should I use it?
- Which hops work together in combination?
- How can I use a variety to its maximum effect?



Hop Evaluation-approach cautiously

- ▶ Supplier evaluations and flavor descriptors may not reflect your beer flavor
- ▶ A hop rub does not equal the flavors you will get in your beer
- ▶ The only way to really evaluate a hop is to *brew* with it yourself!
- ▶ Many hop suppliers have installed really nice pilot brewing systems

AN AROMA HOP
EKUANOT™
HBC 366

Region: United States

Alpha: 13 - 15.5%

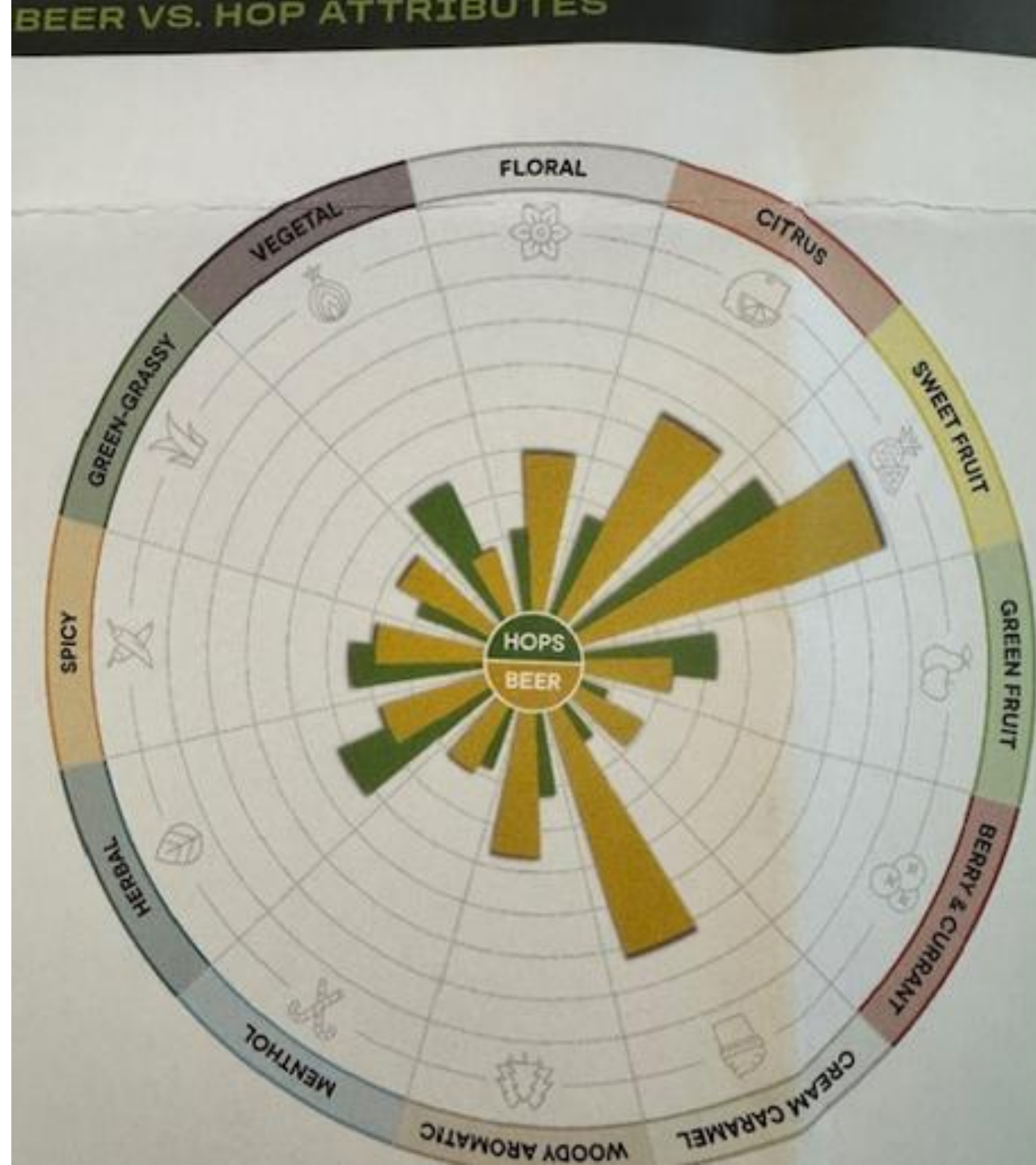
Beta: 4 - 5%

Co-H: 31 - 36% of alpha acids

Total Oil: 2.5 - 4 mL/100g

Aroma: Specific descriptors include melon, berry, orange peel, lime, papaya, pine and fresh peppers.

Hop Rub vs Brewing: Dolcita



New Hop Varieties-Public American Varieties

- ▶ Vera (HRC-003): Tropical, Stone Fruit, Citrus, light floral. Intense
- ▶ Thora- (USDA and Hop Quality Group) vibrant passionfruit, guava, grapefruit, and stone fruit. Also has high free thiol content

New Hop Varieties-Private American Varieties

- ▶ Segal Ranches:
 - ▶ Anchovy-Watermelon Jolly Rancher, candied fruit, pine
 - ▶ Tangier-Orange, Tangerine, Citrus. Good hoppy lager hop
 - ▶ Zumo-Lime Zest and Citrus
 - ▶ Ramosa-Pineapple
- ▶ Hop Breeding Company (HBC)
 - ▶ Dolcita (HBC 1019) Peach rings and Orange Creamsicle, Coconut
 - ▶ KRUSH (HBC 586) Complex tropical fruit
- ▶ Steiner:
 - ▶ Contessa: Noble hop character
 - ▶ Alora: Intense peach
- ▶ BRU-1: Pineapple and pear

New Hop Varieties-Private American Varieties

- ▶ Great Lakes Hops

- ▶ Pixi - Fruity Pebbles
- ▶ Hydra-Orange citrus blend, green grape
- ▶ Bergamot-super orange

- ▶ Indie Hops:

- ▶ Strata-Strawberry, Cannabis
- ▶ Luminosa: Tropical fruits, mango, lemonade, orange, passionfruit and guava

New Hops New Zealand and Australia

- ▶ Nectaron-Passionfruit, citrus and juicy peach
- ▶ Superdelic: Berry, red candy, tropical fruit and citrus. Good biotransformer
- ▶ Eclipse-Mandarin, Orange Peel, Pine
- ▶ Enigma-White grape, Red Berry, Cantaloupe

Hop Research: Oils-Volatile compounds

- ▶ 300- 400 compounds contribute to hop flavor.
 - ▶ Hydrocarbons/terpenes: Myrcene, Pinene, Humulene
 - ▶ oxidized hydrocarbons-terpenoids: Linalool, Geraniol, Citronellol
 - ▶ sulfur compounds-thiols
- ▶ Concentration does not equal flavor intensity
 - ▶ High levels of myrcene or linalool don't necessarily mean more intense hop flavor.
 - ▶ Sulfur compounds, in the smallest concentrations, may be the most potent.
- ▶ Things that influence hop flavor intensity:
 - ▶ Oxidation products of hop oils. Air = bad.
 - ▶ Dry Hopping in beer, bio transformation of oils floral to citrus flavor compounds. Geraniol to B-Citronellol
 - ▶ Hydrolysis of non-aromatic glycoside compounds in hops into aromatic terpenoids by enzymes in yeast cells and by pH
 - ▶ Glycoside =terpenoid/glucose compound
 - ▶ Impact of temperature and time

Hop Research

- ▶ Hop Processing impact on flavor
 - ▶ Early vs late harvest-impact on fruit vs. garlic/onion
 - ▶ Low or high temperature kilning
 - ▶ How to minimize garlic/onion?
 - ▶ Direct pelletizing-no baling: is there a flavor difference?
 - ▶ Loose pack pellets vs. hard pack pellets
- ▶ Best way to measure IBU in highly hopped beer?
- ▶ Hop Pre-isomerization to increase utilization-up to 65%
- ▶ Impact of oxidation on hop bitterness and hop flavor
- ▶ The “real” impact of mash hopping, first wort hopping???

Wrapping up

- ▶ IPAs are still the number style in craft beer
- ▶ New types of IPAs are focusing on lager ingredients and techniques
- ▶ Hop breeding remains the # 1 innovation tool for IPA brewers
- ▶ Liquid hop products and terpene extracts are rapidly gaining acceptance with craft brewers for:
 - ▶ Creating interesting flavors, augmenting existing hop flavor and aroma
 - ▶ Extending shelf life and flavor stability of IPA
 - ▶ Making brewing processes more efficient
- ▶ Hop research making huge impacts on understanding components of beer flavor

Thank you!

Questions?