



Workshop on U.S. Hops

Hop Growers of America

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NHC San Diego - June 2011



Hop Growers of America (HGA)



HGA is a not-for-profit organization that represents all hop growers in the U.S. It does not sell hops. Its goal is to promote the increased use of American hops through education and marketing.



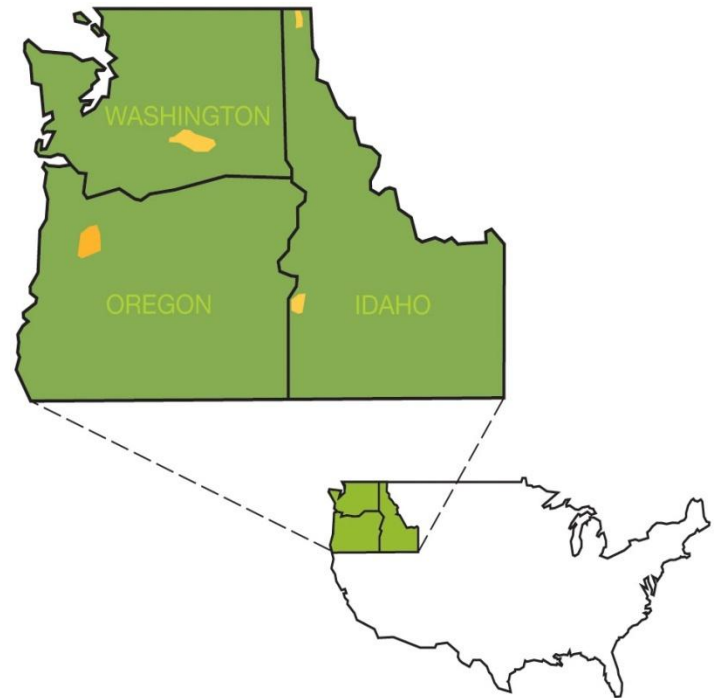
Presentation Outline

- Overview of the U.S. Hop Industry
- Overview of the U.S. Craft Beer Industry
- Brewing with American Hops
 - American Craft Brewers approach to making hoppy beer
- Tasting of Beers brewed with American Hops
- Brewing Competition with American Hops



USA Hops: A European Tradition

- British and Dutch colonists first brought hop plants to New York in the 17th and 18th centuries.
- Hop farming gradually moved west – settling solely in the Northwest U.S.



- Almost all American hop farms are family owned operations.
- Most family farms date back 3, 4, or 5 generations.



Diversity in growing climates...

Unlike leading producers in Europe, U.S. farmers grow hops in two distinct climates:

Willamette Valley (Oregon)
Wet and mild (Bavarian-like) climate.



Yakima Valley (Washington) and
Boise Valley (Idaho) – Semi-desert
climate (irrigation is vital)





...leads to diversity of hop varieties and advantages in production and supply consistency

- Oregon growers specialize in aroma hops, including many specialty hops for U.S. craft beer sector.
- Washington and Idaho farmers grow all variety types, but lead the world in production of super-high alpha hops.
- Yakima Valley generally has the best alpha yields of any growing region in the world.
- Yakima Valley growers can plant and harvest up to 80% of a mature crop in just one season. This is a huge advantage in being able to respond to a quickly changing market (and provides security for brewery customers).

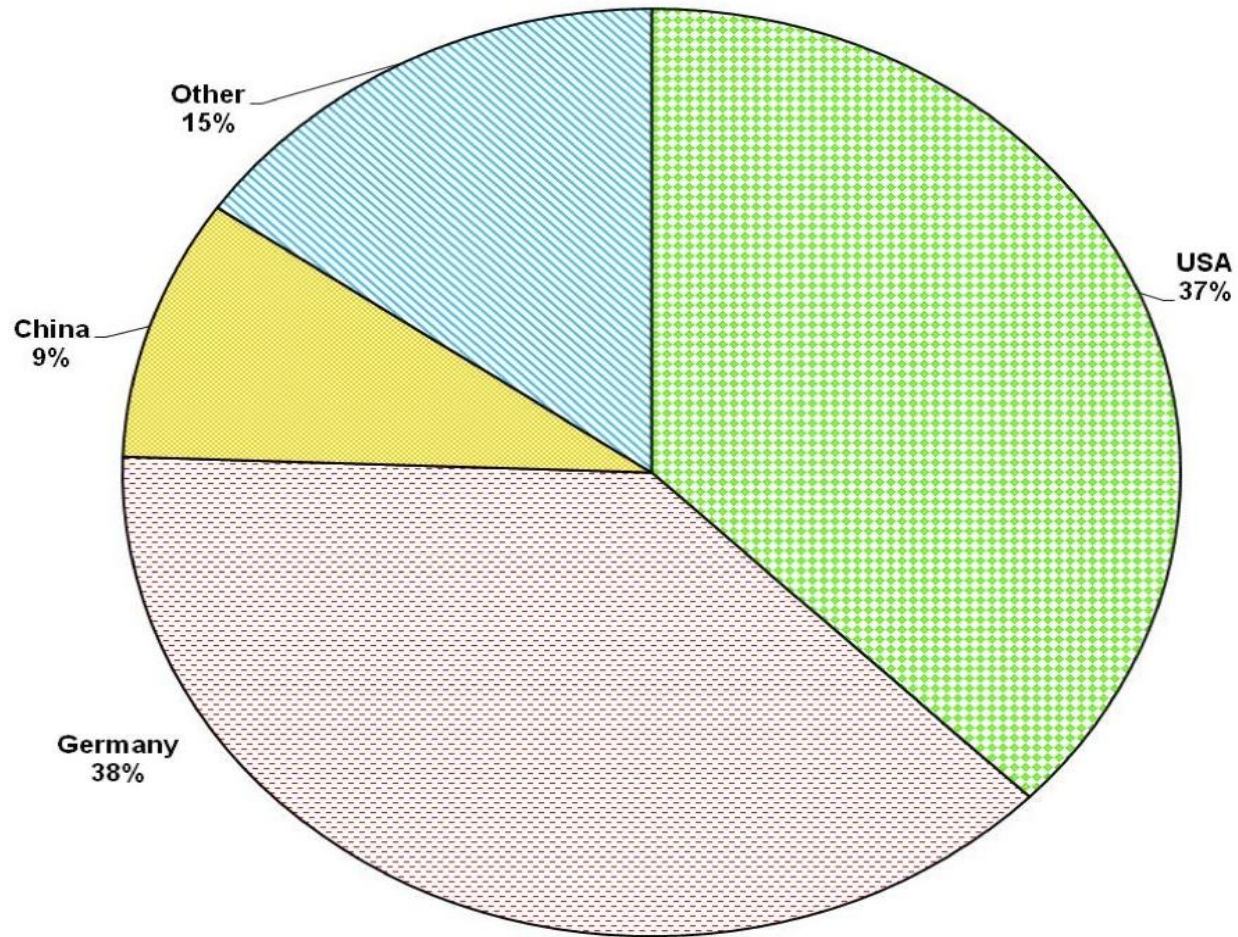


Alpha/Bittering Hops vs. Noble/Aroma Varieties

- Traditionally, the U.S. was the leading producer of high alpha bittering hops, while Germany was the world's leading supplier of aroma varieties.
- Today both Germany and the U.S. grow a well balanced portfolio of High Alpha and Aroma hops.
- U.S. aroma hop examples:
 - Cascade (most popular U.S. aroma variety among craft brewers)
 - Willamette (widely used by both large and small brewers - similar to Fuggle, Styrian Golding and Tettnang)
 - Mt. Hood (a daughter of Hallertauer Mittelfrueh)
 - Sterling (good substitute for Czech Saaz)

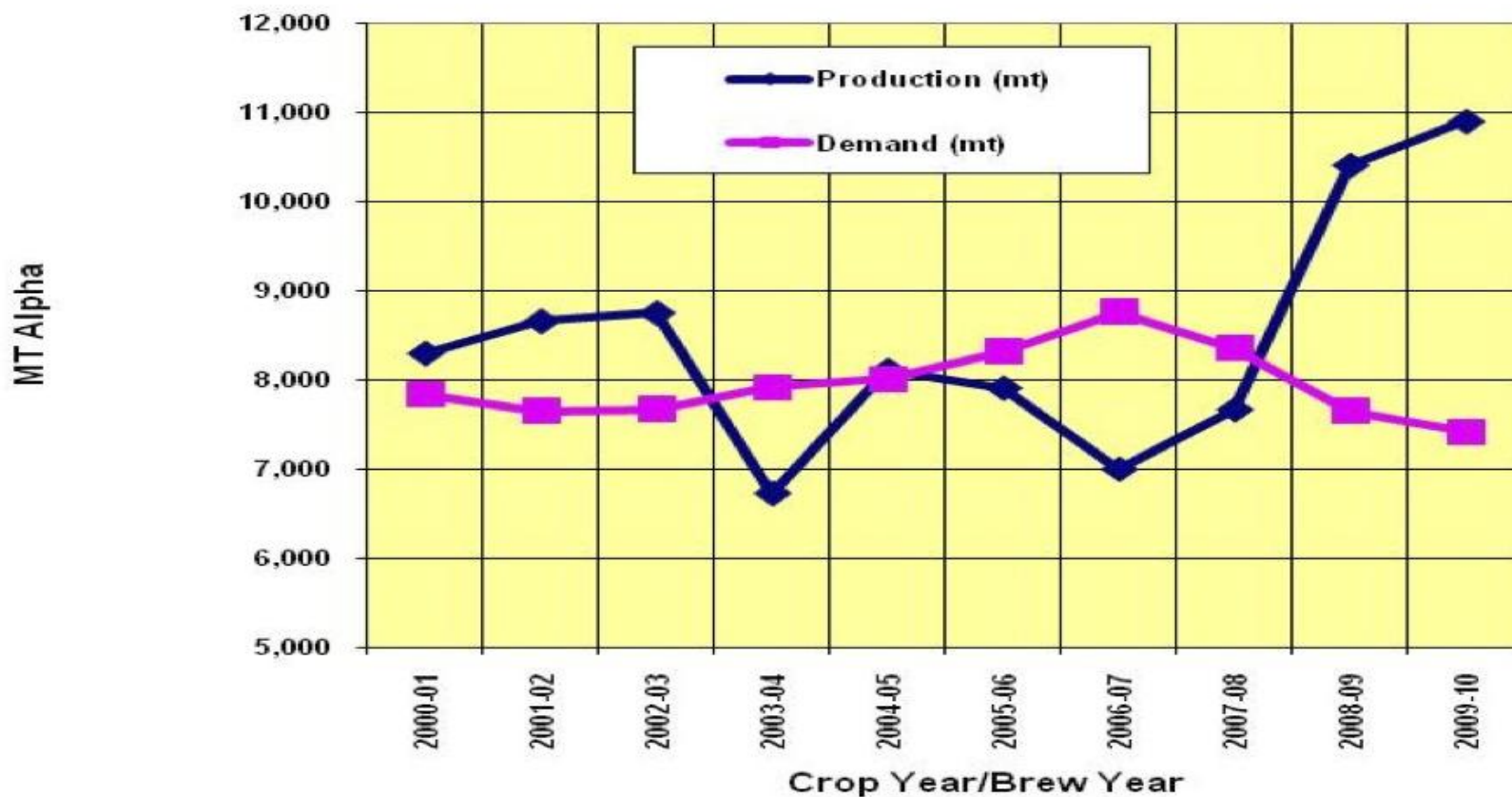


WORLD'S LARGEST ALPHA PRODUCERS - 2010





WORLD ALPHA PRODUCTION & DEMAND 2001 – 2010 (11 YEARS)



SOURCE: Barth Report. Prepared by HGA.



USA Harvest Statistics

- 2010 U.S. acreage decreased 21% to 12,647 ha.
- 2010 U.S. production reduced was 30% to 30 million kg (2009 = 43 mil kg)
- This decrease was in response to the oversupply of hops in the world

2009

Hop Acreage (ha)

Washington – 11,974 ha (75%)

Oregon – 2,472 ha (15%)

Idaho – 1,631 ha (10%)

Total – 16,077 ha

U.S. Hop Production (MT)

Washington – 34.0 million kg (79%)

Oregon – 5.4 million kg (13%)

Idaho – 3.6 million kg (8%)

Total – 43.0 million kg

2010

Hop Acreage (ha)

Washington – 9,759 ha (77%)

Oregon – 1,939 ha (15%)

Idaho – 949 ha (8%)

Total – 12,647 ha

U.S. Hop Production (MT) - ESTIMATE

Washington – 24.0 million kg (80%)

Oregon – 3.7 million kg (12%)

Idaho – 2.3 million kg (8%)

Total – 30.0 million kg



2010 USA Harvest Statistics

Number of Hop Farms

70

Average Size of Farms

450 acres

Acreage

31,289 acres (26% of world total)

Average Yield per Acre

2093# / acre

Production (dried hops)

65.5 mil # USA (32% of world total)

75.2 mil # GER

Alpha Acid Production (estimate)

3.5 mil kg USA (37% of world total)

3.6 mil kg GER (38% of world total)

Percentage of U.S. Crop Exported

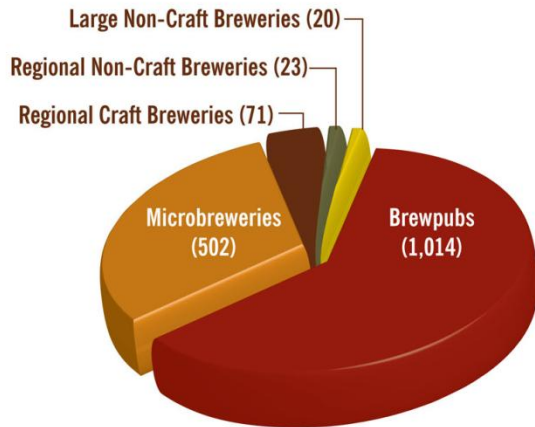
75%





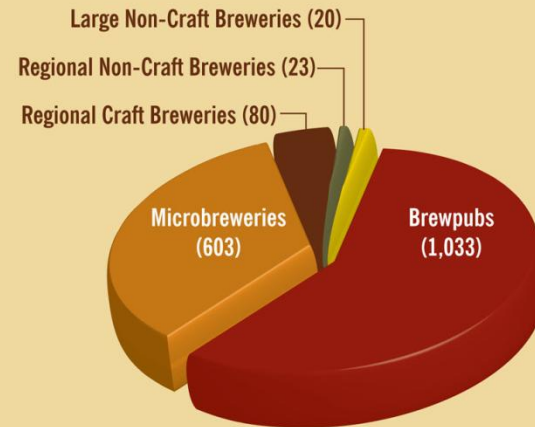
Craft Brewers Continue to Climb

2009 Total U.S. Breweries



1587 of 1630 breweries operating in 2009 were craft breweries

2010 Total U.S. Breweries



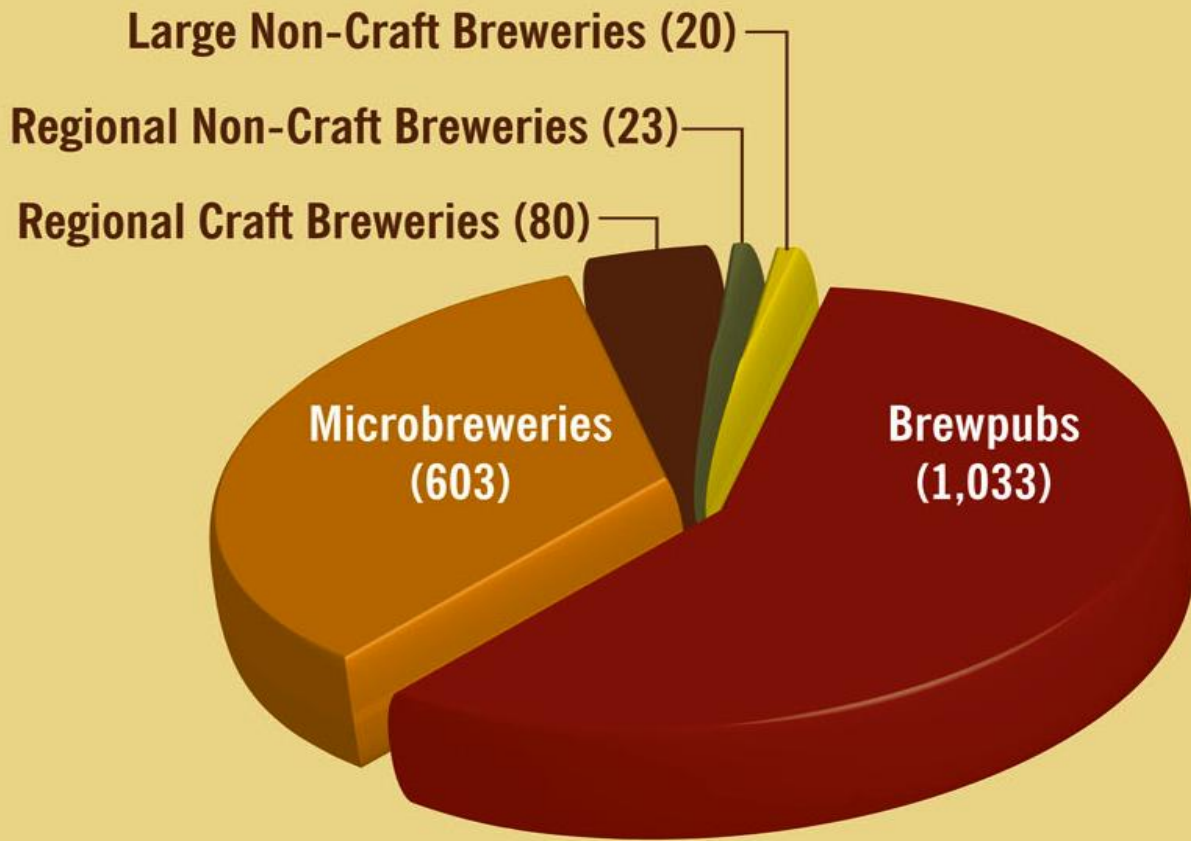
1716 of 1759 breweries operating in 2010 were craft breweries

110 Year Brewery Count





2010 Total U.S. Breweries



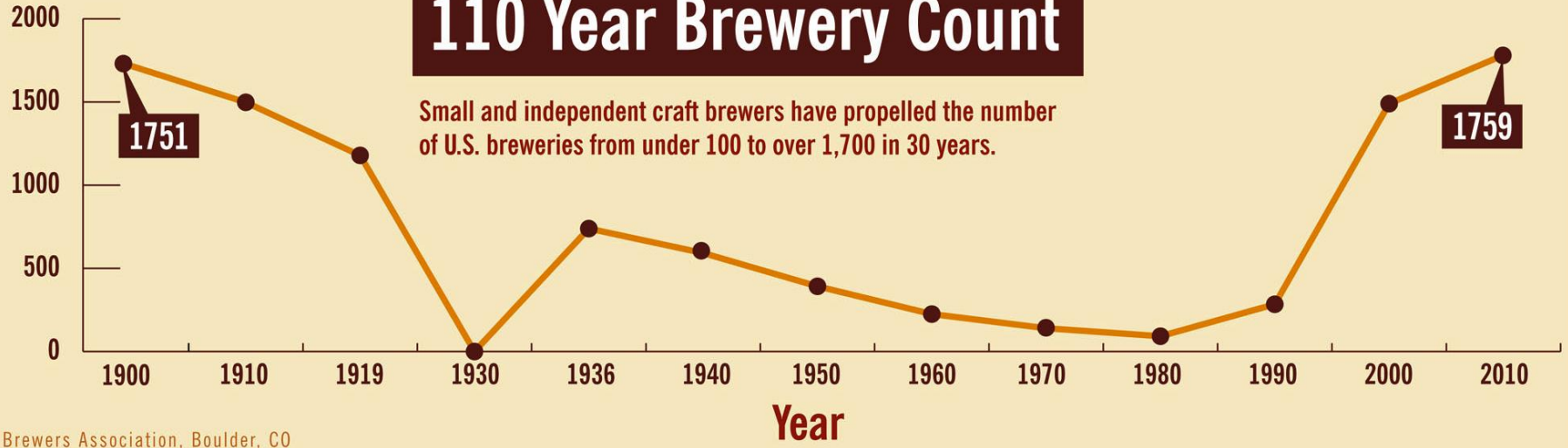
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Number of Breweries

110 Year Brewery Count

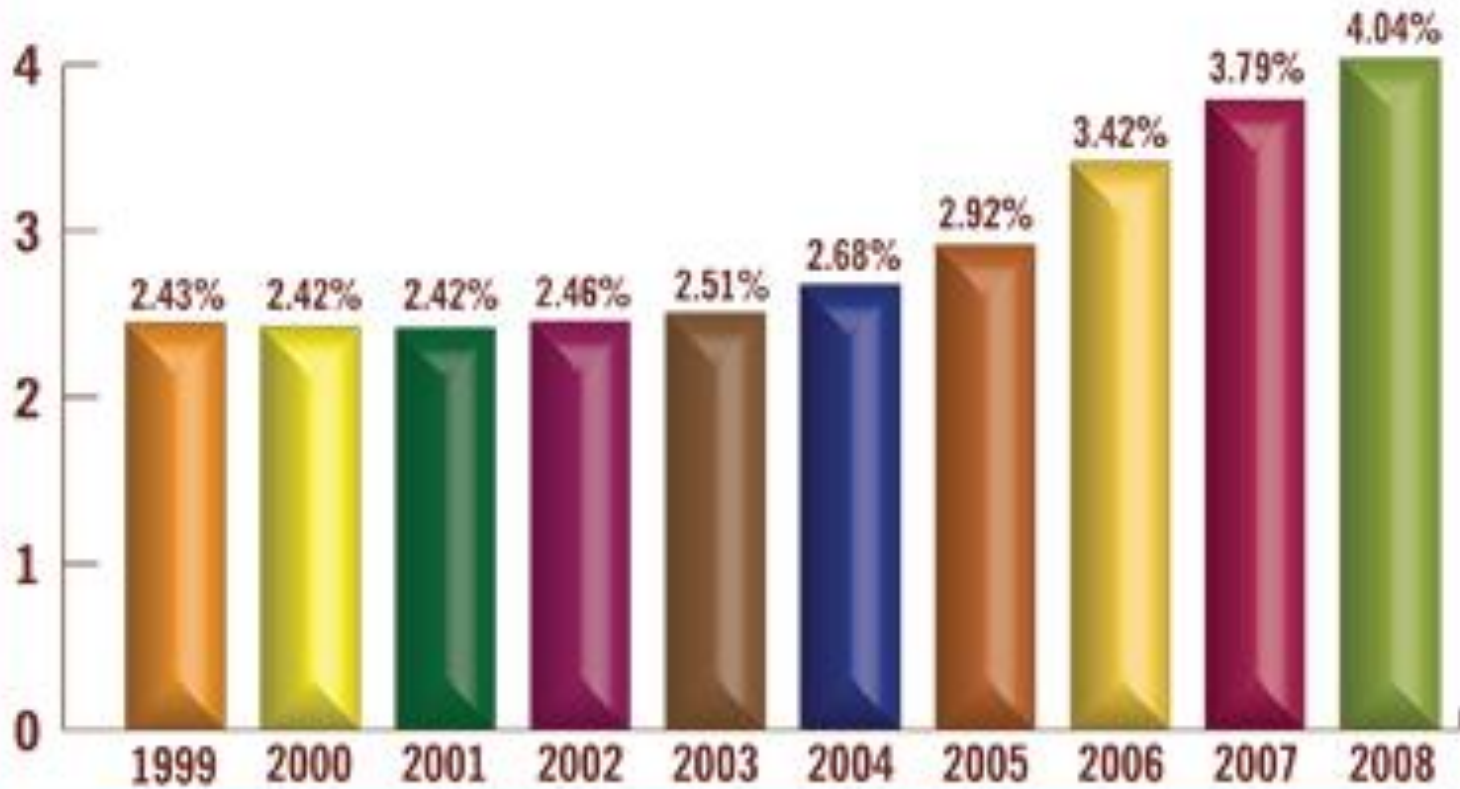
Small and independent craft brewers have propelled the number of U.S. breweries from under 100 to over 1,700 in 30 years.



Source: Brewers Association, Boulder, CO



Craft Beer Share of U.S. Beer Market (volume)

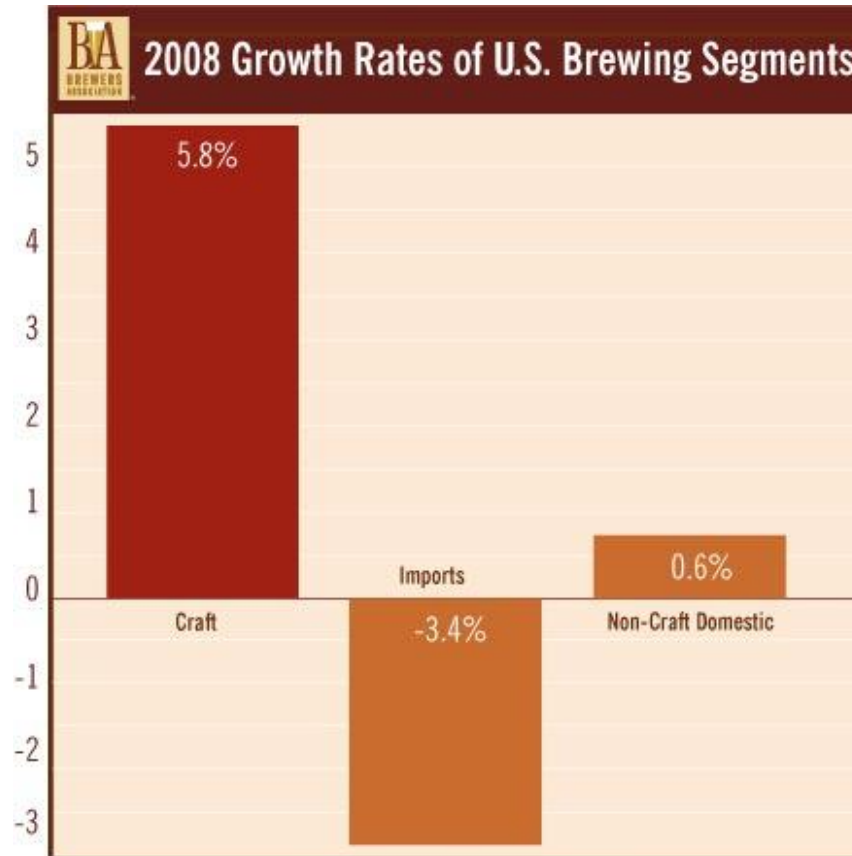


Source: Brewers Association, Boulder, CO / Contact: Julia Herr, julia@brewersassociation.org



2008 U.S. Craft Beer Growth

- Grew 5.8% by volume to 10.1 million hl and 10.5% by value to \$6.32 billion
- Large U.S. domestic breweries grew by just 0.6%
- Imports fell by 3.4%

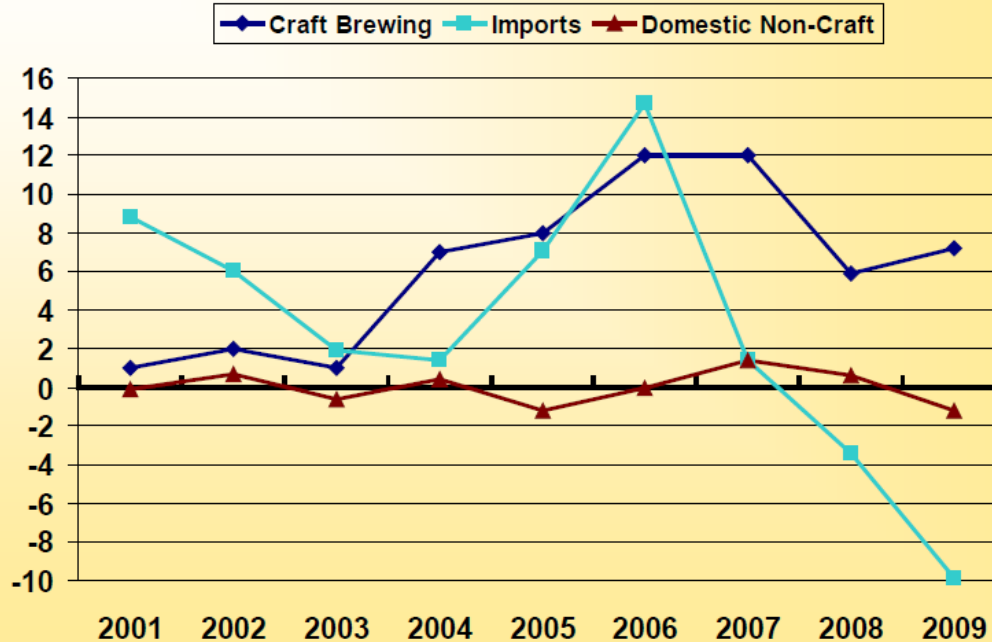




2009 U.S. Craft Beer Growth

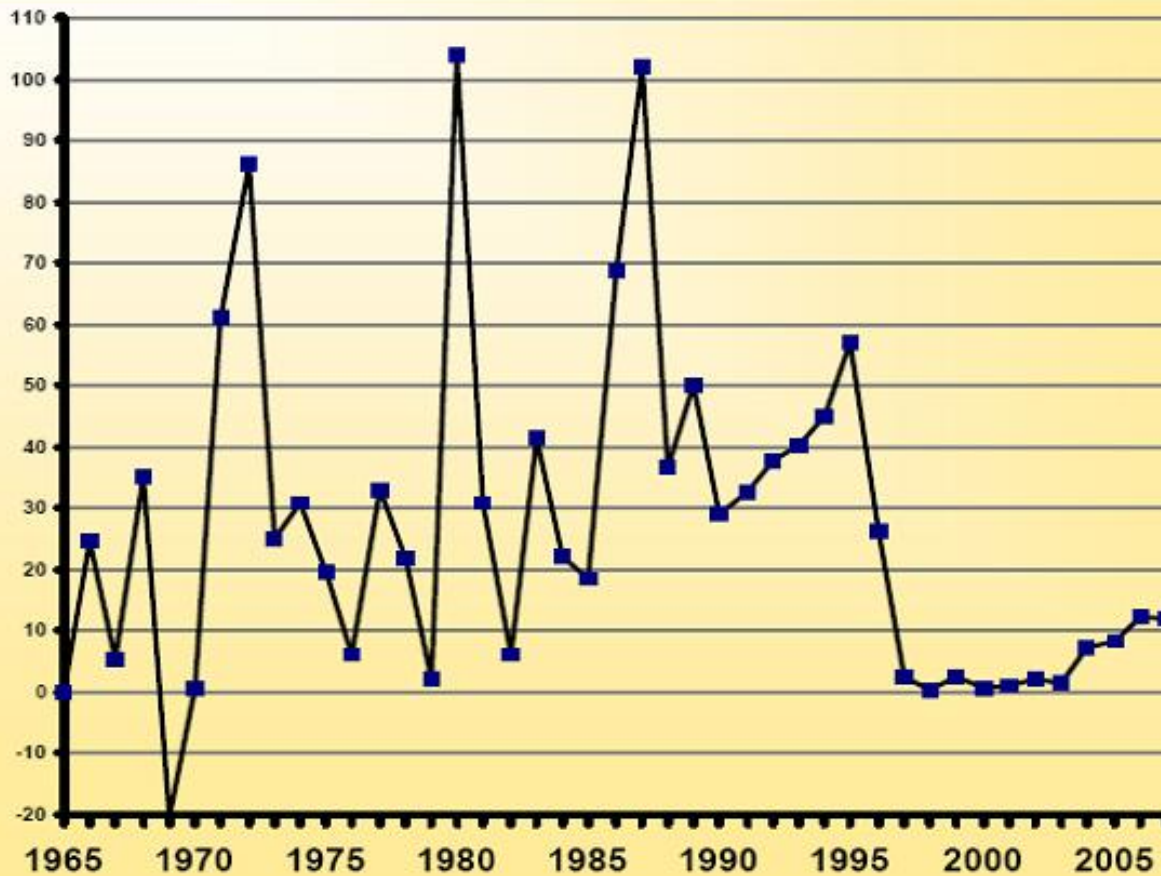
- In 2009, U.S. beer market declined 2.2% to approx \$101 billion.
- Craft breweries grew 7% by volume to 10.7 million hl and 10% by value to \$7 billion
- Craft now has 4.3% U.S. market share by volume and 6.9% market share by value

Beer Sector Percentage Growth





Total Craft Industry Percentage Annual Growth





The Top 50 Craft Brewers in America Part II

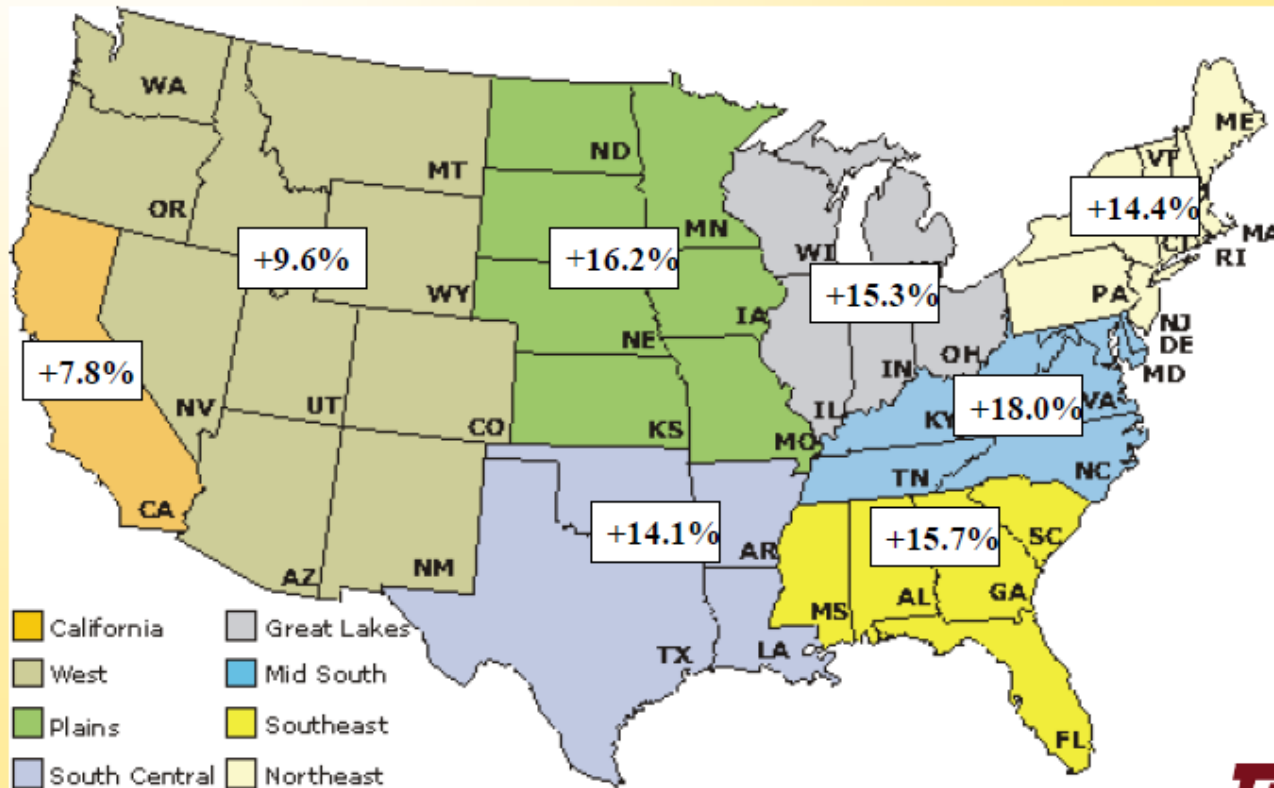


1. Boston Beer Co.
2. Sierra Nevada Brewing
3. New Belgium Brewing
4. Spoetzl Brewery
5. Pyramid Breweries
6. Deschutes Brewing
7. Matt Brewing Co.
8. Boulevard Brewing
9. Full Sail Brewing
10. Magic Hat Brewing

- | | | | | | |
|--------------------------------|---------------------------|-------------------------------------|------------------------|--|----------------------|
| 11. Alaskan Brewing Co. | - Juneau, AK | 25. Rogue Ales / Oregon Brewing Co. | - Newport, OR | 38. Gordon Biersch Brewery Restaurants | - Chattanooga, TN |
| 12. Harpoon Brewery | - Boston, MA | 26. Great Lakes Brewing Co. | - Cleveland, OH | 39. Karl Strauss Brewing Co. | - San Diego, CA |
| 13. Bell's Brewery Inc. | - Galesburg, MI | 27. The Lagunitas Brewing Co. | - Petaluma, CA | 40. Breckenridge Brewery | - Denver, CO |
| 14. Kona Brewing Co. | - Kailua, HI | 28. Firestone Walker Brewing Co. | - Paso Robles, CA | 41. Lost Coast Brewery and Cafe | - Eureka, CA |
| 15. Anchor Brewing Co. | - San Francisco, CA | 29. SweetWater Brewing Co. | - Atlanta, GA | 42. Otter Creek Brewing Co. | - Middlebury, VT |
| 16. Shipyard Brewing Co. | - Portland, ME | 30. Flying Dog Brewing Co. | - Frederick, MD | 43. Utah Brewers Cooperative | - Salt Lake City, UT |
| 17. Summit Brewing Co. | - Saint Paul, MN | 31. BJ's Restaurant & Brewery | - Huntington Beach, CA | 44. North Coast Brewing Co. | - Fort Bragg, CA |
| 18. Stone Brewing Co. | - Escondido, CA | 32. Rock Bottom Brewery Restaurants | - Louisville, CO | 45. Blue Point Brewing Co. | - Patchogue, NY |
| 19. Abita Brewing Co. | - Abita Springs, LA | 33. BridgePort Brewing Co. | - Portland, OR | 46. Boulder Beer Co. | - Boulder, CO |
| 20. The Brooklyn Brewery | - Brooklyn, NY | 34. Odell Brewing Co. | - Fort Collins, CO | 47. Pete's Brewing Co. | - San Antonio, TX |
| 21. New Glarus Brewing Co. | - New Glarus, WI | 35. Victory Brewing Co. | - Downingtown, PA | 48. McMenamins Breweries | - Portland, OR |
| 22. Dogfish Head Craft Brewery | - Milton, DE | 36. Mac and Jack's Brewery | - Redmond, WA | 49. Anderson Valley Brewing Co. | - Boonville, CA |
| 23. Long Trail Brewing Co. | - Bridgewater Corners, VT | 37. Big Sky Brewing Co. | - Missoula, MT | 50. The Saint Louis Brewery Inc. | - St Louis, MO |
| 24. Gordon Biersch Brewing Co. | - San Jose, CA | | | | |



Craft Segment Dollar Sales % Change vs YA IRI Eight U.S. Food Regions



IRI Census Data 52 Weeks Ending Dec 27, 2009

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Analysis of Beers Containing American Hops

Research done at Sierra Nevada Brewing Company



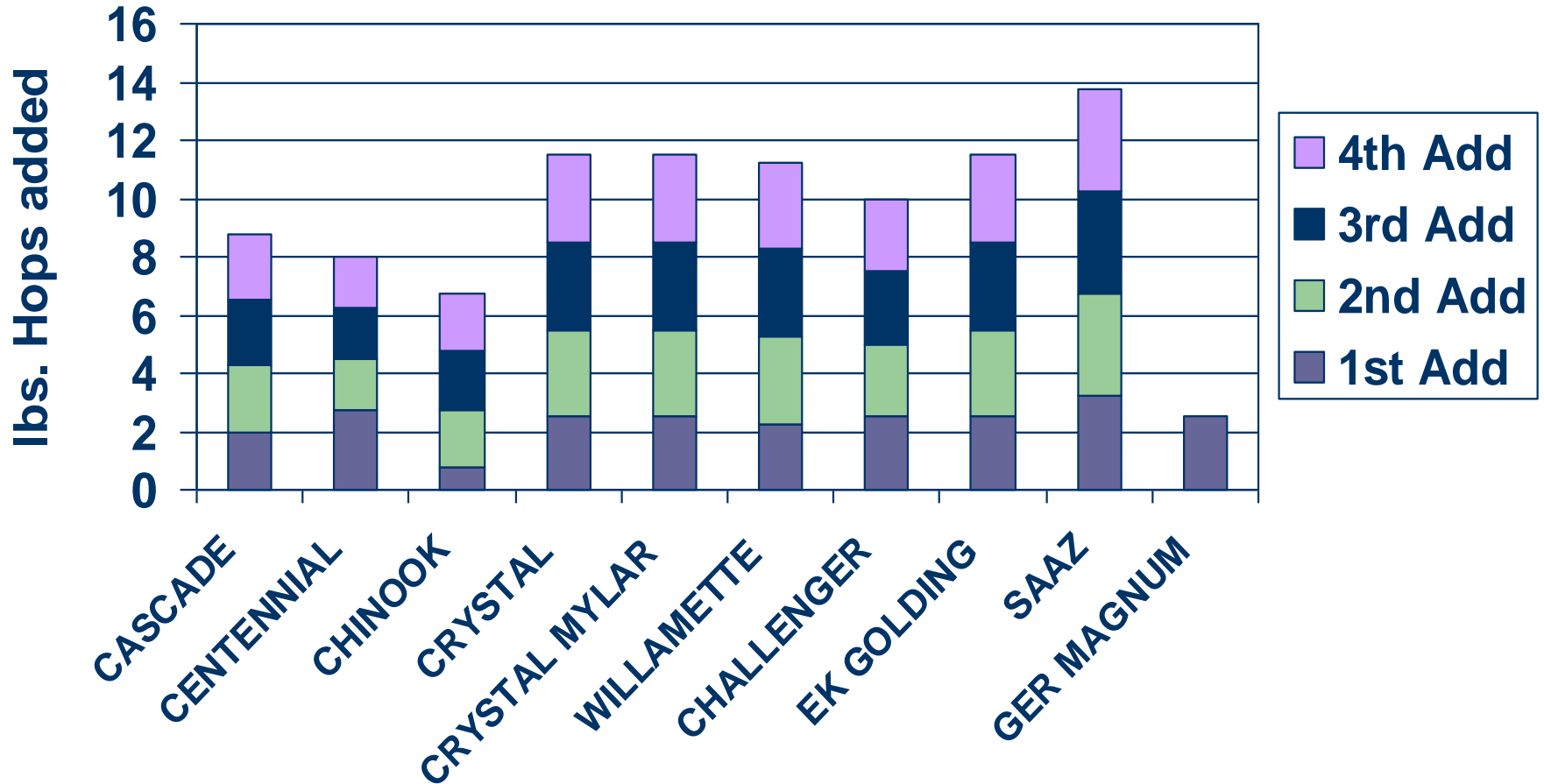


Standardization of Hop Additions

- Target 35-40 BU beer.
- Target similar oil content for all beers.
- From total oil analysis of the cone hops, more or less aroma hop was used to standardize total oil levels added to the kettle from each variety.
- Bittering German Magnum addition was adjusted or floated to compensate for the variable amounts of alpha added from the aroma hop additions.

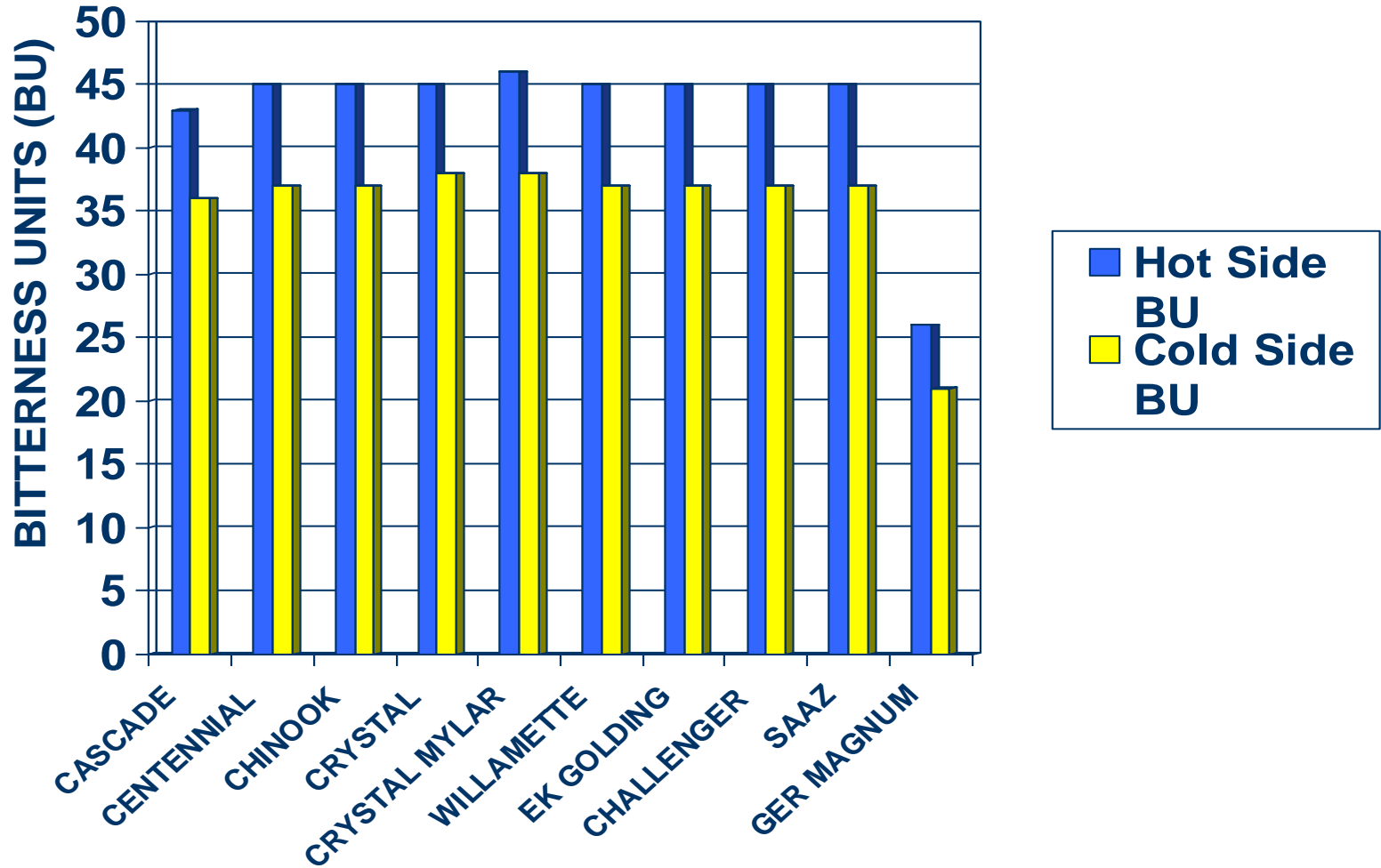


Hop Grist Formulation



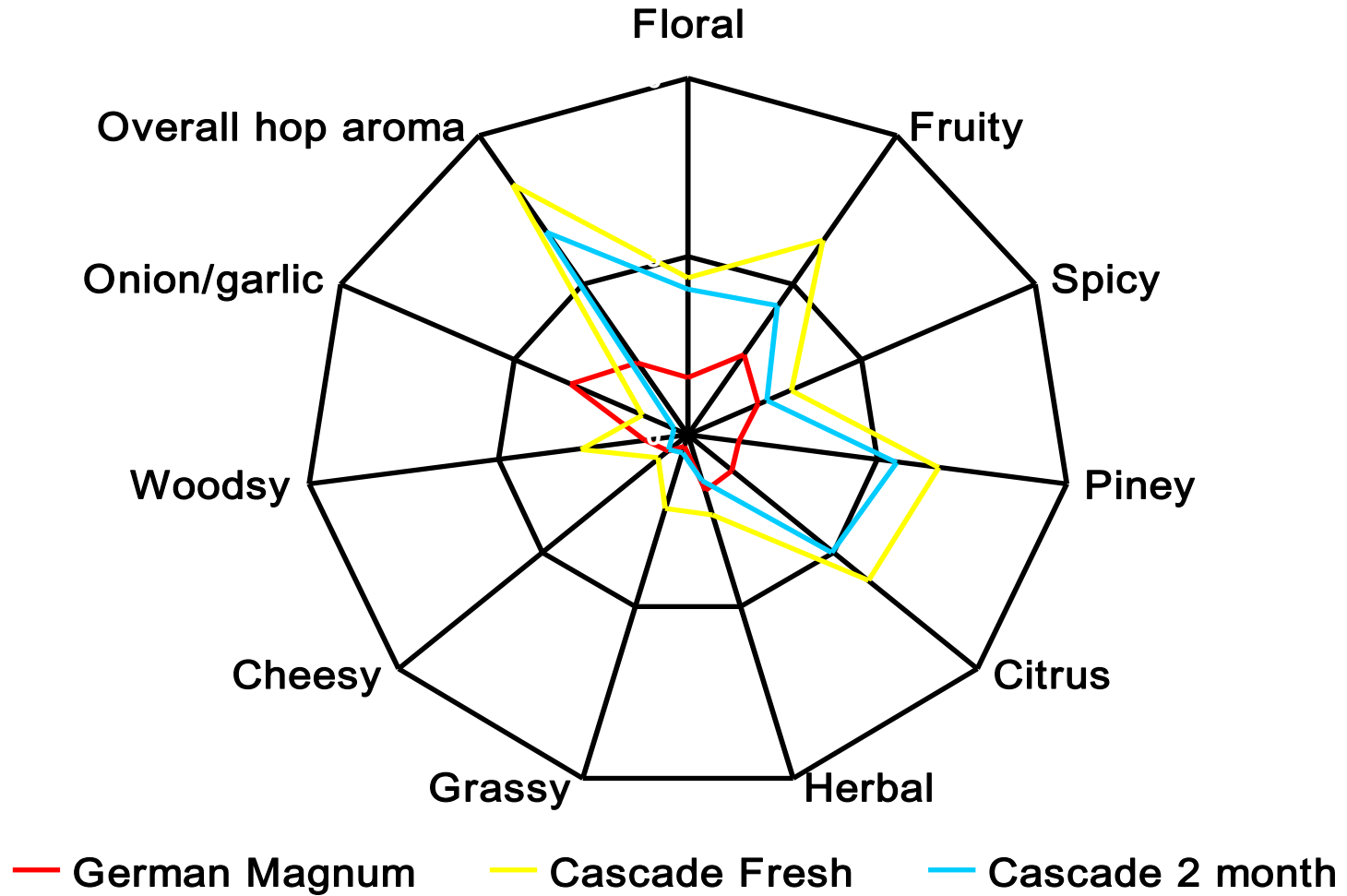


Hot and Cold Side Bitterness Units



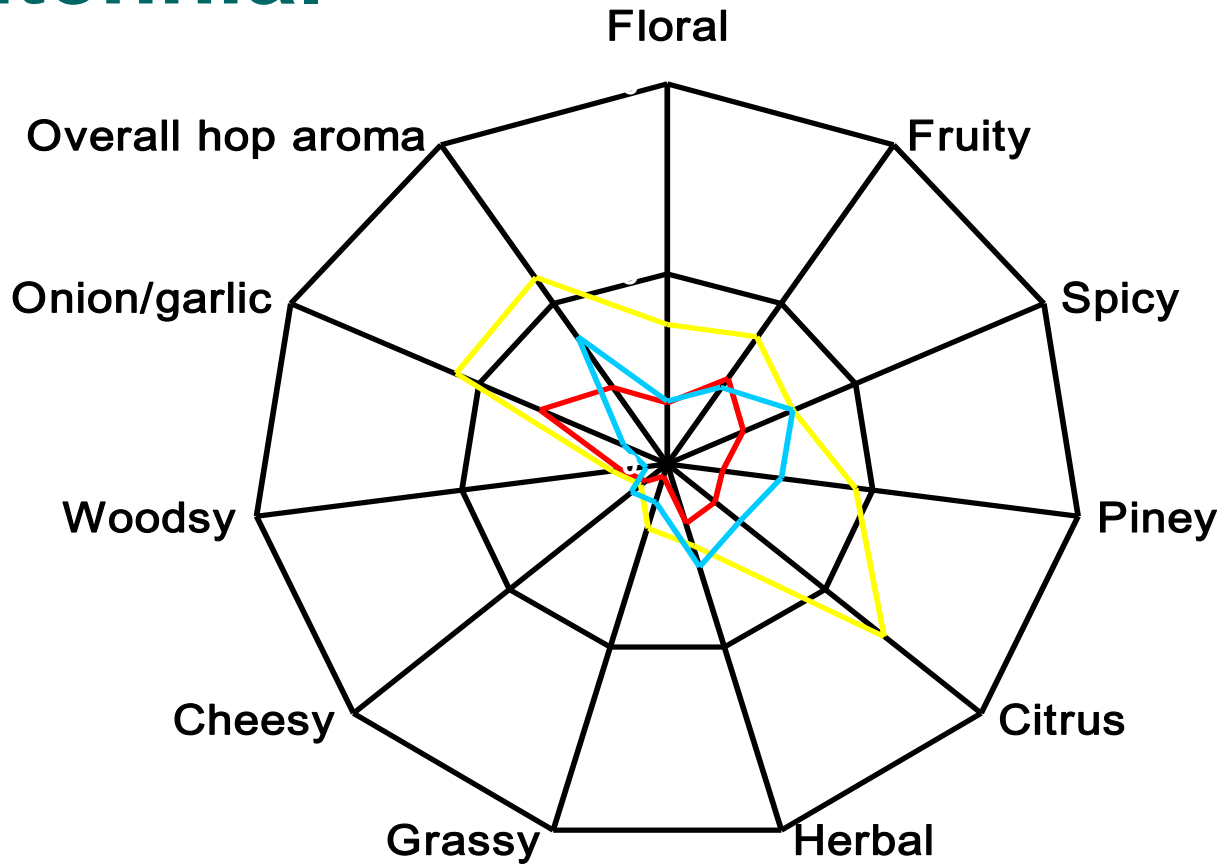


Cascade





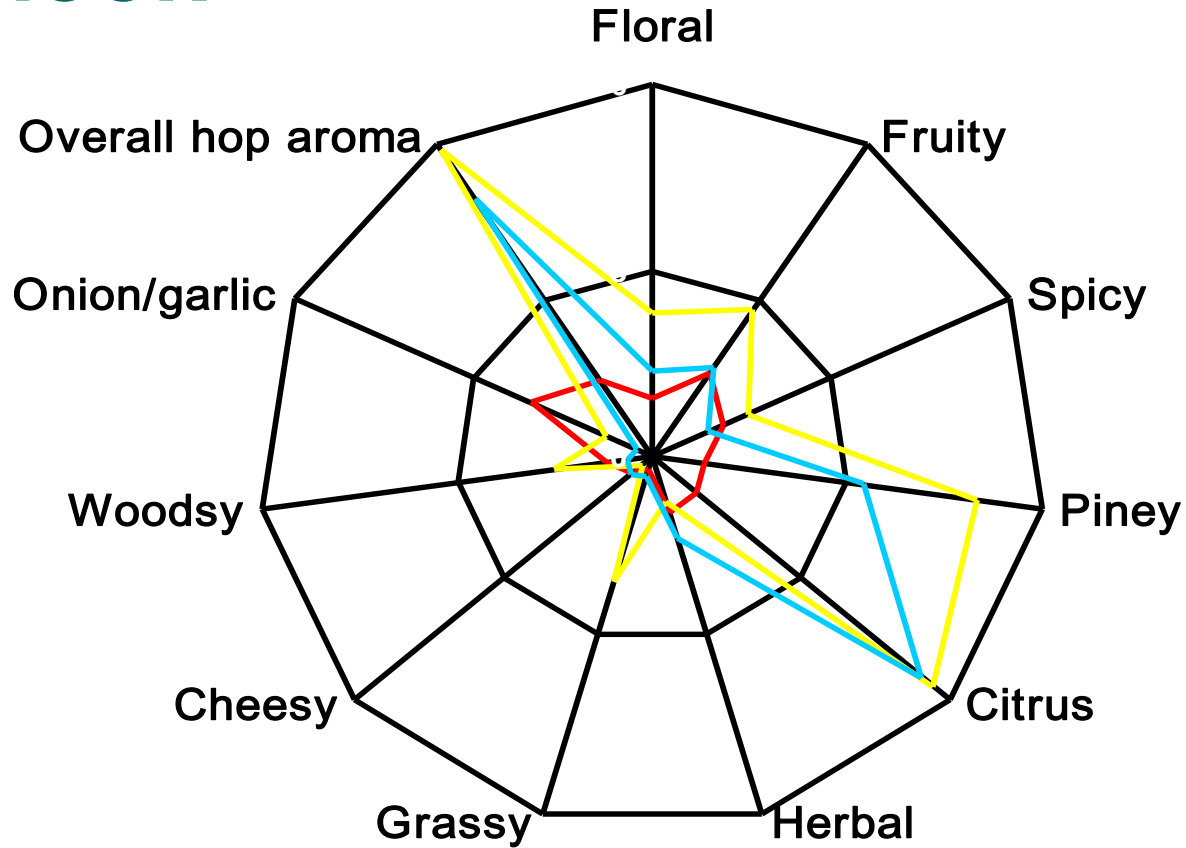
Centennial



— German Magnum — Centennial fresh — Centennial 2 month



Chinook



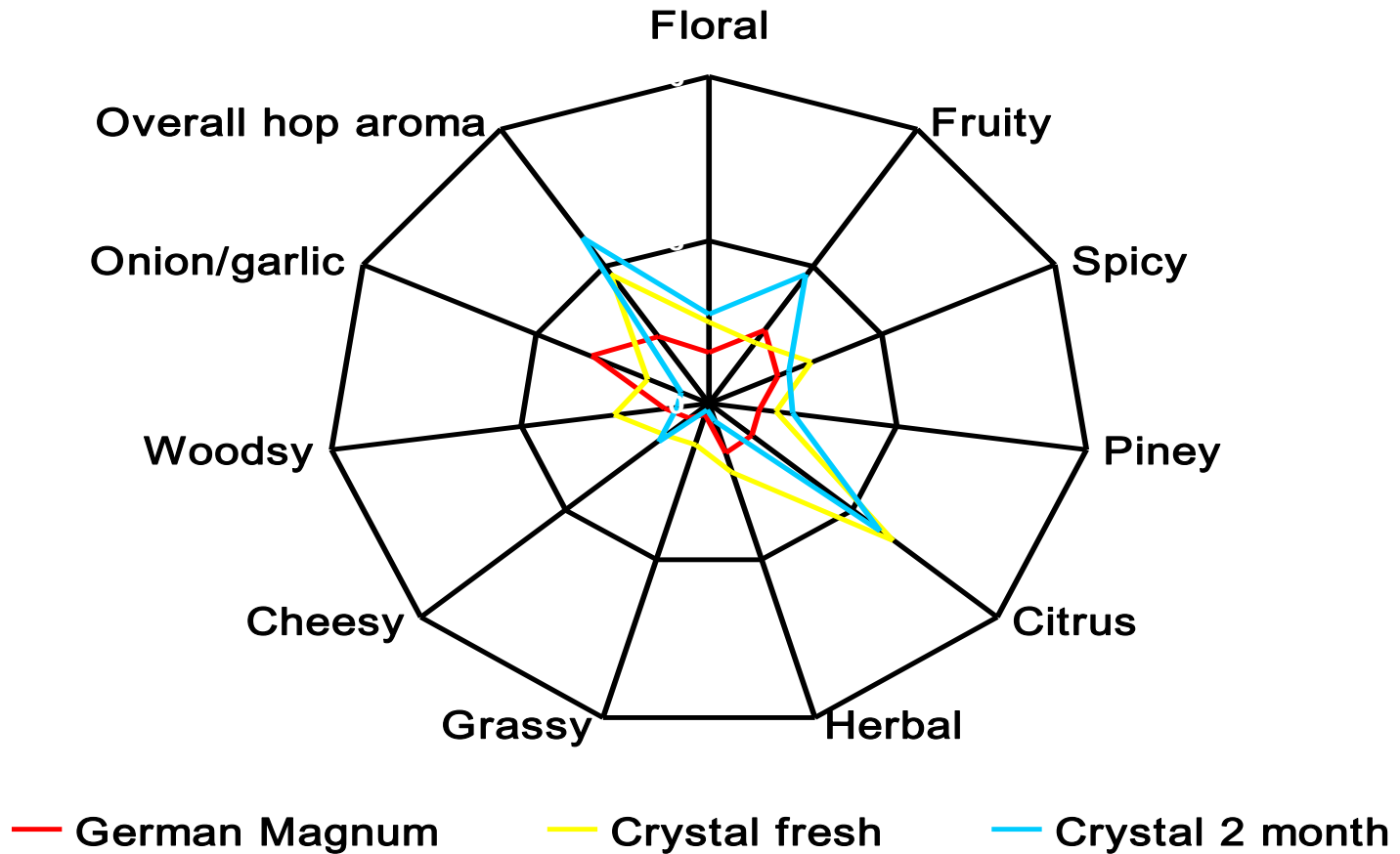
— German Magnum

— Chinook fresh

— Chinook 2 month

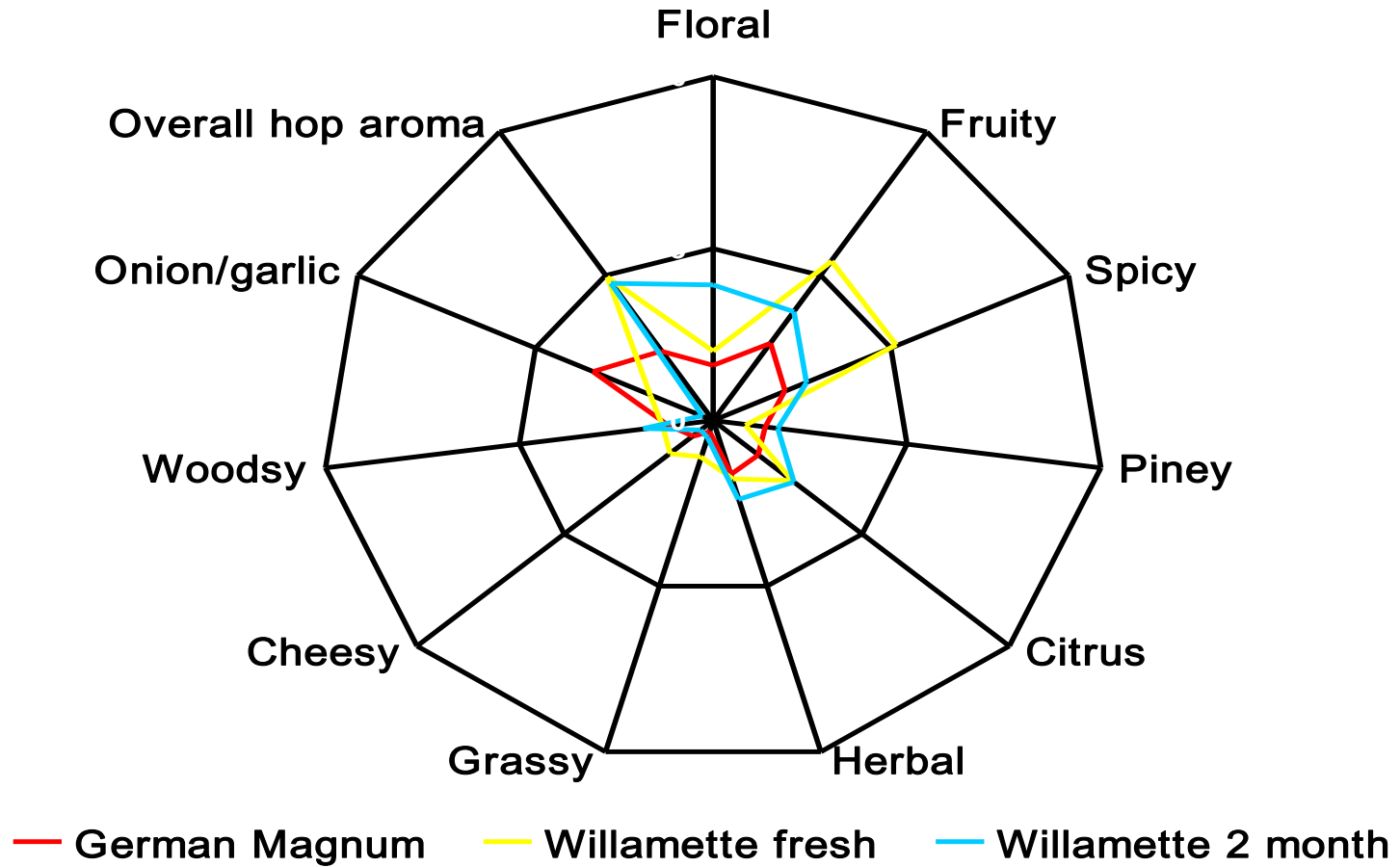


Crystal



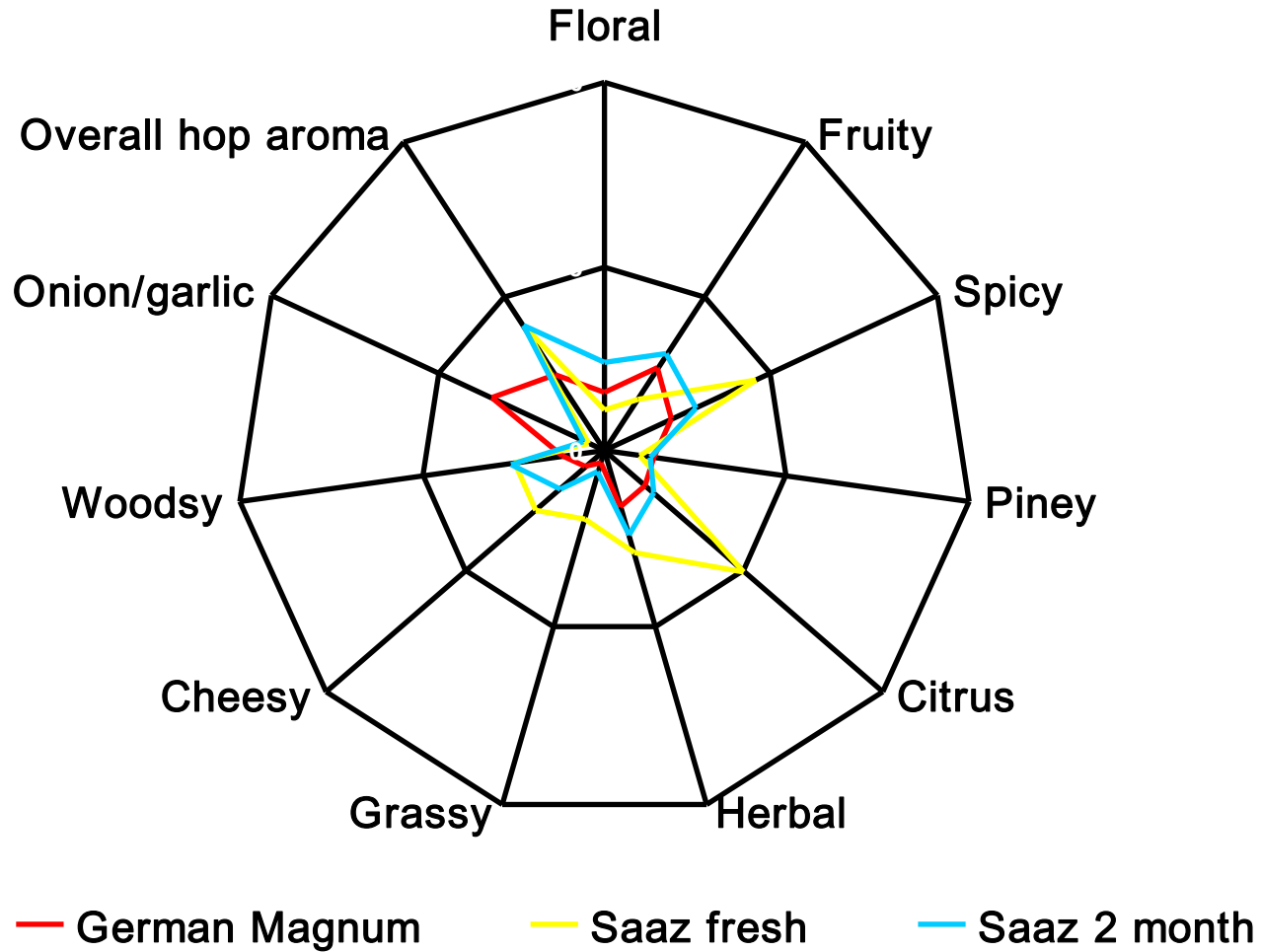


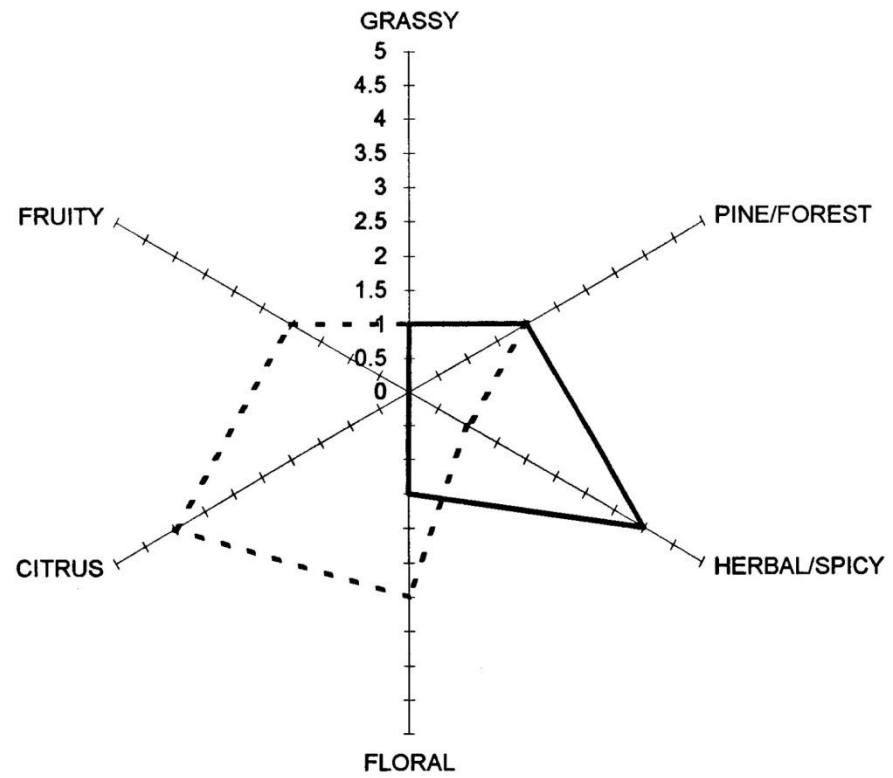
Willamette





Czech Saaz





— GERMAN HERSBRUCKER - - - DOMESTIC CHINOOK



Geraniol

Present

- Citra
- Cascade
- Centennial
- Chinook
- Pacific Hallertau
- Southern Cross
- Motueka
- Aurora
- Styrian Golding

Not Present

- UK Challenger
- US Challenger
- Alsace Strisselspalt
- Spalt Select
- Sterling
- Czech Saaz
- Millenium
- German Magnum



4-methyl-4-mercapto-2-pentanone (4-MMP)

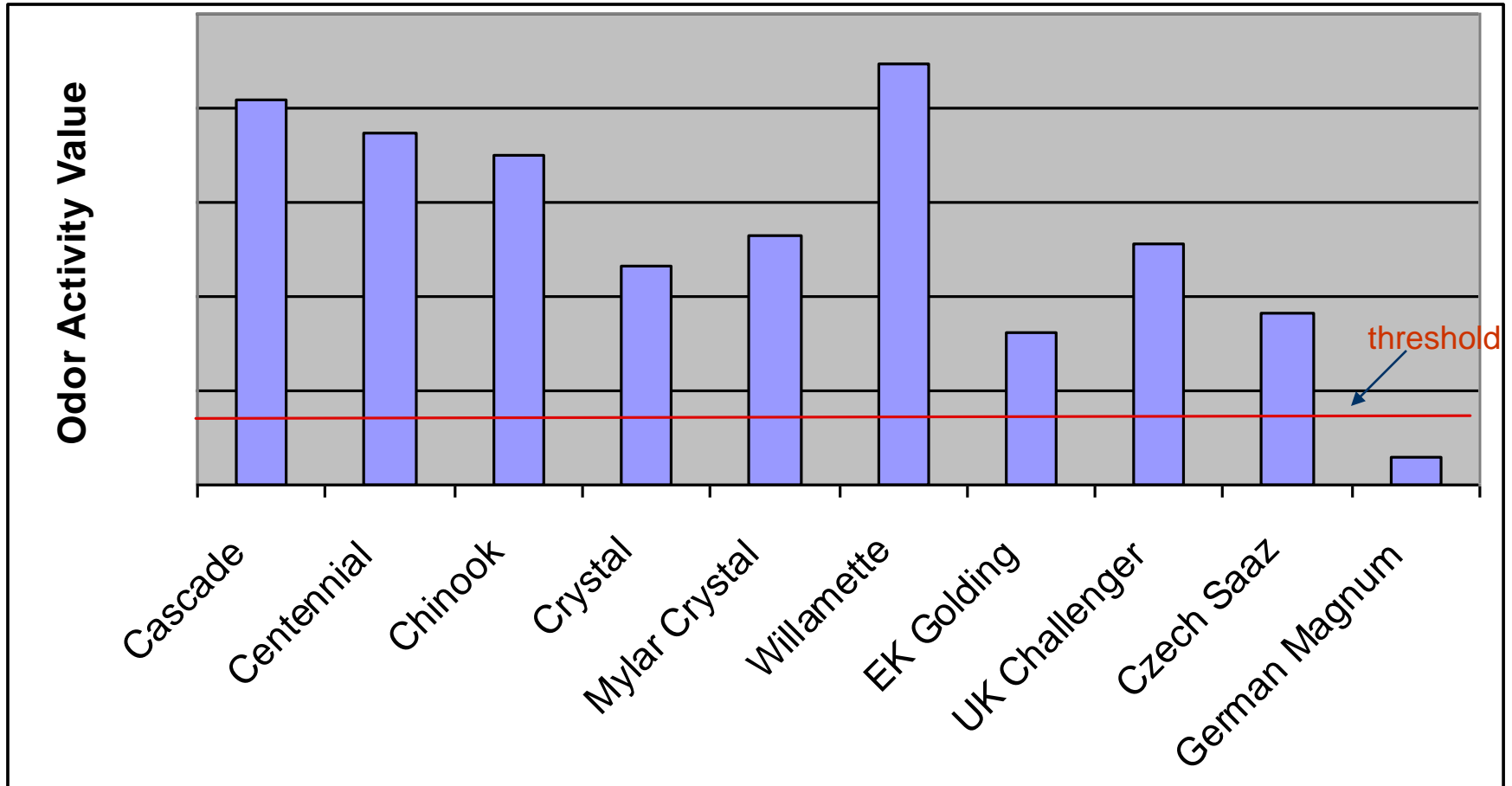
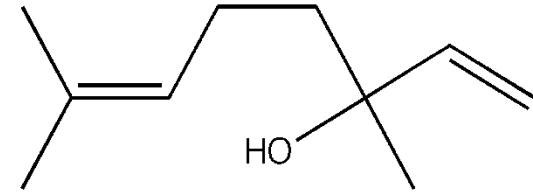
Occurs in

- Citra
- Cascade
- Chinook
- Simcoe
- Summit
- Apollo
- Topaz
- Kishimoto (Asahi)
 - Correlates high copper content of European hops and lack of 4-MMP.
 - New American varieties have little to no copper ions and contain significant amounts of 4-MMP and like compounds.



Linalool : Floral

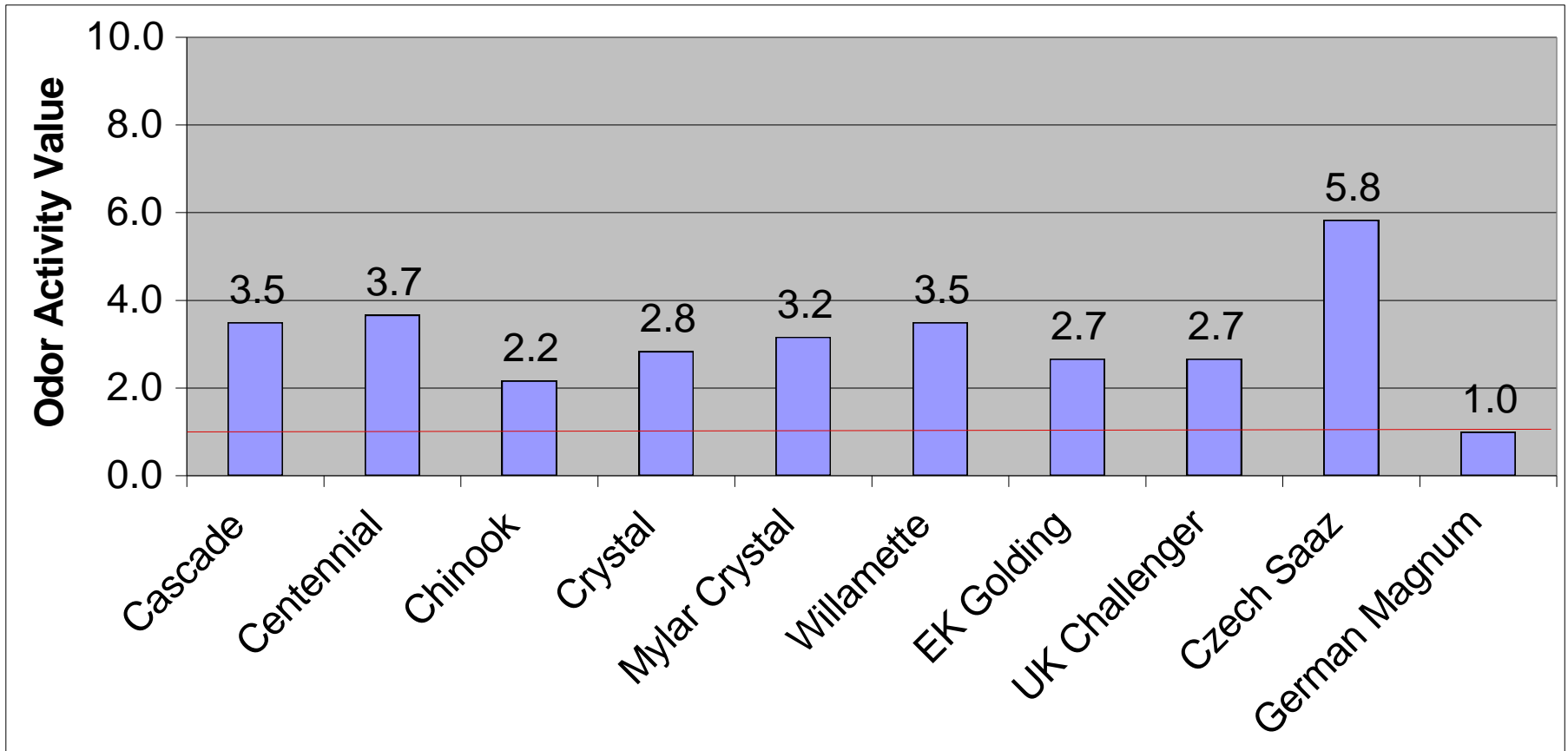
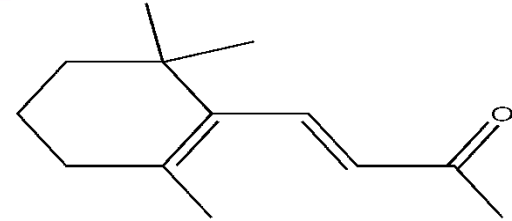
Threshold in beer ~ 10 ug/L





β -Ionone : Floral

Threshold in beer = 0.06 ug/L





Top 20 Hop Varieties Used by Craft Brewers

1. Cascade (US)
2. Centennial (US)
3. Willamette (US)
4. Columbus (US)
5. Chinook (US)
6. Sterling (US)
7. Saaz (CZ)
8. East Kent Golding (UK)
9. Amarillo (US)
10. Simcoe (US)
11. Hallertau Hersbrucker (GR)
12. East Kent Golding (UK)
13. Warrior (US)
14. Nugget (US)
15. Liberty (US)
16. Hallertau Mittelfrueher (GR)
17. Styrian Golding (SL)
18. Magnum (US)
19. Mt. Hood (US)
20. Perle (GR)



Varieties By Oil Content

MOXEE, WASHINGTON

Variety	Alpha Acids (% wt)	Beta Acids (% wt)	Total Oil (% wt)	Myrcene (% total oil)	Humulene (% total oil)	Caryophyllene (% total oil)	Farnesene (% total oil)	Myrcene (% wt)	Sesquiterpeno ids (% wt)	H / C ratio	Alph/Beta Ratio
ADHA484	13.25	3.90	0.50	3.2	23.49	11.91	0.25	0.02	0.18	1.97	3.40
Hallertau, GR	4.50	3.50	1.00	15.0	32.50	8.50	1.00	0.15	0.42	3.82	1.29
ADHA483	15.14	4.97	0.70	18.7	28.01	13.38	0.25	0.13	0.29	2.09	3.05
Spalt, GR	4.50	4.50	0.80	20.0	21.50	12.50	12.50	0.16	0.37	1.72	1.00
Saaz, Czech	3.80	3.80	0.60	22.5	42.50	11.00	13.00	0.14	0.40	3.86	1.00
Tettnang, GR	4.50	4.30	0.80	22.5	22.50	8.00	14.00	0.18	0.36	2.81	1.05
Vanguard, US	5.80	6.50	1.10	22.5	47.50	13.00	1.00	0.25	0.68	3.65	0.89
Golding (Kent), UK	4.80	2.80	0.80	23.0	45.00	14.00	1.00	0.18	0.48	3.21	1.71
Fuggie, UK	4.80	2.50	1.10	26.0	37.50	12.00	6.00	0.29	0.61	3.13	1.92
Saaz, US	3.80	3.80	0.80	27.5	37.50	12.00	11.00	0.22	0.47	3.75	1.00
Golding, US	4.50	2.50	0.80	27.5	40.00	12.50	1.00	0.22	0.43	3.20	1.80
Liberty, US	4.00	3.50	0.90	30.0	37.50	10.50	1.00	0.27	0.44	3.57	1.14
Santiam, US	6.00	7.00	1.40	31.5	24.50	7.50	14.50	0.44	0.65	3.27	0.86
Magnum, US	13.00	5.30	2.10	32.5	37.00	10.00	1.00	0.68	1.01	3.70	2.45
Millennium	15.5	4.8	2.0	35.0	25.0	10.5	0.5	0.70	0.72	2.38	3.23
Bravo, US	15.5	3.5	2.00	37.5	19.00	11.00	0.25	0.75	0.61	1.73	4.43
Brewer's Gold, US	9.00	4.00	2.20	38.5	30.00	7.30	1.00	0.85	0.84	4.11	2.25
Hallertau, US	4.50	4.50	0.80	39.5	34.00	11.00	1.00	0.32	0.37	3.09	1.00
Herkules, GR	14.5	4.8	2.0	40.0	37.5	9.5	0.3	0.80	0.95	3.95	3.05
Summit	16.5	5.0	2.0	40.0	20.0	12.5	0.5	0.80	0.66	1.60	3.30
Apollo, US	17.00	6.75	2.00	40.0	27.50	17.00	0.25	0.80	0.90	1.62	2.52
Chinook, US	13.0	3.5	2.2	40.0	20.50	10.00	0.50	0.88	0.68	2.05	3.71
Tettnang, US	4.50	3.50	0.60	40.5	20.50	6.50	6.50	0.24	0.20	3.15	1.29
Fuggie, US	4.80	1.80	1.00	45.0	23.00	8.00	4.50	0.45	0.36	2.88	2.67
Columbus, US	15.50	4.50	2.50	45.0	15.00	10.00	0.25	1.125	0.63	1.50	3.44
Hallertau, NZ,	8.00	6.30	1.00	46.5	11.00	6.00	5.00	0.47	0.22	1.83	1.27
Cluster, US	7.00	5.00	0.60	50.0	16.50	6.50	1.00	0.3	0.14	2.54	1.40
Willamette, US	5.00	3.50	1.30	50.0	25.00	7.50	5.50	0.65	0.49	3.33	1.43
Centennial, US	10.50	4.00	1.90	50.0	14.00	6.50	1.00	0.95	0.41	2.15	2.63
Ahtanum, US	6.00	5.80	1.00	52.5	18.00	10.50	1.00	0.53	0.30	1.71	1.03
Cascade, US	5.80	5.80	1.20	52.5	13.00	4.50	6.00	0.63	0.28	2.89	1.00
Crystal, US	4.5	5.5	1.3	52.5	21.00	6.00	1.0	0.66	0.35	3.50	0.82
Galena Super, US	14.5	9.0	2.0	52.5	21.5	10.0	0.5	1.05	0.64	2.15	1.61
Pacific Gem, NZ,	15.00	8.20	1.40	55.0	18.00	7.00	1.00	0.77	0.36	2.57	1.83
Nugget, US	13.00	5.00	2.00	55.0	17.00	8.50	1.00	1.10	0.53	2.00	2.60
Galena, US	12.5	8.0	1.1	57.5	11.5	5.0	1.0	0.63	0.19	2.30	1.56



Popular American Dry Hop Varieties

Variety (% total oil)

- Cascade (0.8-1.5%)
- Centennial (1.5-2.3%)
- Columbus/Tomahawk/Zeus (1.5-2%)
- Chinook (1.5-2.5%)
- Simcoe # (2-2.5%)
- Amarillo # (1.5-1.9%)
- Ahtanum # (0.8-1.2%)
- Crystal (1.0-1.5%)
- Summit # (2-2.5%) %

Total oil for some traditional aroma Varieties utilized for dry hopping

- Saaz (0.4-0.7%)
- East Kent Golding (0.6-1%)
- Styrian Golding (0.5-1%)

Descriptor

- Geraniums, Alfalfa, Citrus, Floral
- Juicy Fruit, Trix, Fruity, Citrus
- “Dank”, Onion, Garlic, Spicy
- Piney, Peppery, Spruce, Catty
- Pineapple, Grapefruit, “Grungy”
- Apricot, Peach, Fruity
- Citrus, Resiny, Fruity
- Spicy, Peppery, Fruity
- Tangerine, Onion, “Dank”

“Onion” is a sulferous aroma note associated with the compound dimethyl trisulfide (DMTS) found in hops^{4,15}



Defining “Hoppy” Characteristics

- Traditional European Hop Aroma
 - “Nobel” Hop Aroma – Woody, Deep-Rich Resin Like
 - Centering on the oxidized sesquiterpenoids
 - α -humulene, β -caryophyllene and β -Farnesene
 - H/C (humulene / caryophyllene) ratios of 3/1 or higher
 - Flavor stable hop oil compounds
 - Jean De Clerck wrote in A Textbook of Brewing “American hops are characterized by a rather **fruity** flavor which is unsuitable for European beer.”
 - Classic European hop varieties-
 - *Hallertauer Mittelfrueh, Tettnanger, Spalter, and Saaz*



Defining “Hoppy” Characteristics

- New American Craft Brewer “Hoppy” Aroma
 - Fruity, Flowery with some Sulfur-Containing Hop Notes
 - Monoterpene / light oil character
 - Less flavor stable hop oil components
 - No established hop oil ratio to utilize as a selection aid
 - Potential marker oils
 - Limonene, **Linalool**, and Geraniol
 - Selection of high total oil % cultivars popularized by American Craft Brewers



Hop Oils

Associated with American Hops

A world of flavors to offer

- Monoterpenoids
 - Myrcene- Spicy
 - Linalol- Floral
 - Geraniol- Floral
 - Limonene- Citrus, fruity
 - Terpineol- Woody, resinous
 - Pinene- Spicy, Piney
 - Citral- Citrus
 - Cadinene- Citrus
 - Associated with fresh / non-oxidized dry hop aroma
- Sesquiterpenoids
 - Humulene
 - Caryophyllene
 - Humulene epoxide
 - When in oxidized form they are associated with “hoppy” “noble”



Brewing with American Hops

- High Alpha vs. Aroma

- Use of aroma varieties for the bittering charge
- Some mash & “first wort” hopping to achieve more complex aroma and flavor
- Aroma hops in beginning of boil
- Deletion of / or reduction of middle additions
- Large late kettle, whirl-pool or hop back additions

- Dry Hopping

- Use of Hop Backs

- Hot side (Brewhouse) and cold side (cellar)

- Fresh or Wet Hop Beers

- Other unique practices

- Dogfish Head (continuous hopping & the “Randall”)



Whirl-pool Hopping





Hop Backs





Dry Hopping with Pellets



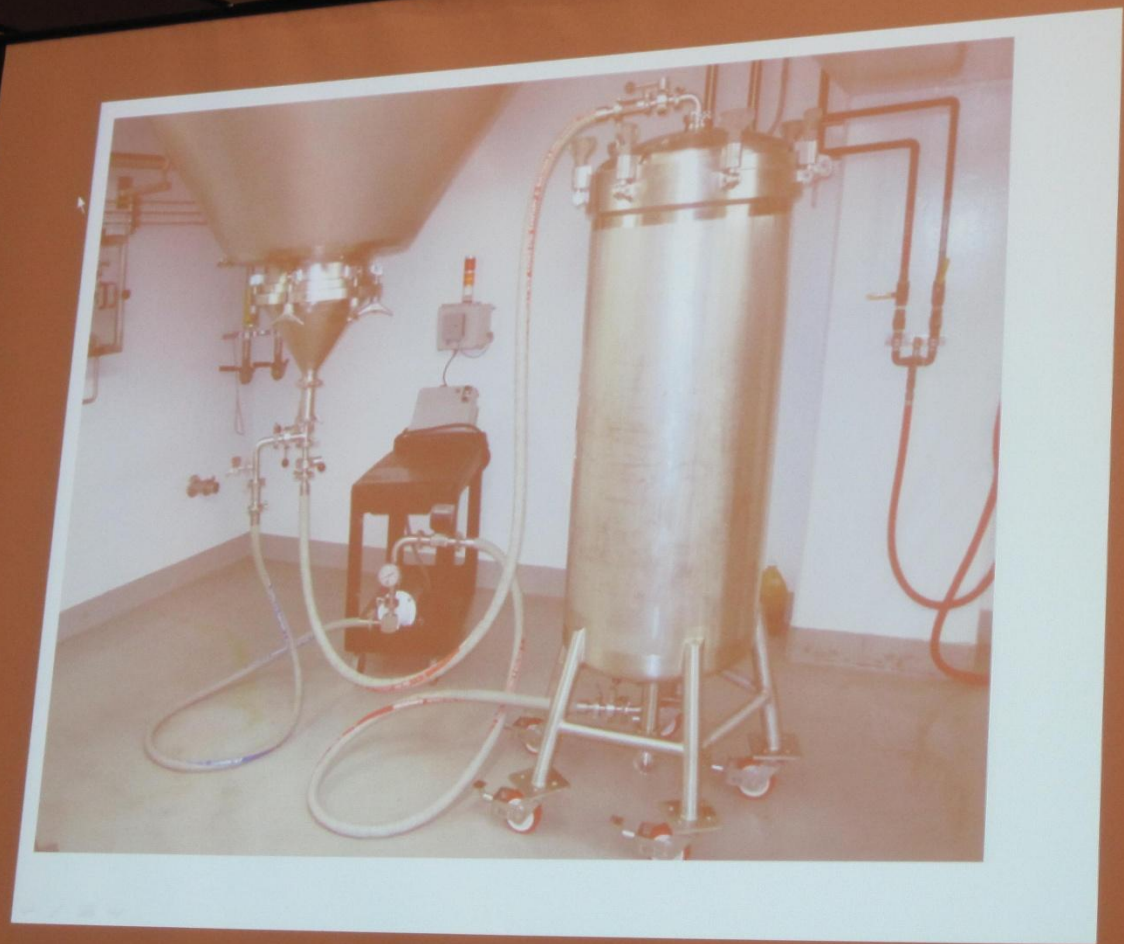






QUALITY
VARIETY
TRADITION







QUALITY
VARIETY
TRADITION





Dry- Hopping Considerations

- Selection of best (new crop year) aroma varieties
 - Blending hops for consistency and complexity
- Yeast Activity
 - Rousing with CO2 to help control DO and mix
- Temperature Considerations (warm or cold?)
 - Extraction better at elevated temperatures
- Emphasis on low dissolved oxygen (DO)
- Removal of yeast plug prior to dry hopping
- Contact time
 - Short contact time (3-4 days) vs. Long contact time (4-14days)
- Sanitary technique
- Effect on clarification and filtration of beer
- Blending of beers at finishing



Microbiological Considerations

Organisms found in hops and dry hopped beer

- Enterobacter
 - Gram negative rod
 - Catalase positive
 - Facultative anaerobe
 - Found easily in brewery environmental samples
 - 1st organism to take hold in spontaneous-fermentation programs
 - Typically dies in beer
 - Histamine producer
 - Non Beer-Spoiler
- Bacillus
 - Gram positive rod
 - Catalase positive
 - Facultative anaerobe
 - Found in dirt and plant material
 - Common in barley and malt
 - Spore former which can survive boil and other extreme environments
 - Non Beer-Spoiler

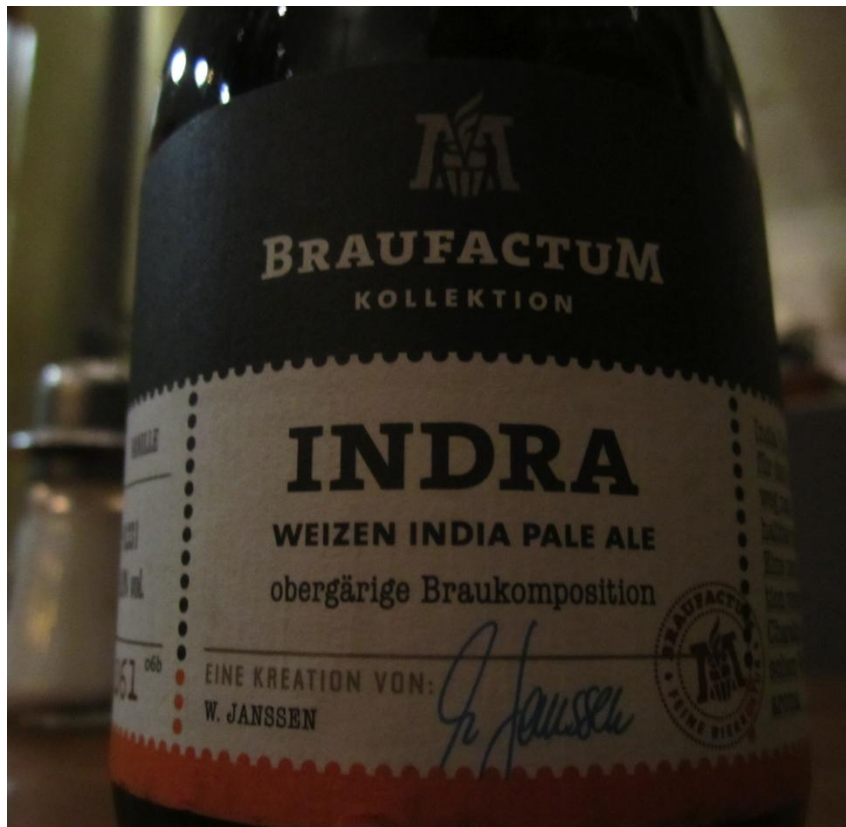


Hop Oils Associated with American Hops A world of flavors to Offer

- Monoterpenoids
 - Myrcene- Spicy
 - Linalol- Floral
 - Geraniol- Floral
 - Limonene- Citrus, fruity
 - Terpineol- Woody, resinous
 - Pinene- Spicy, Piney
 - Citral- Citrus
 - Cadinene- Citrus
 - Associated with fresh / non-oxidized dry hop aroma
- Sesquiterpenoids
 - Humulene
 - Caryophyllene
 - Humulene epoxide
 - When in oxidized form they are associated with “hoppy” “noble”



Non- Traditional Weizenbeir made in Germany





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Thank you for your kind attention!

