Discovering Hops, February 24th 2007

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Alpha acids aren't very soluble in wort. When wort is boiled with hops, the alpha acids undergo a chemical reaction called isomerization. The now isomerized alpha acids are soluble in wort, and these iso-alpha acids are what transmit bitterness in the finished beer.

Hops also contain a second group of acids called the beta acids. Beta acids are not bitter and are generally ignored by brewers. Their significance comes into play when analyzing the characteristics of different hop varieties.

In addition to alpha acids, hops also contain essential oils. These hop oils are responsible for the hop aroma and flavour in finished beer. These oils are extremely volatile, meaning that they evaporate very quickly at elevated temperatures. Most of these hop oils are lost within minutes when added to the boil. The heat of the boil changes the character of these oils as well. These oils can influence mouthfeel (body) perception. The major hop oil constituents of significance are myrcene, humulene, and caryophyllene.

There are 4 recognized "noble" hop varieties: Hallertauer Mittelfrüh, Tettnang Tettnanger, Czech Saaz and Spalt Spalter. To be a true noble hop, they must be grown in the correct region. Tettnanger grown anywhere outside of the Tettnang region is not a true noble hop. The qualities that the noble hops have in common are an alpha/beta acid ratio of about 1:1, relatively low alpha and beta acids (approx. 2 – 5%), low cohumulone content, low myrcene in the hop oil (typically < 50%), high humulene in the oil, a ratio of humulene to caryophyllene > 3, and relatively poor storage characteristics.

Czech Saaz α: 3.3% β: 3 – 4% (typical) α/β: 1 (typical) Cohumulone % (typical): 24 – 28% Total Oil % (typical): 0.4 – 0.7% Myrcene % (typical): 20 – 25% Humulene % (typical): 40 – 45% Humulene/Caryophyllene: 3.8	Aroma: Some spice, low perfume
	Flavour: Low spice, low perfume
Tettnanger (German) α: 2.3% β: 3.5 – 5% (typical) α/β: 1 (typical) Cohumulone % (typical): 23 – 29% Total Oil % (typical): 0.6 – 1% Myrcene % (typical): 20 – 25% Humulene % (typical): 20 – 25% Humulene/Caryophyllene: 3	Aroma: Spicy, earthy
	Flavour: Tea, mint, lemon
Tettnang (US) α: 4.1% β: 3 – 4% (typical) α/β: 1.3 (typical) Cohumulone % (typical): 20 – 25% Total Oil % (typical): 0.4 – 0.8% Myrcene % (typical): 36 – 45% Humulene % (typical): 18 – 23% Humulene/Caryophyllene: 3.1	Aroma: Earthy, spice, no mint
	Flavour: Earthy, some small spice

Tradition (German – version of Mittelfrüh) α: 5.8% β: 4 – 5% (typical) α/β: 1.3 (typical) Cohumulone % (typical): 26 – 29% Total Oil % (typical): 1 – 1.4% Myrcene % (typical): 20 – 25% Humulene % (typical): 45 – 55% Humulene/Caryophyllene: 4.1	Aroma: Lemon, perfume, tea, subdued earthiness Best so far Flavour: Same as aroma, balanced
Hersbrucker (German) α: 2.8% β: 4 – 5.5% (typical) α/β: 1 (typical) Cohumulone % (typical): 19 – 25% Total Oil % (typical): 0.7 – 1.3% Myrcene % (typical): 15 – 25% Humulene % (typical): 15 – 25% Humulene/Caryophyllene: 2.1	Aroma: Spicy, low earth, low lemon Now best Flavour: Spicy, low lemon
Hallertauer T-45 (German) α: 8.0% β: 3 – 4% (typical) α/β: 2 (typical) Cohumulone % (typical): 17 – 24% Total Oil % (typical): 0.7 – 1.3% Myrcene % (typical): 10 – 20% Humulene % (typical): 30 – 35% Humulene/Caryophyllene: 3.8	Aroma: Sweet tea, earthy, low candy good Flavour: Sweet tea, earthy, candy, mint

Organic Hallertauer (New Zealand) α: 8.8% β: 6 – 6.5% (typical) α/β: 1.3 (typical) Cohumulone % (typical): 35% Total Oil % (typical): 0.9 – 1.1% Myrcene % (typical): 45 – 48% Humulene % (typical): 10 – 12% Humulene/Caryophyllene: 1.8	Aroma: Lemon, perfume, tea English bitter
	Flavour: Mild citrus, some earthy character, woody
Spalt (German) α: 3.3% β: 4 – 5.5% (typical) α/β: 1.0 (typical) Cohumulone % (typical): 22 – 28% Total Oil % (typical): 0.5 – 1.1% Myrcene % (typical): 15 – 25% Humulene % (typical): 18 – 20% Humulene/Caryophyllene: 1.7	Aroma: Spicy, lemon, “Belgian”
	Flavour: Mild rich spice, some earthy
Santium (US) α: 5.1% β: 6 – 8% (typical) α/β: 0.9 (typical) Cohumulone % (typical): 22 – 24% Total Oil % (typical): 1.3 – 1.5% Myrcene % (typical): 27 – 36% Humulene % (typical): 23 – 26% Humulene/Caryophyllene: 3.3	Aroma: Spicy, aromatic, perfume, smells like Becks Good for European lagers
	Flavour: Spicy, flowery

Northern Brewer (German) α: 5.5% β: 3 – 5% (typical) α/β: 2 (typical) Cohumulone % (typical): 28 – 33% Total Oil % (typical): 1.6 – 2.1% Myrcene % (typical): 30 – 35% Humulene % (typical): 25 – 30% Humulene/Caryophyllene: 3.5	Aroma: Citrus (can't identify), wood, earthy
	Flavour: Citrus, some earth, oak?
Strisselspalt (France) α: 1.8% β: 3 – 5.5% (typical) α/β: 1 (typical) Cohumulone % (typical): 20 – 25% Total Oil % (typical): 0.6 – 0.9% Myrcene % (typical): 20 – 30% Humulene % (typical): 15 – 25% Humulene/Caryophyllene: 2.2	Aroma: Tea, perfume
	Flavour: Green tea
Ahtanum (US) α: 5.4% β: 5 – 6.5% (typical) α/β: 1 (typical) Cohumulone % (typical): 30 – 35% Total Oil % (typical): 0.8 – 1.2% Myrcene % (typical): 50 – 55% Humulene % (typical): 16 – 20% Humulene/Caryophyllene: 1.7	Aroma: Candy, some citrus
	Flavour: Earthy, spice, pepper

Glacier (US) α: 4.9% β: 8.2% (typical) α/β: 0.6 (typical) Cohumulone % (typical): 11 – 13% Total Oil % (typical): 0.7 – 1.6% Myrcene % (typical): 33 – 62% Humulene % (typical): 24 – 36% Humulene/Caryophyllene: 3.6	Aroma: Grapefruit & perfume
	Flavour: Grapefruit, perfume, clean, well rounded
Amarillo (US) α: 8.0% β: 6 – 7% (typical) α/β: 1.5 (typical) Cohumulone % (typical): 21 – 24% Total Oil % (typical): 1.5 – 1.9% Myrcene % (typical): 68 – 70% Humulene % (typical): 9 – 11% Humulene/Caryophyllene: 3.5	Aroma: Big citrus like cascade Very nice
	Flavour: Big grapefruit, not sharp, very rounded
Galena (US) α: 13.0% β: 7 – 9% (typical) α/β: 1.6 (typical) Cohumulone % (typical): 38 – 42% Total Oil % (typical): 0.9 – 1.2% Myrcene % (typical): 55 – 60% Humulene % (typical): 10 – 15% Humulene/Caryophyllene: 3	Aroma: Citrus & pine/turpentine
	Flavour: Like aroma, not pleasant

Chinook (US) α: 11.6% β: 3 – 4% (typical) α/β: 3.8 (typical) Cohumulone % (typical): 29 – 34% Total Oil % (typical): 1.5 – 2.5% Myrcene % (typical): 35 – 40% Humulene % (typical): 20 – 25% Humulene/Caryophyllene: 2.3	Aroma: Grapefruit not good
	Flavour: Pepper with grass & dirt
Warrior (US) α: 16.3% β: 4.5 – 5.5% (typical) α/β: 3.2 (typical) Cohumulone % (typical): 24+% Total Oil % (typical): 1.0 – 2.0% Myrcene % (typical): 40 – 50% Humulene % (typical): 15 – 20% Humulene/Caryophyllene: 1.9	Aroma: Floral, some tea Nice
	Flavour: Subdued, well rounded, flowers, tea (low)

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Fuggle (UK) α: 4.0% β: 2.5 – 3.0% (typical) α/β: 1.8 (typical) Cohumulone % (typical): 26% Total Oil % (typical): 1.4% Myrcene % (typical): 24 – 28% Humulene % (typical): 35 – 40% Humulene/Caryophyllene: 3.3 A chance seedling raised in England about the turn of the 20th century.	Aroma: Flowery, vegetal, boiled green beans
	Flavour: Subdued
Willamette (US) α: 4.6% β: 3 – 4% (typical) α/β: 1.4 (typical) Cohumulone % (typical): 30 – 35% Total Oil % (typical): 1 – 1.5% Myrcene % (typical): 45 – 55% Humulene % (typical): 20 – 30% Humulene/Caryophyllene: 3.3 A triploid seedling of the English Fuggle variety.	Aroma: Earthy, some pine, flowery Classic American Pilsner
	Flavour: Sweet, pine, flowery
Styrian Goldings (Slovenia) α: 4.2% β: 2.3 – 3% (typical) α/β: 2 (typical) Cohumulone % (typical): 28% Total Oil % (typical): 0.8% Myrcene % (typical): 27 – 33% Humulene % (typical): 34 – 38% Humulene/Caryophyllene: 3.1 An ecotype of Fuggle. Also known as Savinja Golding.	Aroma: Sulfur, earthy
	Flavour: Sulfur, tang (orange drink crystals)

East Kent Goldings (UK) α: 5.5% β: 2 – 3.5% (typical) α/β: 2.3 (typical) Cohumulone % (typical): 20 – 25% Total Oil % (typical): 0.3 – 1% Myrcene % (typical): 20 – 26% Humulene % (typical): 42 – 48% Humulene/Caryophyllene: 3.5 The Goldings are the traditional Old English hop. Developed by clonal selection from 1790 on starting from Canterbury Whitebine.	Aroma: Flowery, some earth, low pine Flavour: Subdued
Progress (UK) α: 4.0% β: 2 – 2.5% (typical) α/β: 2.7 (typical) Cohumulone % (typical): 25 – 30% Total Oil % (typical): 0.6 – 1.2% Myrcene % (typical): 30 – 35% Humulene % (typical): 40 – 47% Humulene/Caryophyllene: 3.2 A daughter of Whitbread's Golding variety bred with wild American germplasm on the male side.	Aroma: Mint/pine, vegetables, grass Nice Flavour: Low grass, mint
Challenger (UK) α: 7.0% β: 4 – 4.5% (typical) α/β: 1.8 (typical) Cohumulone % (typical): 20 – 25% Total Oil % (typical): 1.0 – 1.7% Myrcene % (typical): 30 – 42% Humulene % (typical): 25 – 32% Humulene/Caryophyllene: 3.2 A granddaughter of Northern Brewer bred in England with German downy mildew resistant males.	Aroma: Green grass, earth, flowers Nice Oatmeal stout Flavour: Vanilla & cream, rounded

Organic First Gold (UK) α: 9.5% β: 3 – 4% (typical) α/β: 2.7 (typical) Cohumulone % (typical): 31 – 36% Total Oil % (typical): 0.7 – 1.5% Myrcene % (typical): 27 – 28% Humulene % (typical): 20 – 24% Humulene/Caryophyllene: 3.4 A cross-pollination of Whitbread Golding variety and a dwarf male.	Aroma: Vegetal/green, pine, flowers Irish red ale, Russian imperial stout Flavour: Black patent malt bite, black currants
Northdown (UK) α: 6.5% β: 5 – 5.5% (typical) α/β: 1.6 (typical) Cohumulone % (typical): 24 – 30% Total Oil % (typical): 1.5 – 2.5% Myrcene % (typical): 23 – 29% Humulene % (typical): 40 – 45% Humulene/Caryophyllene: 2.8 A first generation selection from Northern Brewer crossed with a German male resistant to downy mildew.	Aroma: Citrus, sweet, perfume Belgian, American styles Well rounded, very nice Flavour: Floral, citrus
Target (UK) α: 10.0% β: 5 – 5.5% (typical) α/β: 2.1 (typical) Cohumulone % (typical): 29 – 35% Total Oil % (typical): 1.6 – 2.6% Myrcene % (typical): 45 – 55% Humulene % (typical): 17 – 22% Humulene/Caryophyllene: 2.2 A second generation selection from Northern Brewer by a male seedling of English Goldings.	Aroma: Big citrus Best so far IPA Flavour: Spice, citrus at end

Bramling Cross (UK) α: 5.0% β: 2.2 – 2.8% (typical) α/β: 2.8 (typical) Cohumulone % (typical): 26 – 31% Total Oil % (typical): 0.7 – 1.0% Myrcene % (typical): 37% Humulene % (typical): 31% Humulene/Caryophyllene: 2.0 Bred from a crossing of a Bramling (a traditional English Golding variety) with a wild Canadian male from Manitoba. Bred in 1927.	Aroma: Perfume & flowers Nice Bitters, pale ales Flavour: Spice, smoke, floral up front
Perle (German) α: 7.7% β: 4 – 5% (typical) α/β: 1.8 (typical) Cohumulone % (typical): 27 – 32% Total Oil % (typical): 0.7 – 0.9% Myrcene % (typical): 45 – 55% Humulene % (typical): 28 – 33% Humulene/Caryophyllene: 2.8 Bred at the Hüll Hop Research Institute from the English Northern Brewer variety.	Aroma: Subdued fruit, low lemon Nice German lagers, Kolsch (low) Flavour: Spicy, peppery, lemon
Cascade (US) α: 9.1% β: 4.5 – 7% (typical) α/β: 1 (typical) Cohumulone % (typical): 33 – 40% Total Oil % (typical): 0.8 – 1.5% Myrcene % (typical): 45 – 60% Humulene % (typical): 10 – 16% Humulene/Caryophyllene: 4 Open pollination of a Fuggle seedling, itself derived from crosses between Fuggle and the Russian hop Serebrianker.	Aroma: Grapefruit, classic grapefruit Classic Flavour: Same as aroma

Amarillo (US) α: 8.0% β: 6 – 7% (typical) α/β: 1.5 (typical) Cohumulone % (typical): 21 – 24% Total Oil % (typical): 1.5 – 1.9% Myrcene % (typical): 68 – 70% Humulene % (typical): 9 – 11% Humulene/Caryophyllene: 3.5 Privately grown and registered.	Aroma: Big grapefruit, not as intense as cascade. Sweeter grapefruit, orange/lemon Classic Flavour: More lemon in flavour than anything, rounded, not intense
Sterling (US) α: 5.3% β: 4 – 6% (typical) α/β: 1.5 (typical) Cohumulone % (typical): 22 – 28% Total Oil % (typical): 1.3 – 1.9% Myrcene % (typical): 44 – 48% Humulene % (typical): 19 – 23% Humulene/Caryophyllene: 3.5 Released in 1998.	Aroma: Pepper, “Belgian” spice, earthy Belgians/lager hop Flavour: Pepper, sweetness, spice, earth
Nelson Sauvin (New Zealand) α: 12.2% β: 6 – 8% (typical) α/β: 1.8 (typical) Cohumulone % (typical): 24% Total Oil % (typical): 1.1% Myrcene % (typical): 22% Humulene % (typical): 36% Humulene/Caryophyllene: 3.4 A triploid variety bred from Smoothcone New Zealand variety and a selected New Zealand male. Released in 2000.	Aroma: Fruit & cat’s litter box (ammonia) Actually quite nice Flavour: Mild, fruity

Simcoe (US) α: 12.0% β: 4 – 5% (typical) α/β: 2.9 (typical) Cohumulone % (typical): 15 – 20% Total Oil % (typical): 2.0 – 2.5% Myrcene % (typical): 60 – 65% Humulene % (typical): 10 – 15% Humulene/Caryophyllene: 1.9 Released in 2000.	Aroma: Pine, juniper berries, pine forest Very nice Mix with cascade Flavour: Very subdued – all in aroma
Columbus (US) α: 15.1% β: 4.5 – 5.5% (typical) α/β: 3.0 (typical) Cohumulone % (typical): 30 – 35% Total Oil % (typical): 1.5 – 2.0% Myrcene % (typical): 25 – 45% Humulene % (typical): 15 – 25% Humulene/Caryophyllene: 2.1 Bred and selected from the Hopunion breeding program.	Aroma: Lemon tea, floral Mix with cascade, aroma/flavour only Flavour: Lemon tea, bitter tea
Nugget (US) α: 12.2% β: 4 – 6% (typical) α/β: 2.7 (typical) Cohumulone % (typical): 24 – 30% Total Oil % (typical): 1.7 – 2.3% Myrcene % (typical): 51 – 59% Humulene % (typical): 12 – 22% Humulene/Caryophyllene: 2 Selected from a cross between Brewer's Gold and a high alpha acids male with good storage properties.	Aroma: Floral, fruit, some pine Okay Flavour: Mild, pepper, some fruit/lemon