

May 2024

BREWING WITH NEW ZEALAND HOPS

The science, tips and techniques



WAIMEA WEST HOPS, Nelson, New Zealand



- *Growing hops since 1912*
- *100 tonnes hops*
- *10 varieties of hops*
- *Locally owned and managed*

NEW ZEALAND



HOPS GROWING CRITERIA



Latitude

- Latitude is important in hops production, because it determines seasonal day length which, in part, drives canopy growth patterns and timing of flowering induction. Most of the world's commercial hops are grown between latitudes 35° to 55° North.



Climate

- Sunshine – >2,200 hrs
- Temperature – high Summer medium temperatures
- Frost – Long hard cold Winter period with heavy frosts
- Low wind



Soils & Water

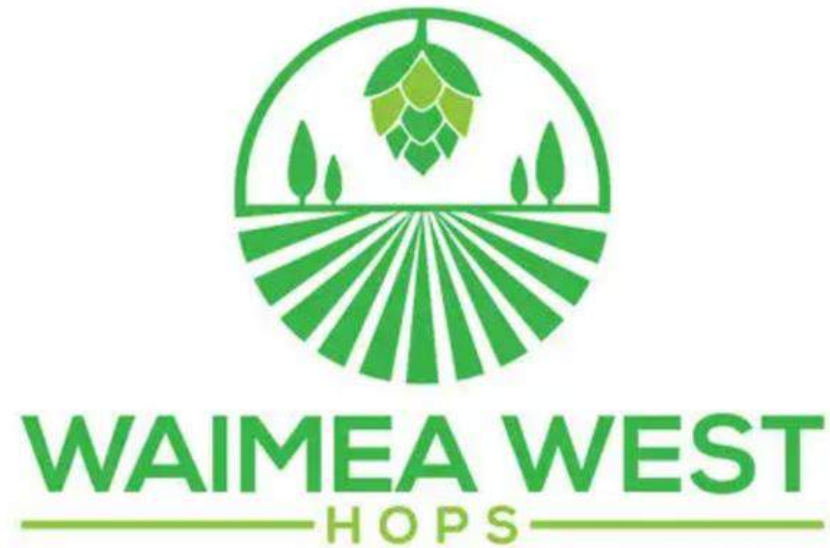
- Free draining & fertile
- pH >6.2 & <6.8
- Olsen P of 25-35
- 8 litres/plant/day over 110 days



KELLY RYAN - WAI HOPS



- Brewer
- Beer judge
- Sensory expert
- Hop farmer
- *'Brewer in the hop field hand picking the hops'*



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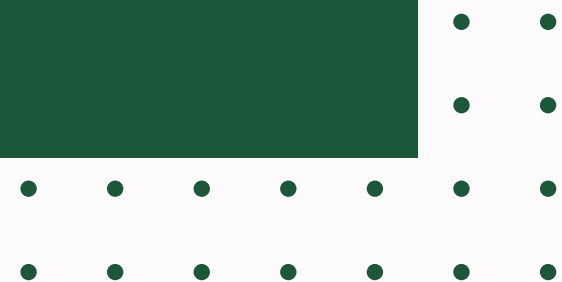
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Introduction



Stodie

- **Professor Jean-Pierre Dufour. The University of Otago in Dunedin, NZ**
- **Two year Trainee Brewer Programme (2001 - 2003) with DB Breweries (joint ownership by Asia Pacific Breweries and Heineken) at Tui Brewery (North Island, NZ)**
- **Brewed at Fyne Ales (Scotland), Thornbridge Brewery (England) before returning to NZ in 2011. Championed non-traditional hops in UK cask ale (Jaipur and Kipling)**
- **Epic Brewing Company (Auckland, NZ) in 2011, developing NZs first Double IPA (Hop Zombie). Champion IPA of NZ (Armageddon IPA)**
- **Initial head brewer at Good George Brewery (2012-2013), developing NZs first dry-hopped cider, which won Champion Cider of NZ**
- **Head brewer at Fork & Brewer in Wellington NZ (2014-2020), Champion Pale Ale and back-to-back Champion Small Brewery of NZ**
- **Brewery Manager at Boniface Brewing Company (2021-2023), Champion International Lager of NZ**
- **International beer judge since 2007**

From brewhouse to hop kiln

- **Late 2023, moved from brewing to quality and technical sales role with Waimea West Hops**
- **Waimea West Hops is one of the 27 cooperative farms of NZ Hops Ltd.**
- **Made a decision to look at direct to market (from farm to brewery) approach and set up a separate company (Wai Hops) to do this**
- **Initial offering of Motueka, Riwaka and Nelson Sauvignon (mid and late harvest) T90 pellets**
- **My experience as a brewer showed that its not always that there is a solid knowledge base with raw materials such as hops. We want to change this on a number of levels**
 - **Questions and queries about hops and quality**
 - **Understanding of the agronomics and farming techniques - impact on hop quality**
 - **Field sensory throughout harvest and hitting target picking windows**
 - **Aligning foliar testing data, sensory and the final dried hops**
 - **Trends through kilning and how this relates to hop aroma and flavour**

NZ hops - what's different?

- **Unique breeding programme - Initiated by Dr. Rudi Roborgh in the 1950s and by the 1960s, had cracked the code for breeding disease-resistant, seedless cultivars.**
- **Continuation by NZs own Hopfather and NZ Hops Ambassador, Dr. Ron Beatson, who was at the cutting edge for 40 years. 16 cultivars developed.**
 - **Riwaka**
 - **Nelson Sauvín**
 - **Motueka**
 - **Superdelic**
 - **Nectaron**
- **Succeeded by Dr. Kerry Templeton**
- **Initial germplasm (seed, tissue etc.) from American and European varieties**
- **Selective breeding resulted in disease-resistance, particularly fungal pathogens**
- **Development of triploid cultivars**
 - **Less fragile and brittle cones**
 - **Huge drop in percentage seed weight**



Dr. Ron in his happy place amongst our first year Superdelic at Waimea West Hops, Nelson, NZ

NZ hops - what's different?



- Dr. Ron led the **Hops with a Difference** programme, focusing on aroma-led varieties with medium alpha acid content
- A unique pathway using a combination of North American genetic material (including wild hop genetics) and old line European material

Pacific Gem

Southern Cross

Pacifica

Wakatu

Nelson Sauvín

Riwaka

Motueka

Pacific Sunrise

Pacific Jade

Wai-iti

Kohatu

Waimea

Moutere

Hort9909

Nectarón

Superdelic

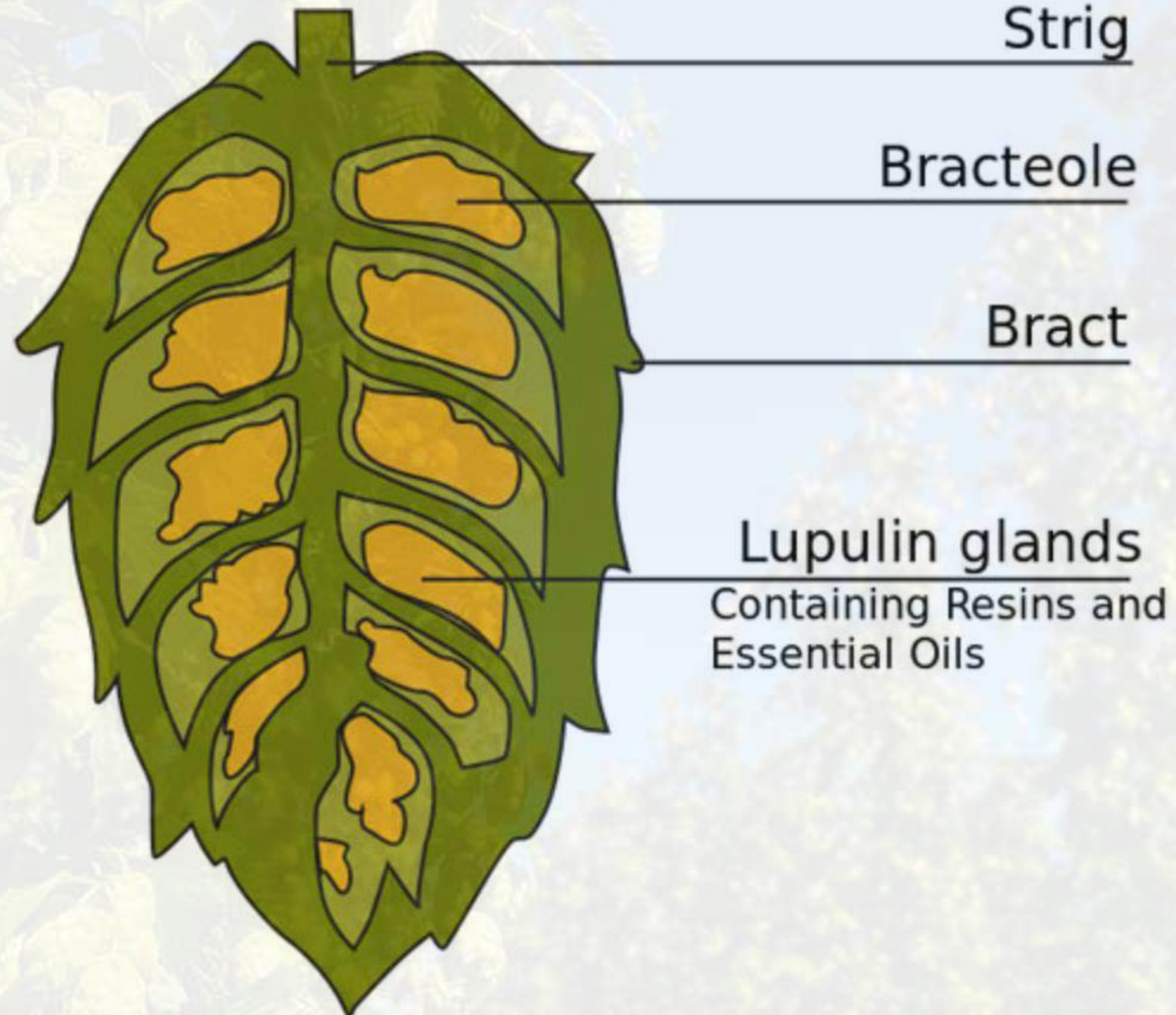


nzhops Ltd





Let's talk Hops



Let's talk Hops



Female hop burr

Let's talk Hops

Female strobile (cone) of *Humulus lupulus*

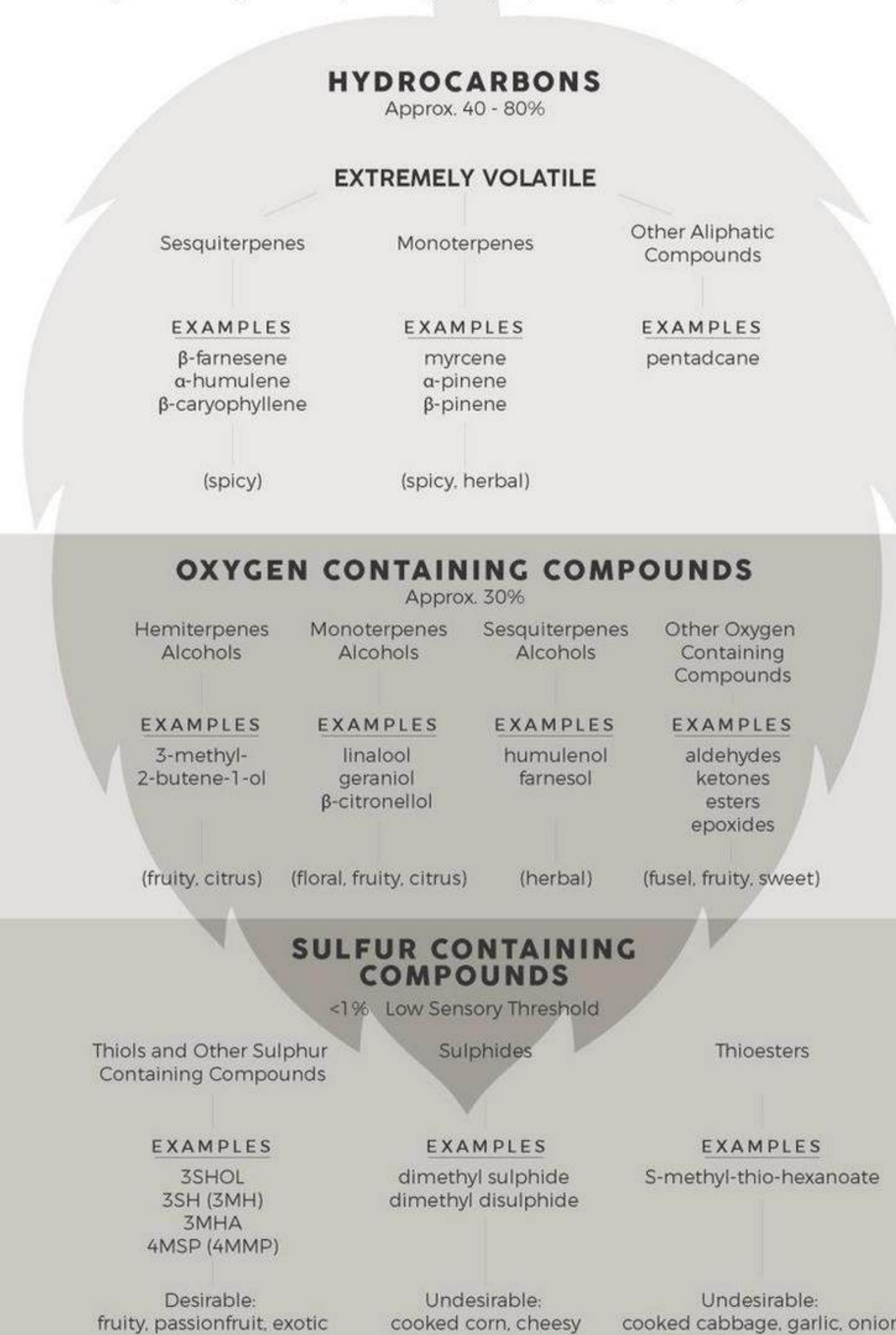
Three major constituents

- **α -acids (humulones)**
 - humulone (20-50%)
 - adhumulone (15%)
 - cohumulone (20-50%)
- **β -acids (lupulones)**
- **Essential oils (0.5-5%)**
 - Close to 500 different compounds
 - Three key classes

- **Hydrocarbons (40-80% of the oil)**
 - **e.g. Myrcene, α -humulene, β -caryophyllene**
- **Oxygen containing compounds (~30%)**
 - e.g. alcohols, ketones, aldehydes, esters. Key compounds are the terpene alcohols
- **Sulphur compounds (<1%)**
 - e.g. thiols, sulphides, thioesters. Some aroma positive and others aroma negative
 - 3-MH threshold of 55 ng/L
 - 3-MHA threshold of 5 ng/L

CHEMICAL COMPOSITIONS OF THE ESSENTIAL OILS OF HOPS

Based on general averages, actual percentages vary depending on hop variety and other factors.



- **Image credit - Scott Janish**
- **The New IPA - A scientific guide to hop aroma and flavour**
- **Synopsis of current research**
- **Must read!**

Biotransformation

- **Enzymatic cleaving (acidic cleaving and other yeast metabolic processes) that result in the transformation of more flavour and aroma active compounds from existing precursors. Often terpenes can be bound to glycosidic precursors, so enzymatic cleavage frees these for further transformation.**
 - **E.g. bound geraniol versus free geraniol or conversion of geraniol to citronellol**
- **Research has shown that hot-side whirlpool additions boost potential biotransformation and can produce a more aromatic beer than just dry-hopping alone (Sharp et. al, Journal of the Society of American Brewing Chemists, 2017)**
- **Terpene alcohol precursors need to be freed from their bound forms. How?**
 - **Mash hopping - utilise bound geraniol-rich hops like Taiheke/NZ Cascade**
 - **Yeast selection**
 - **Release of enzymes such as β -glucosidase**
- **Terpene alcohols (or oxygenated terpenes) will undergo some cold-side extraction, however emphasis needs to be placed on their volatilisation. Whirlpool stand at cooler temperatures (85°C) are better at retaining these.**
- **Key finding from research into this group of compounds is their synergistic effect with other aroma and flavour compounds, such as thiols.**

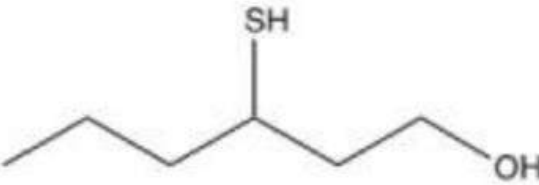
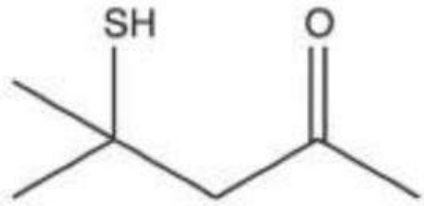
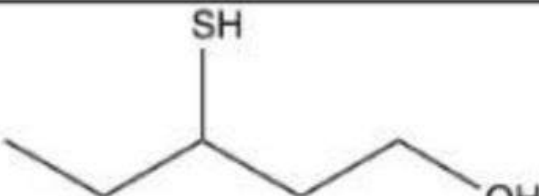
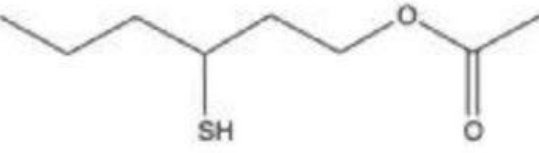
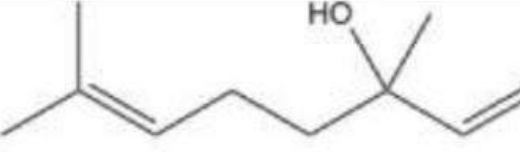
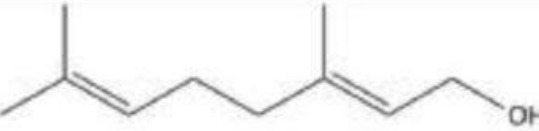
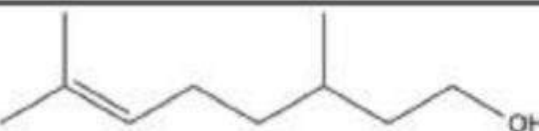
Biotransformation



- **What are thiols?**
 - **Group of sulphur containing compounds found in varieties like Nelson Sauvignon, Motueka, Mosaic, Bravo. Also known as mercaptans.**
 - **Highly aroma active, even in extremely low concentrations. Less than 1% of the essential oils.**
 - **Often present in bound precursors, need to be released via enzyme such as β -lyase**
 - **Linked to the IRC7 gene in yeast**
 - **Encodes β -lyase enzyme which frees thiols from their bound precursors**
 - **Enzyme activated when nitrogen is scarce (thiol precursors are bound to amino acids)**
 - **Gene expressed in some wine strains when low in nitrogen**
 - **Wort is high in nitrogen, so gene is less likely to express**
 - **Need to choose yeast strains with high lyase activity. These are often bioengineered (Omega Yeast)**
- **The main aroma-active thiols are:**
 - **4-mercapto-4-methyl-pentan-2-one (4MMP or 4S4MP). Black currant 6 ng/L**
 - **3-mercaptohexanol (3MH or 3SH). Exotic, citrus, grapefruit 55 ng/L**
 - **3-mercaptohexyl acetate (3MHA or 3SHA). Passion fruit 5 ng/L**



Aroma active thiols and terpene alcohols

Compound	Abbreviation	Aroma description	Flavour threshold	Precursors found in	Enzyme activity to release	Molecular structure
3-mercaptohexanol / 3-sulfanylhexan-1-ol	3MH / 3SH	Grapefruit	55-60 ng/L	Malt, hops, grapes	β -lyase activity, to release from cysteinylated and glutathionylated precursors	
4-mercapto-4-methylpentan-2-one / 4-methyl-4-sulfanylpentan-2-one	4MMP / 4MSP	Black currant,	1.5 ng/L	Hops, grapes	β -lyase activity, to release from cysteinylated and glutathionylated precursors	
3-sulfanyl-4-methyl-pentan-1-ol	3S4MP	Grapefruit, Rhubarb	70 ng/L	Hops	β -lyase activity, to release from cysteinylated and glutathionylated precursors	
3-mercaptohexyl acetate / 3-sulfanylhexyl acetate	3MHA / 3SHA	Passion fruit, guava	4 ng/L	Malt, hops, grapes	Acetyl transferase activity, to convert 3MH into 3MHA	
Linalool		Lavender	5 μ g/L	Hops, grapes	β -glucosidase, also α -L-arabinofuranosidase and/or α -L-rhamnosidase	
Geraniol		Rose-like	6 μ g/L	Hops, grapes	β -glucosidase, also α -L-arabinofuranosidase and/or α -L-rhamnosidase	
Citronellol		Lemon-like and/or lime-like	8 μ g/L	Hops, grapes	NADPH dehydrogenase 2 (encoded by <i>OYE2</i>) reduces geraniol into β -citronellol	

Maximise terpenes and thiols

- **Play with your own synergies**
 - **Yeast choice - experiment**
 - **Temperature of fermentation and dry hopping**
 - **Dip hopping (75-80°C for up to 30 minutes)**
 - **Whirlpool temperature and hop choice**
- **Targeting early terpene biotransformation?**
 - **Dry hop early to aid terpene release**
 - **Think outside the box!**
 - **Brettanomyces bruxellensis trois vrai**
- **Target temperature for thiol release**
 - **Example - two-fold increase in 3-MHA release (guava and passionfruit) at 15°C vs 21°C**
- **Don't forget hop derived esters like 2-MIB (2-methylbutyl isobutyrate). Southern Cross, Pacific Jade, Waimea and Riwaka are high in this compound. Big apricot character.**
- **A little age on hops can increase fatty acid esters that have synergy with terpenes**

Deep Dive - Motueka

- **Saaz ancestry**
- **Alpha - 6-9%**
- **Beta - 5-6%**
- **Total oil - 0.8-2 mL/100g**
- **Referred to as the 'mojito' hop due to notes of lemon and lime**
- **Descriptors include:**
 - **Orange, lime and lemon. Tropical, stone fruits.**
 - **Floral, specifically rose.**
 - **Herbal, sometimes with some spice character**
- **Contains high amounts of free geraniol. Rare amongst NZ varieties. Biotransformation!**



Deep Dive - Motueka

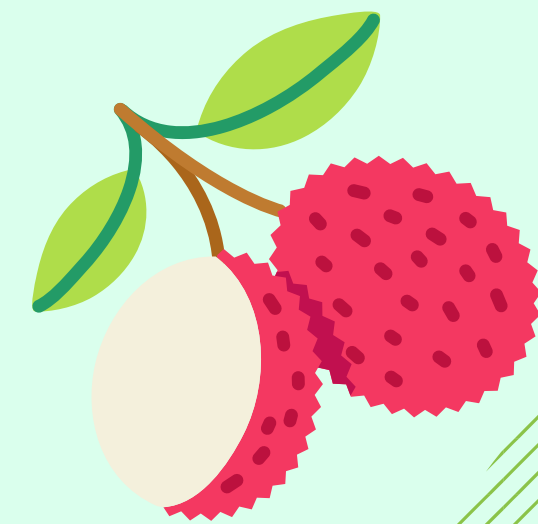
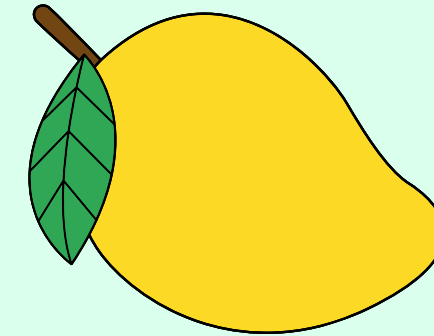
- **Jason Bathgate - head brewer of McLeod's Brewery.**

- **Loves Motueka as a supporting hop that plays really well with others**
- **Larger late additions in whirlpool**
- **Small part of a dry hop profile**
- **Synergises well, boosting flavours when used as part of a varied hop bill**

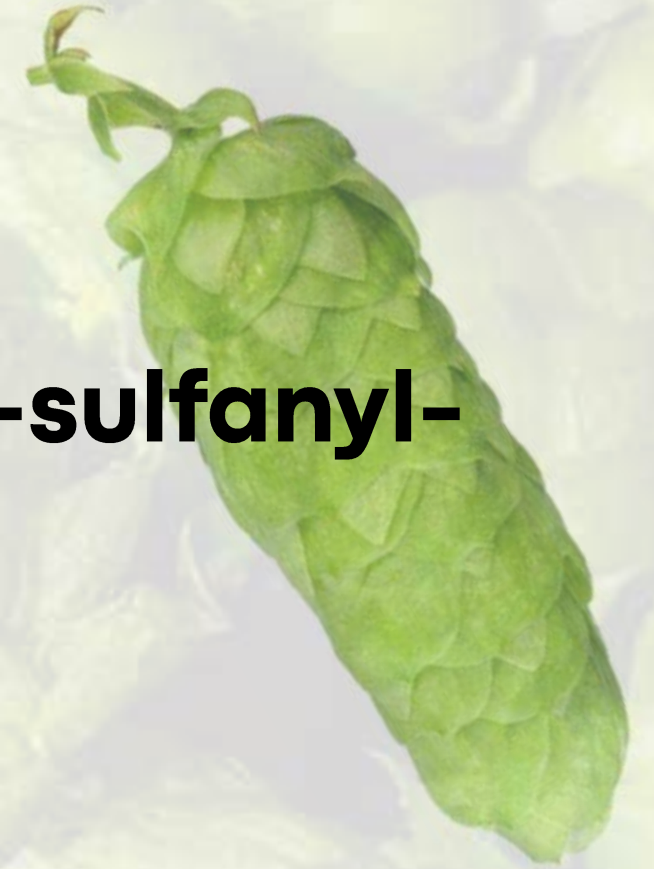


Deep Dive - Nelson Sauvvin

- Released in 2000 after a 15 year breeding programme
- Alpha - 10-13%
- Beta - 6-8%
- Total oil - 1-2 mL/100 g
- Aromatics include Sauvignon Blanc wine and grapes, lychee, mango, passion fruit, apricot, gooseberry, green culinary grape, grapefruit, blood orange, grass and slight onion/garlic (harvest window dependent)
- Variations between early/mid harvest
 - More wine-like with brighter citrus
- Later harvest
 - More tropical aromatics and some dankness



Deep Dive - Nelson Sauvin



- **Thiol-rich hop**
 - **3-sulfanyl-4-methylpentan-1-ol (3S4MP), and 3-sulfanyl-4-methylpentyl acetate (3S4MPA)**
 - **3S4MP - grapefruit and rhubarb**
 - **3S4MPA - Grapefruit, peach and rhubarb**
 - **Synergistic with 2MIB (2-methylbutyl isobutyrate) which Southern Cross is particularly high in.**
 - **Combine to give big apricot character**
- **Low sulphur producing yeast strains**
 - **Bound 2-methyl-3-butene-1-thiol (MBT)**
 - **Lallemand Novalager or Diamond (3SH-freeing)**
 - **Fermentis S-23/AEB Fermolager Berlin**

Deep Dive - Nelson Sauvin



- **Tips from Scott Sharp-Heward (Lallemand Technical Manager - Oceania)**
 - **Moderation is key with Sauvín.**
 - **Favourite styles for this hop are NZ Pilsners and NZ Pale Ales**
 - **Combine with Motueka in mash hop and kettle hop to release bound 3SH (grapefruit).**
 - **Dry hop with Nelson Sauvín**
 - **Ferment with 3SH/3MH-releasing strain (Diamond)**
- **Of note - Nelson Sauvín gives perceived body and mouthfeel, even with high attenuation. Great in lower AbV or leaner malt beers**

Deep Dive - Riwaka

- **Saaz ancestry**
- **Alpha - 4-6.5%**
- **Beta - 4-5%**
- **Total oil - 0.8 - 1.7 mL/100g**
- **Completely unique. Used in NZ Pils, IPAs, Pale Ales predominantly**
- **Descriptors include:**
 - **Blood orange, grapefruit, passion fruit, diesel, hint garlic/onion(depending), citrus and pine, kumquat**
- **High in myrcene. Works well late hot-side or in active fermentation as a dry hop to reduce grassy/green character**

Deep Dive - Riwaka

- **Pale hop cone. Don't be afraid if pellets are less vibrant**
- **Hop that ages well**
- **Very low in α -amylase. Good if wanting to dry hop as less chance of hop creep**
- **High in limonene (lemon peel), geranyl 2-methylbutyrate (strawberry, apple peel, pineapple skin) and nereryl propanoate (fruity, jammy)**
- **Favourite hop of Tracy Banner (Mother of NZ Brewing) of Sprig & Fern in Nelson.**



Using NZ hops in the brewery



- **Key points**

- **Check the myrcene**

- **If too much grassy or green character**
 - **Important in hazies, as tends to stick around when there is a stable haze**
 - **Too much of this can mask or interfere with more tropical or fruity notes**

- **Too much woody or spicy characteristics?**

- **Have a look at the humulene, caryophyllene and farnesene levels**
 - **Humulene (herbal) will increase with longer boiling (the 'noble' note)**
 - **Caryophyllene (spicy) can increase with hop age and add complexity to beer styles that are more lightly hopped. Best used late to accentuate. Spicy hop fractions can increase perceived bitterness**
 - **Farnesene doesn't impact directly but adds a herbal, woody character that can synergise with other compounds**

Using NZ hops in the brewery

- **Key points**

- **Look closely at terpene alcohols**
- **Higher oxygenated fraction generally gives more hop intensity**
- **Aroma not always directly linked to total oil percentage**
- **Mix together high geraniol and high linalool varieties**
 - **More potential biotransformation synergy**

- **High Geraniol**

- **Motueka**
- **Riwaka**
- **Nectaron**
- **Superdelic**
- **Waimea**
- **NZ Chinook**

- **High Linalool**

- **Dr. Rudi**
- **Nectaron**
- **Pacifica**
- **Riwaka**
- **Wakatu**

Using NZ hops in the brewery

- **Key points**

- **Essential oil levels from dry hopping plateau**
 - **1 kg/hL or 10 grams per litre**
- **Use high 3MH hops such as Nelson Sauvin earlier in fermentation**
 - **Promotes esterification by biotransformation/enzymatic activity**
- **The same applies for high 4MMP hops, though these (and free geraniol-rich varieties) are better as later fermentation dry hop**
- **Check your pH!**
 - **Too high a wort pH can increase potential hop creep**
 - **Favours α -amylase activity**
 - **Modify with phosphoric (or lactic) acid at dry hop**
- **Use enzymes such as Lallemand Aromazyme**
 - **Important if your yeast strain has low β -glucosidase activity**
 - **pH also important here - acid hydrolysis (pH 4.0-4.2)**

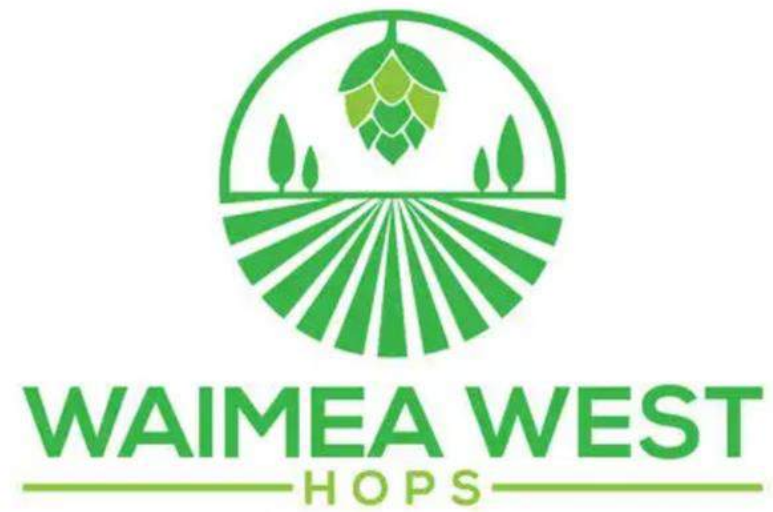
Using NZ hops in the brewery

- **Key points**
 - **Explore dry-hopped sour beers**
 - **Acid-induced biotransformation**
 - **Experiment with dip-hopping**
 - **Whirlpool and/or portion of dry hops**
 - **75-80°C wort or water into FV**
 - **Up to 30 minute rest**
 - **Reduction in garlic/onion thiols**
 - **Inactivation of potential hop creep enzymes**
 - **Good technique for higher myrcene hops (e.g. Riwaka)**
 - **Switch your yeast!**
 - **Lallemand doing great research around biotransformative abilities of different strains**
 - **AEB experimenting with nutrient additions at dry hop to boost thiols**
 - **Omega using genetic manipulation for lyase gene coding**



Waimea West Harvest Team 2024





NGĀ MIHI NUI

Kelly Ryan



+64 274393507



kelly@wwhops.nz



<https://www.facebook.com/waimeawesthops/>



Waimea West Hops
Brightwater
Nelson
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