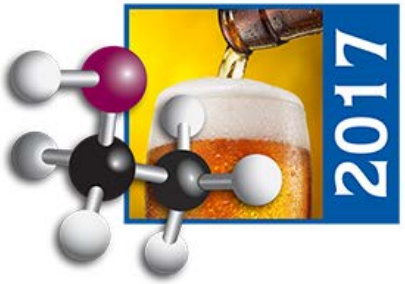


ASBC Annual Meeting

June 4–7 ■ Fort Myers, Florida

See what SCIENCE can brew for you

Bitterness, Perception of Taste and Aroma

Pattie Aron

Rahr Malting

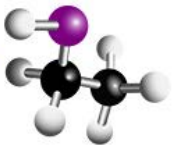
June 2, 2017

Bitterness

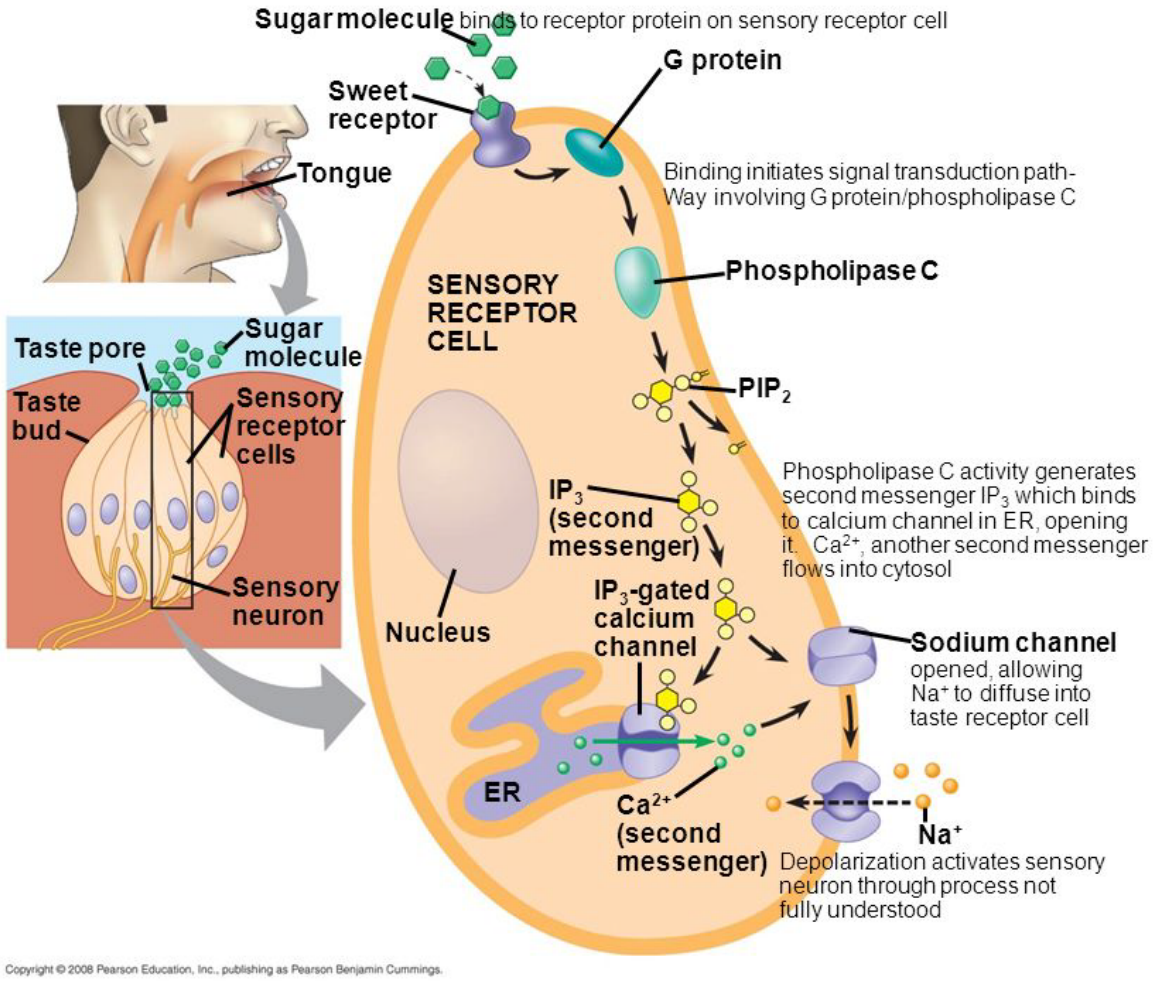
- Bitterness Perception
- Factors that affect perception
- Sources – Main components
- Sensory evaluation and techniques

Bitterness Perception

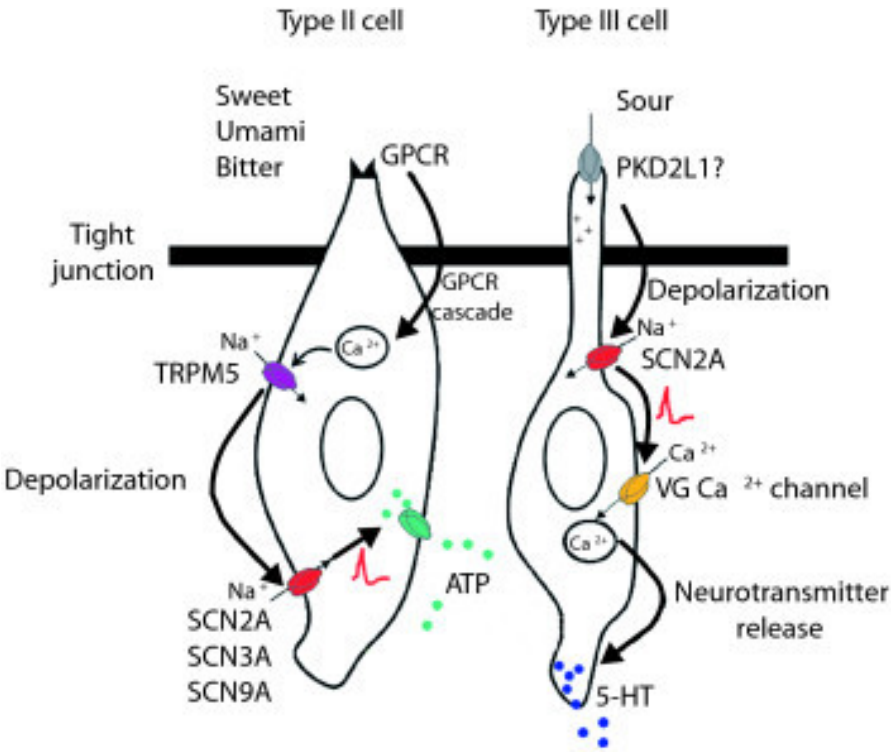
- Molecules bind to receptors on the tongue
  - Type II receptor cells (sweet, umami, bitter)
- Ligand binding site changes shape
- Interacts with a G-protein coupled receptor (GPCRs)
- G- protein activates messenger cell…cascade effect……
- Ion channels activate and cell gradient changes
- Nerve cell stimulated
- Signals the Brain
- ***BITTER!***



G – Protein Response



Type II Receptor



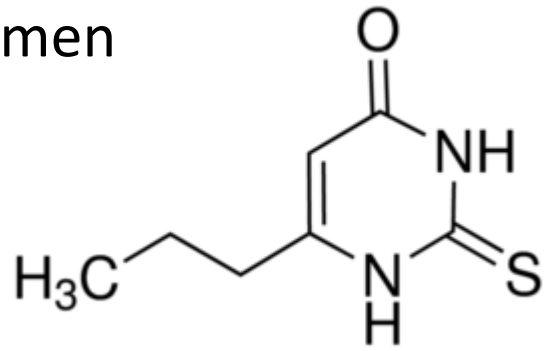
Bitterness – Perception Factors

- **Genetics** –
  - Heritage – 25 Taste Type II Receptors
    - Cluster of genes located on c 5p, 7q, 12 p
    - # of fungiform papillae vary by individual
  - Sex
- **Age** - response declines with age
- **Diet** - brain response change due to 'training'
- Presence of **suppressants and enhancers**
  - Sugar
  - Salt
  - Acids
  - Metals

Nutrients. 2014 Sep; 6(9): 3363–3381.

Bitterness Genetics and PROP

- PROP (6-propyl-2-thiouracil)
  - Bitter receptor – TAS2R38
  - Linked to chromosome locus at 5p15
  - Dominant trait
    - 70% of Caucasians are sensitive
    - 90% of Asians and African Americans
    - Subgroup – supertasters
      - More women than men

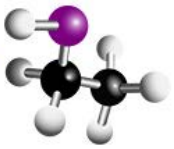


Nutrients. 2014 Sep; 6(9): 3363–3381.

Bitterness – Beer Contributers

- **Hop Oils** Oil 'burn' may enhance bitterness
- **Polyphenols** - bitter
- **Color** (malt roast) – bitter compounds
- **Alcohol** may enhance or reduce
- **Higher pH -** enhances bitterness
- **Mineral Content**
  - Burtonization – sulfate = crisp
  - Carbonate – broader, harsher bitter
- **Carbonation bite** can enhance bitterness
- **Aging** decreases bitterness

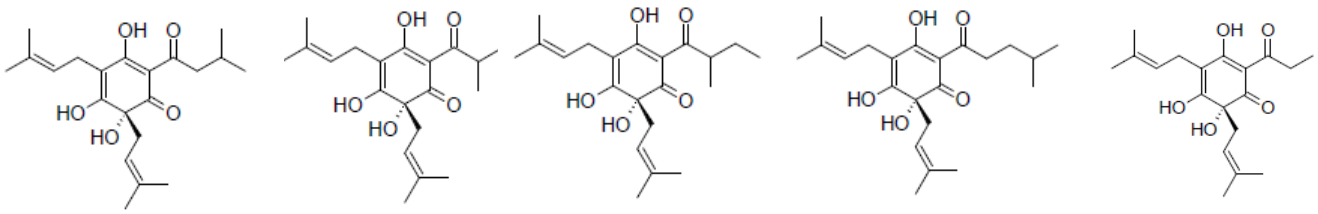
- **<u>Hop Acids and their products…</u>**



Bitterness - Hop Acids

- Alpha Acids
- Beta Acids
- Isomerized alpha acids
- Reduced hop acids

Alpha Acid Analogues



Alpha Acid	Acyl R	MW	%
Humulone*	$CH_2CH(CH_3)_2$	362	35-70
Cohumulone*	$CH(CH_3)_2$	348	20-65
Adhumulone**	$CH(CH_3)CH_2CH_3$	362	10-15
Prehumulone***	$CH_2CH_2CH(CH_3)_2$	376	1-10
Posthumulone***	CH_2CH_3	334	1-3

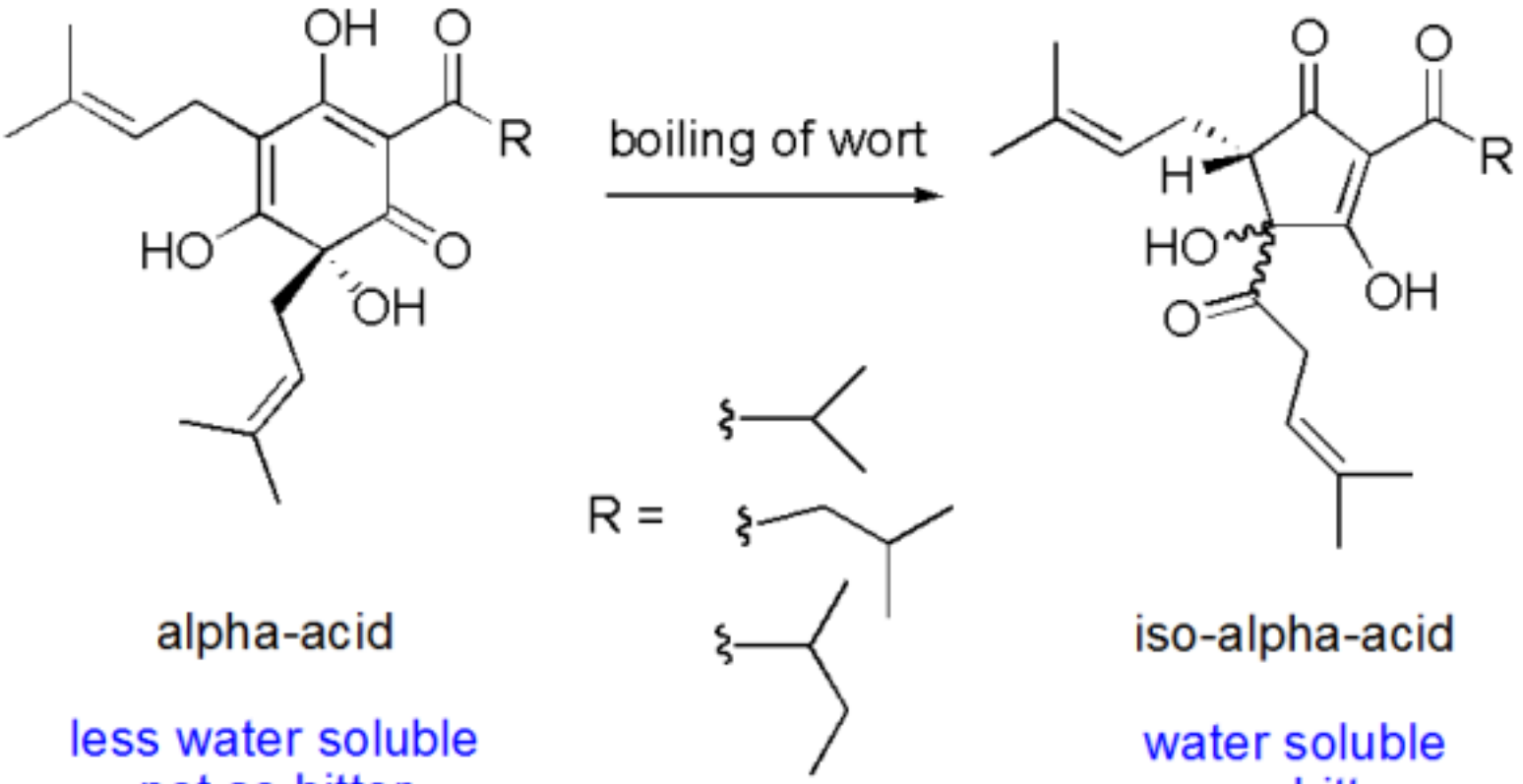
(Rigby, Bethune, *1952, **1953 and ***Verzele 1955)

Bitterness - Alpha Acids

-Not bitter.
-Unstable – oxidize readily in presence of oxygen, heat and light.
-Some oxidized alpha acids form hard resins that do not contribute to beer bitterness.
- Some oxidized alpha acids do contribute to bitterness: humulinones and humulinic acids.
-At 25°C humulone aqueous solubility is low ~6mg/L
-Alpha acids are relatively unsoluble in wort at pH 5, reaching a maximum of about 84 ppm when heated at pH 5.2, and even higher at pH ~6.5.

Isomerized alpha acids: Iso humulones

Isomerization



alpha-acid

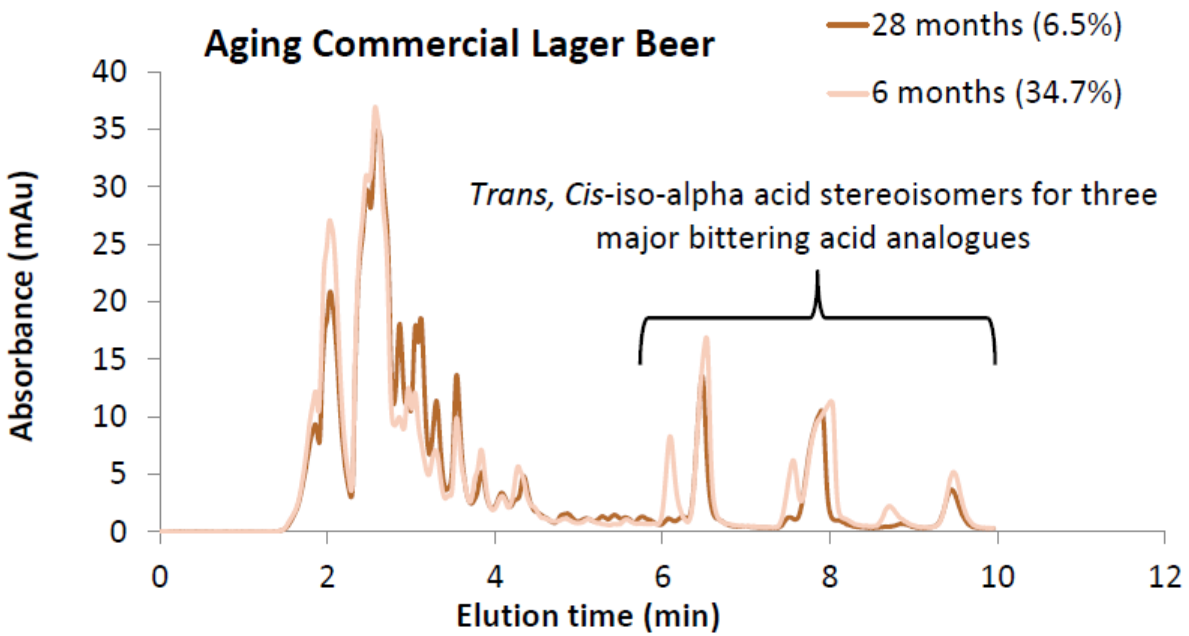
less water soluble
not so bitter

iso-alpha-acid

water soluble
very bitter

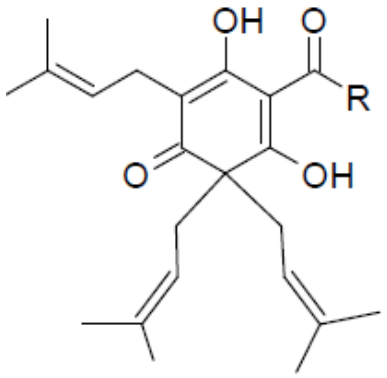
Iso-alpha acid stability

Thermal instability - Cis is thermally more stable, losses of trans occur over time



The Beta Acid Analogues

Beta Acid	Acyl R	%
Lupulone*	$CH_2CH(CH_3)_2$	30-55
Colupulone*	$CH(CH_3)_2$	20-55
Adlupulone**	$CH(CH_3)CH_2CH_3$	10-15
Prelupulone***	$CH_2CH_2CH(CH_3)_2$	1-3
Postlupulone***	CH_2CH_3	?



Beta Acids

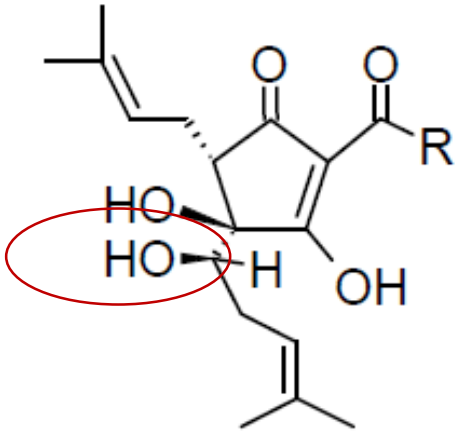
Bitterness - The Beta Acids

-Not bitter unless oxidized.
-Poorly soluble in water and wort.
-Poor solubility as pure compounds (1 g/100mL), but more soluble as a mixture
-Stable to alkaline hydrolysis in absence of oxygen.
-Susceptible to oxidation comparable to alpha acids
- Oxidation results in hulupones – products have ‘undesirable?’ bitterness and can make up for loss of alpha in old hops.

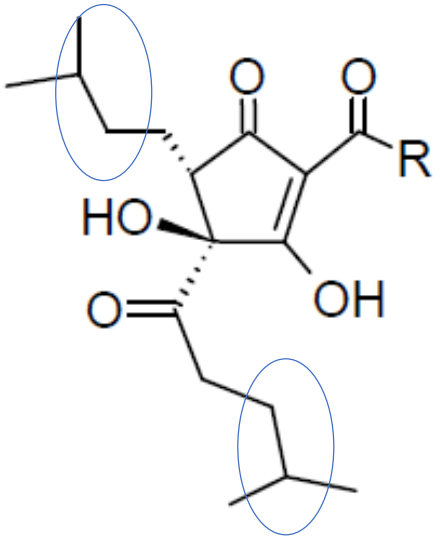
Advanced Hop Acids

Reduced Iso-alpha acids (Rho)

***Trans*-DIHYDRO-ISOHUMULONES or*Trans*-RHO-ISOHUMULONES**

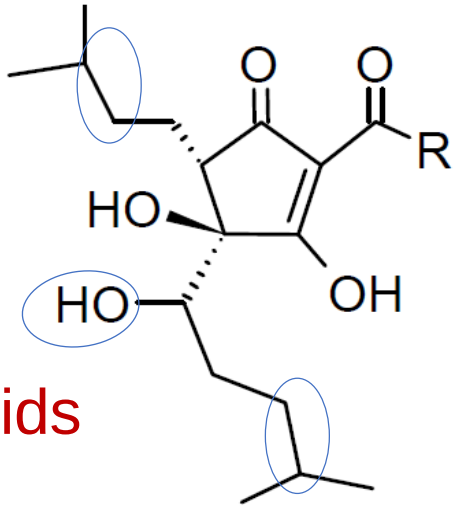


Tetrahydro-Iso-alpha acids



***Trans*-tetrahydro-isocohumulones**

Hexahydro-Iso-alpha acids



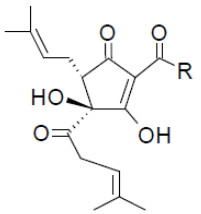
Hexa-hydro-isocohumulones

Bitterness – Sensory Evaluation

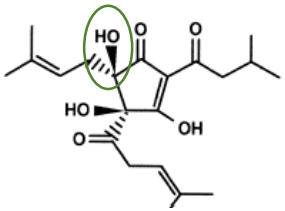
- Bitterness and the IBU
- Bitterness and Quality
- Bitterness Intensity
- Lingering – Time Intensity

Sensory and the IBU

- The IBU measurement includes:
  - Iso-alpha acids, α, β, and oxidized products:
    - Humulinones – more soluble than IAA
    - Beta acid derivatives
    - Other hard resin derivatives
  - Anything soluble in isooctane that also absorbs near 275 nm under acidified conditions:
    - Phenolics: xanthohumol, flavonoids, etc.



Iso- alpha acid

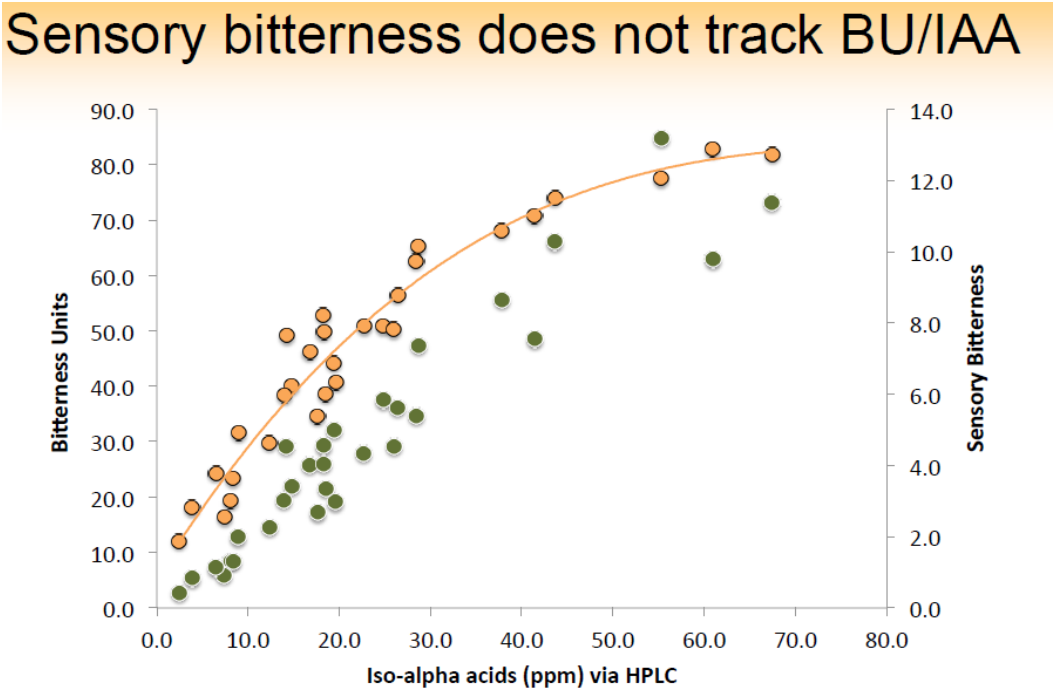


OXI- Iso- alpha acid (humulinone)

Contributions to the IBU: Sensory

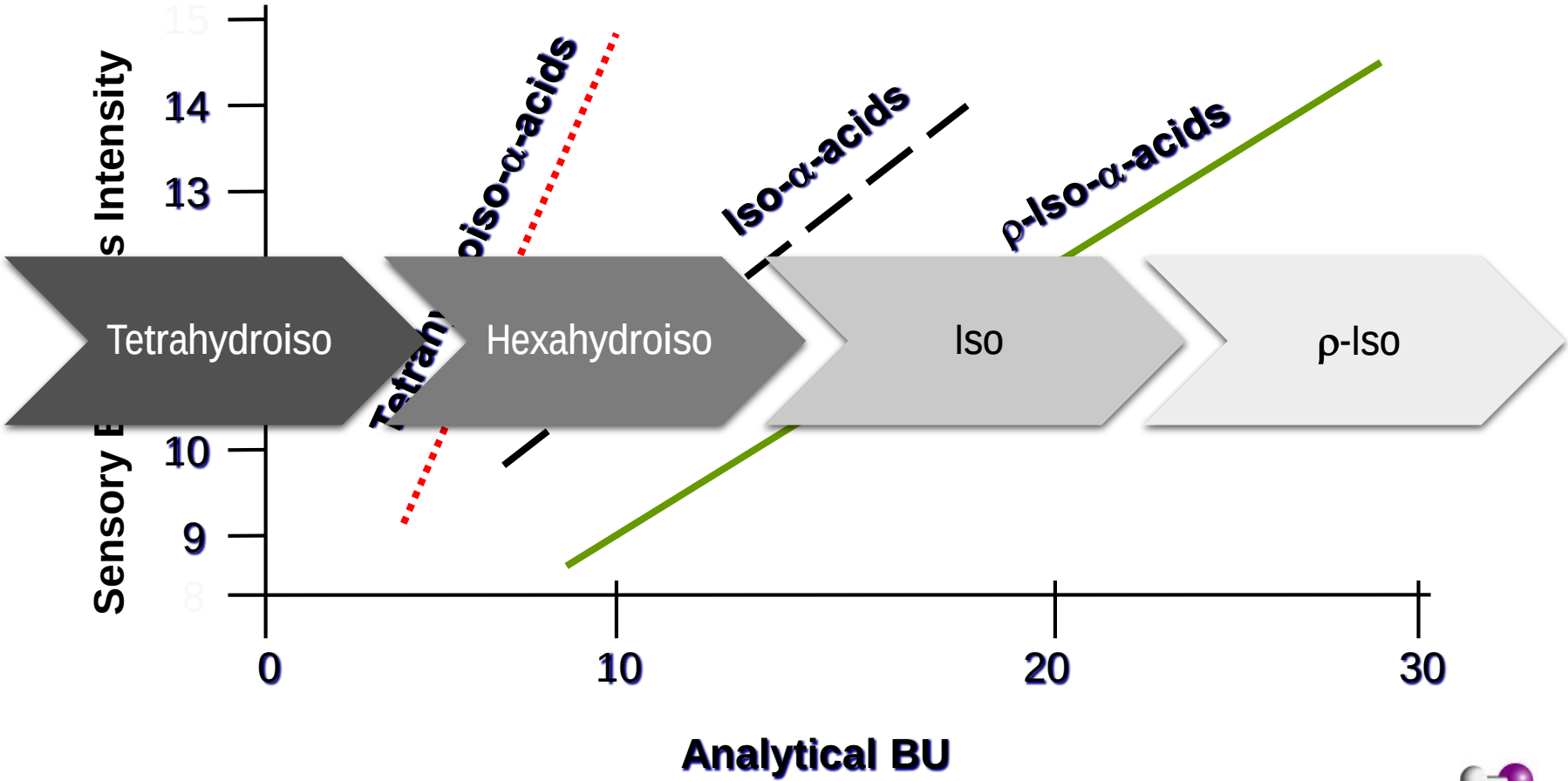
Sensory bitterness will vary based on hopping rates, hopping technology, age of hops, variety of hops.

Qualitative differences may not correlate to IBU



Source: WBC 2014, T. H. Shellhammer, Dry hopping contributions to bitterness

Comparison of Sensory vs. Analytical Bitterness

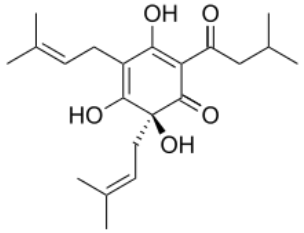


Bitterness Perception - Quality

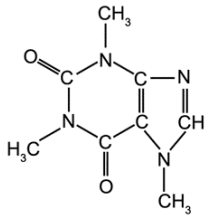
- Harmonious
- Harsh
- Vegetative
- Medicinal
- Short
- Lingering

Bitterness Quality – Training Reference Types

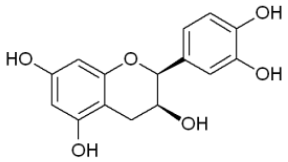
- Iso - alpha acids
  - Beer ranges from 2 ppm to 40 ppm
  - Higher ppm may occur with increased alcohol in specialty beers



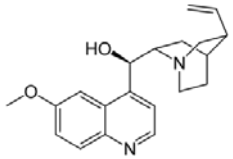
- Caffeine



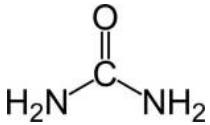
- Polyphenols – Epicatechin, Catechin, etc



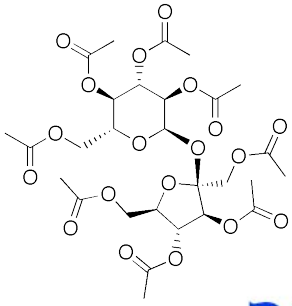
- Quinine



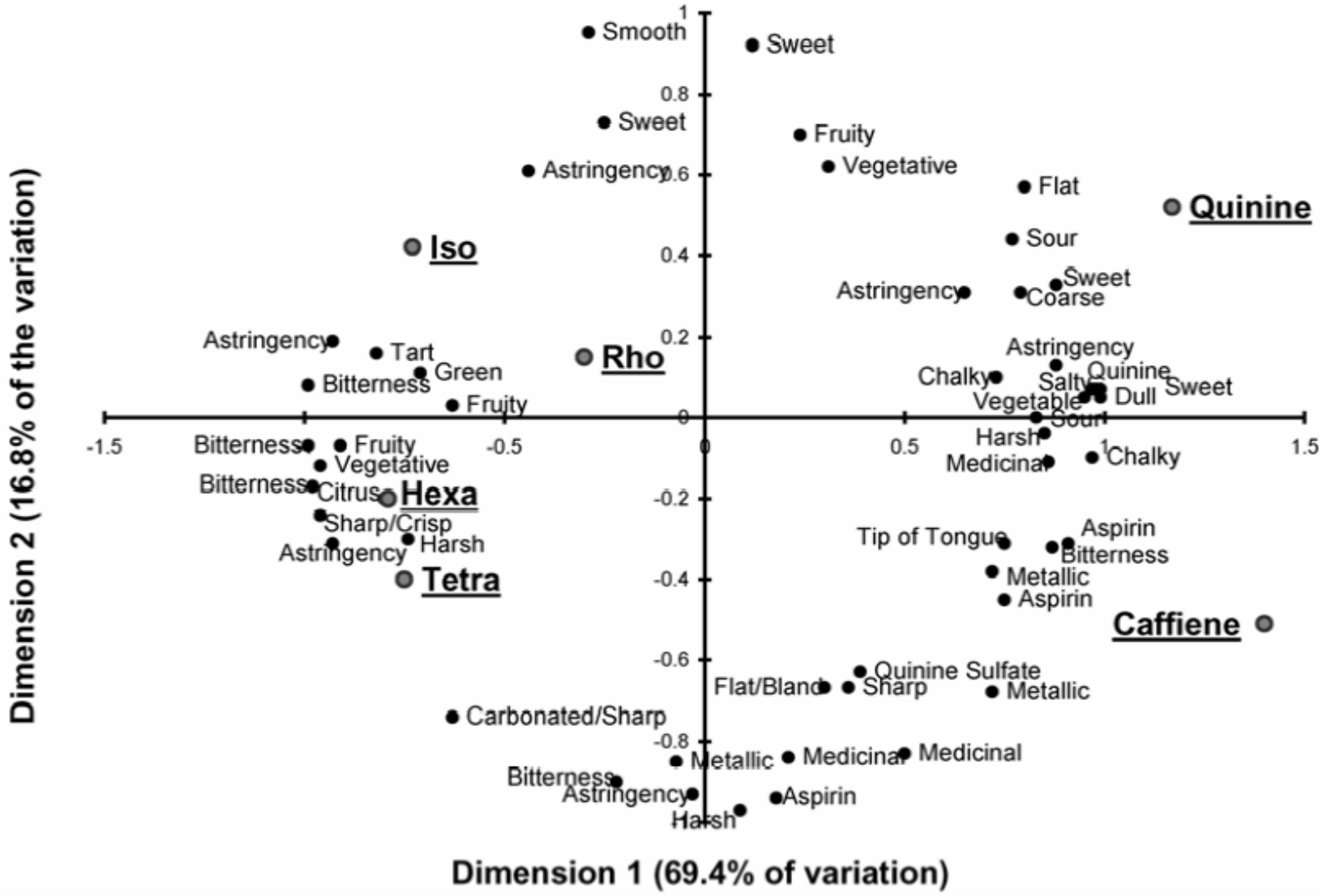
- Urea



- Sucrose octa-acetate

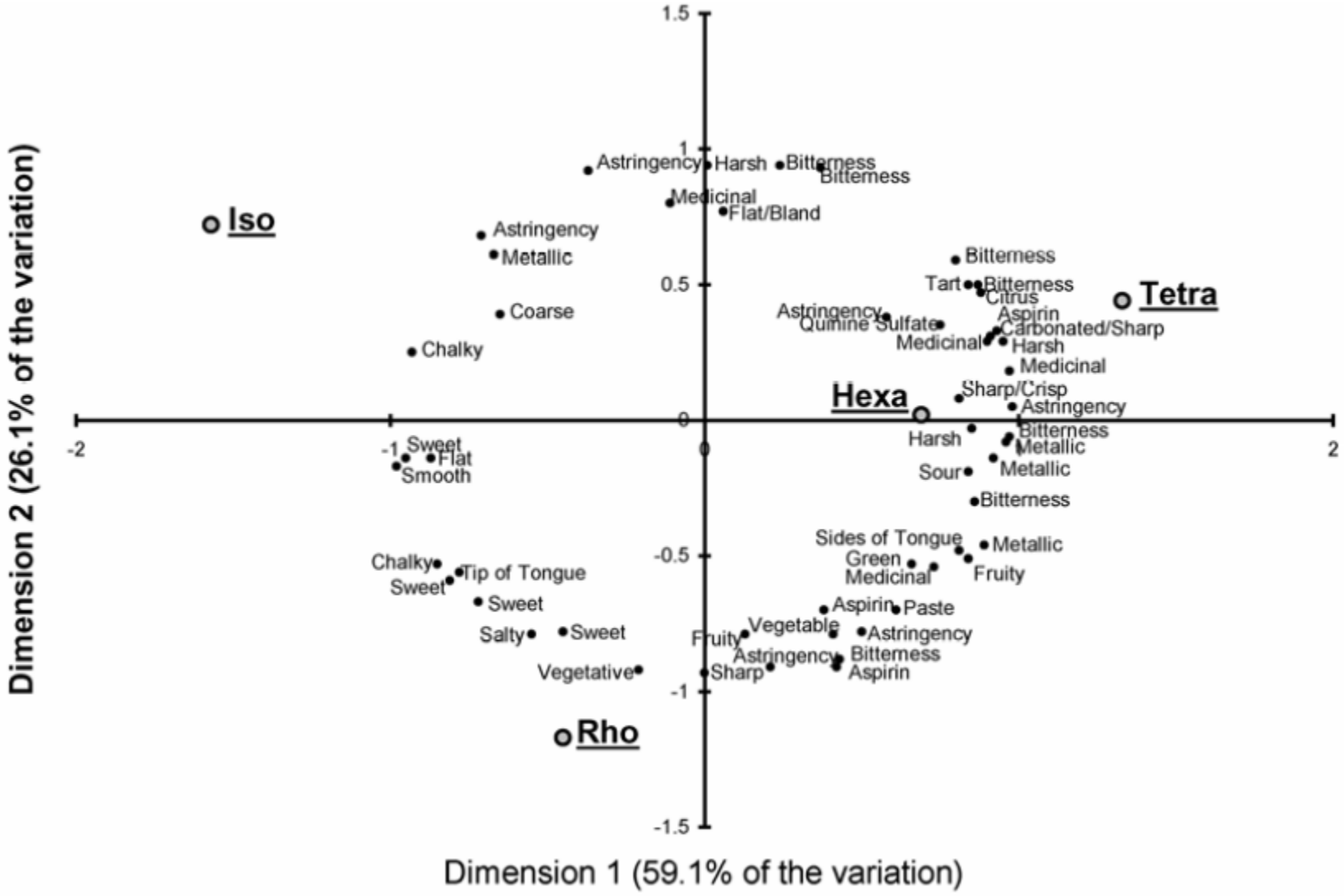


Bitterness Quality



2017 ASBC Meeting

Bitterness Quality



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Bitterness Intensity and Time Intensity

- Applied example

Food Research International

Volume 86, August 2016, Pages 104–111

Modification of perceived beer bitterness intensity, character and temporal profile by hop aroma extract

Olayide Oladokun[a], Amparo Tarrega[a], Sue James[b], Trevor Cowley[b], Frieda Dehrmann[b], Katherine Smart[b], David Cook[a], Joanne Hort[a]

Show more

https://doi.org/10.1016/j.foodres.2016.05.018

Highlights

- Aroma modified intensity, character and temporal profile of bitterness in beer

Bitterness Perception

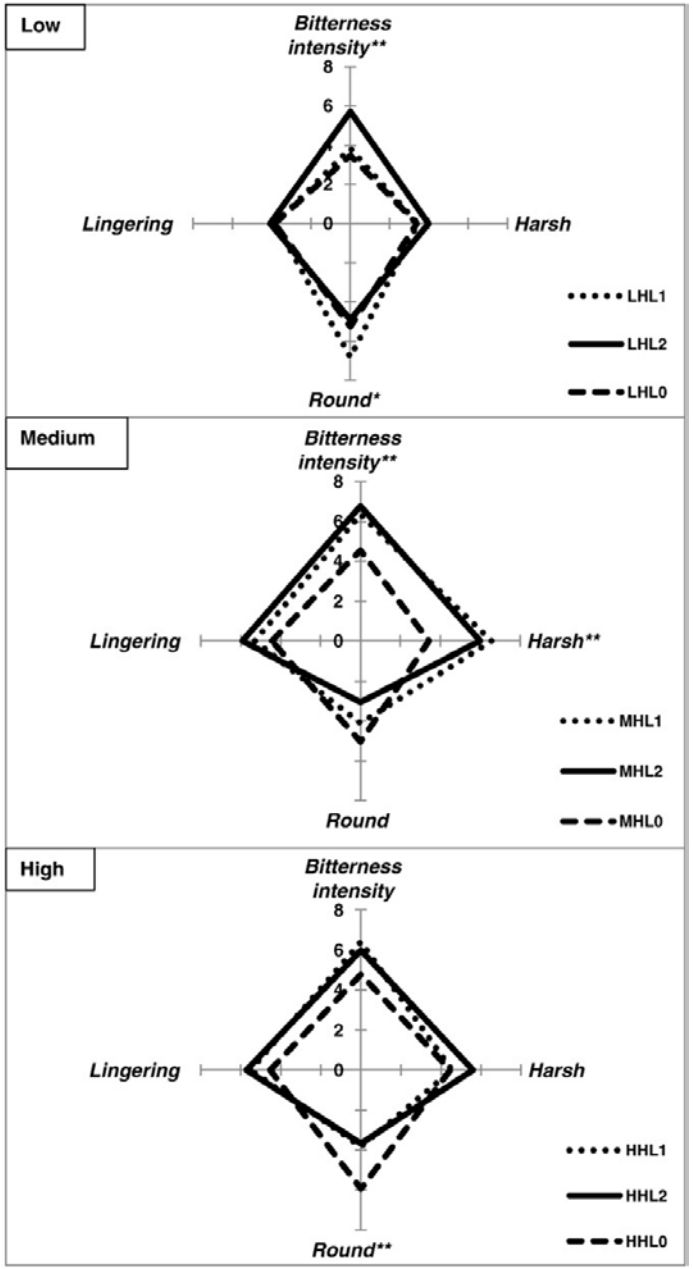

Fig. 1. Spider plots of mean bitterness intensity and bitter character based on intensity ratings. Low: (13 BU) beer, Medium: (25 BU) beer and High: (42 BU) beer. L0, L1 and L2 at each BU level corresponds to hop aroma extract addition levels of 0, 245 and 490 mg/L. Significance denoted at *5% and **1% level.

Time Intensity

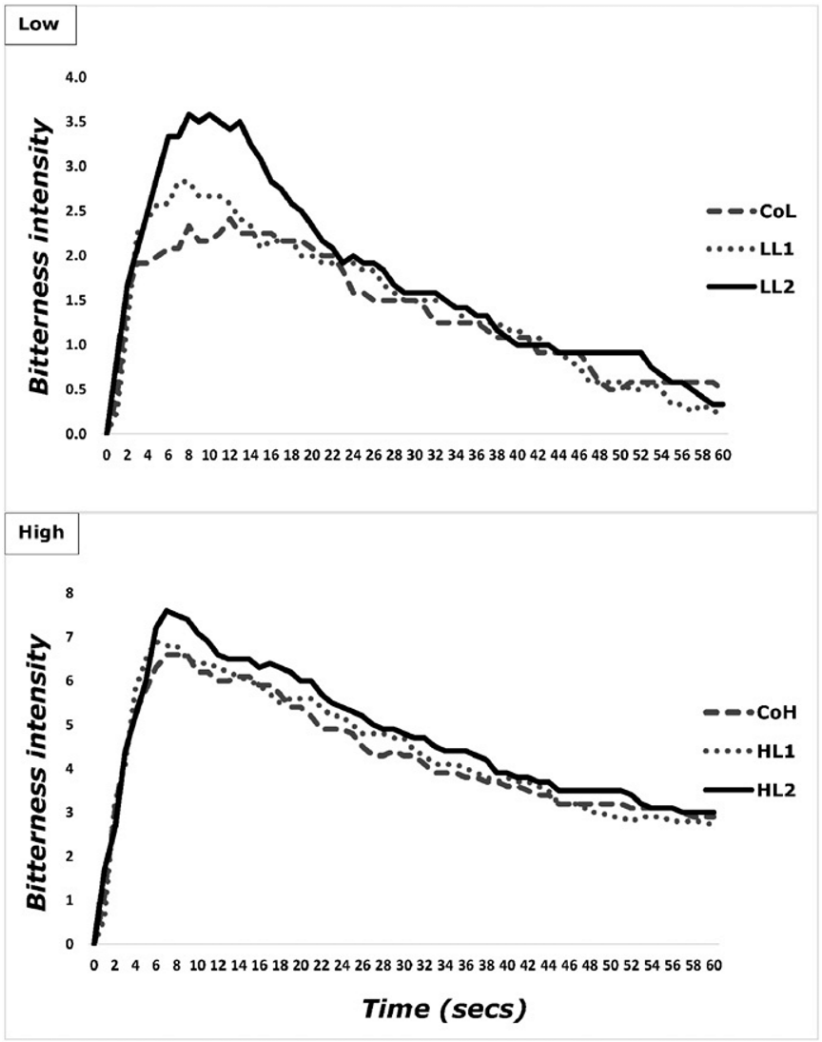

Fig. 4. Average time-intensity curves. Low: (13 BU) beer and High: (42 BU) beer. CoL and CoH, LL1 and HL1, LL2 and HL2 correspond to hop aroma extract addition levels of 0, 245 and 490 mg/L respectively. Significance at 5% level.

Tasting

- Base Beer +10 ppm of Iso
- Base Beer +30 ppm of Iso
- Base Beer +30 ppm of Iso and hop aroma