The Effects of Polyphenols Extracted during Dry Hopping on Beer Flavor Stability

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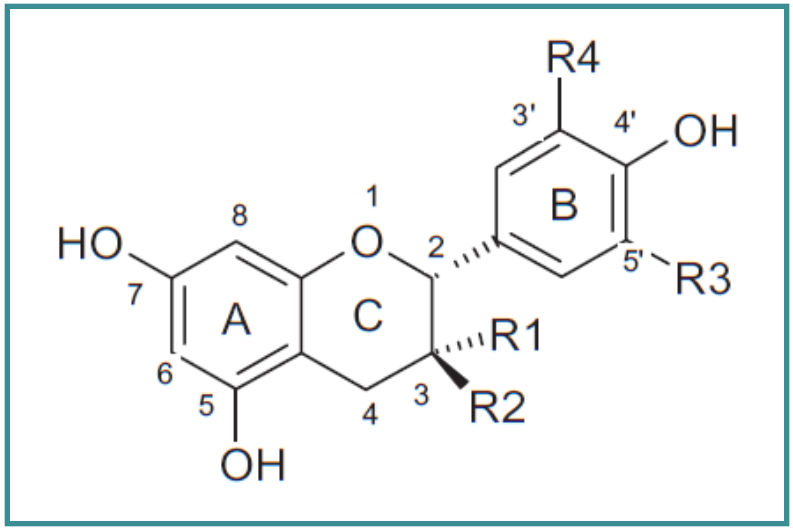
Specific Aims

- Determine impact of dry hopping on flavor stability of beer in relation to polyphenol extraction
- Observe extraction rates of hop-derived flavor-active compounds during dry hopping

Background

Polyphenols and beer flavor



Bitterness

Astringency

Stability

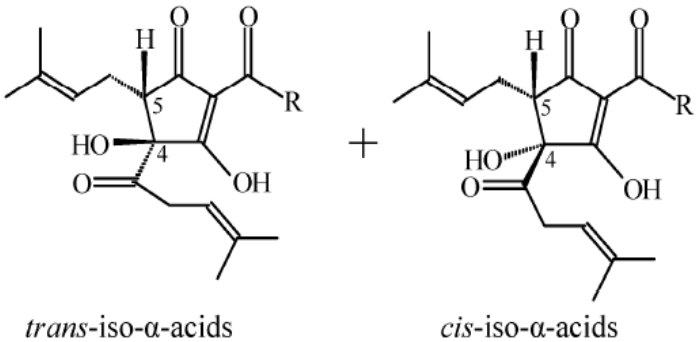
The Science of Beer

Background

Chemical Aging Markers

Aldehydes	
Sources	Compounds
Amino acid degradation (Strecker)	phenylacetaldehyde methional 3-methylbutanal 2-methylbutanal 2-methylpropanal
Maillard reactions	Furfural
Oxidative degradation of lipids	hexanal pentanal
Aldol condensation	(E)-2-nonenal

t/c-*iso*-α-acid ratio



(de Clippeleer et al. 2010; Malfliet et al. 2008; De Cooman et al. 2000)

Experimental Design

Experimental beer

August Busch III Pilot Brewery – UC Davis

- 1.7 hL batch
- 12.5°P
- 5.0% ABV
- Rahr Pale Ale Malt
- Rahr Caramel 20L
- 30 IBUs
- Wyeast 1056
- 18°C fermentation for 4 days
- Sterile filtered

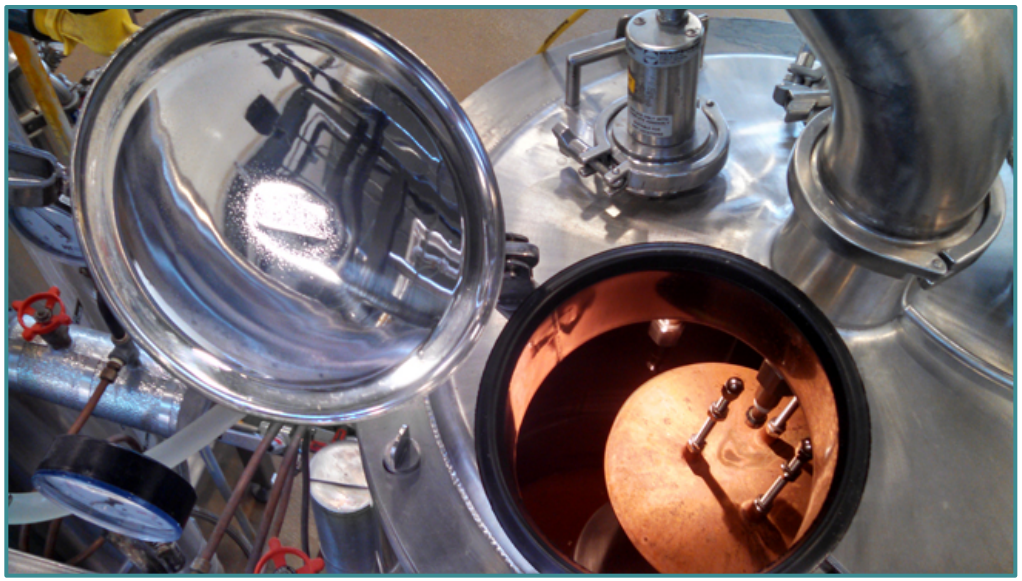
Experimental Design

Experimental process

Experimental Design

Experimental process

Brewing → Fermenting → Dry-Hopping → Bottling → DA, GC → HPLC



Experimental Design

Experimental process

Brewing → Fermenting → Dry-Hopping → Bottling → DA, GC → HPLC

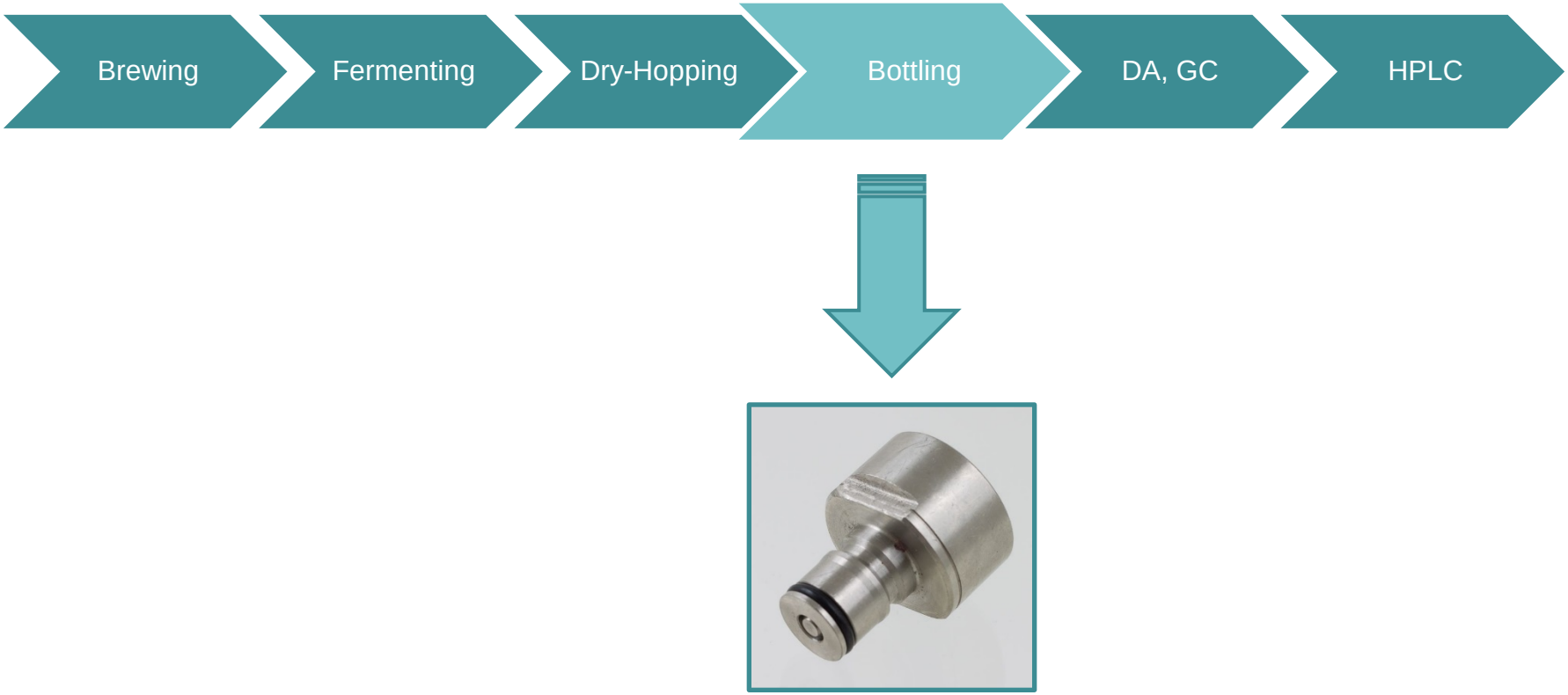
Experimental Design

Experimental process

Dry Hopping	
Hop varietal	Cascade (BSG)
Hop type	Pellets (T-90)
Dry hop amount	½ lbs/bbl
Contact time	0-96 hr

Experimental Design

Experimental process



Experimental Design

Experimental process

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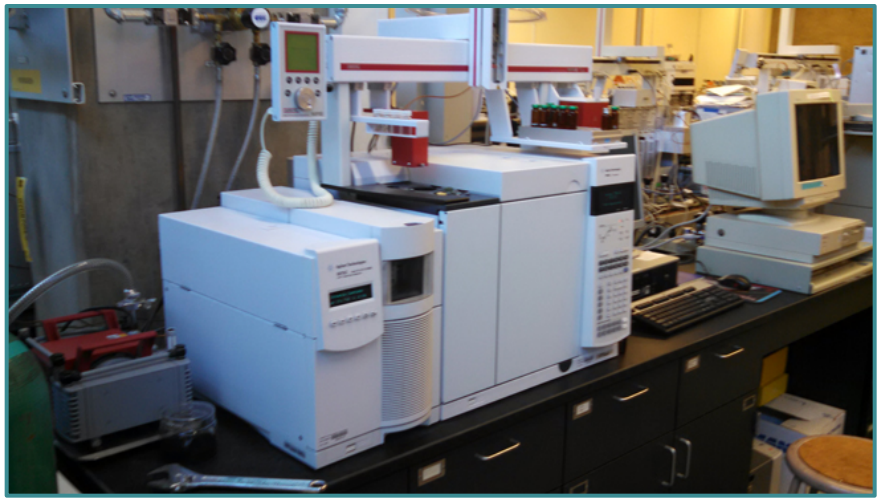

Experimental Design

Experimental process

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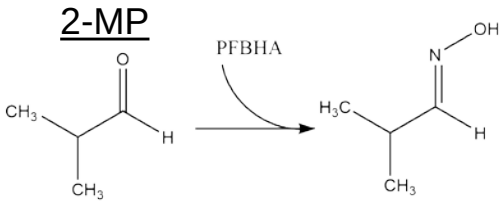
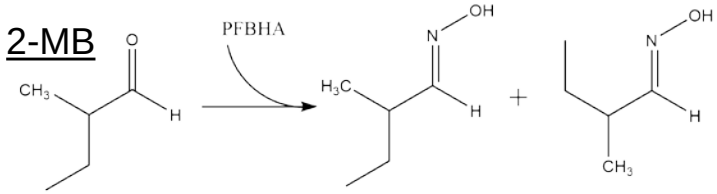
Results

GC and aldehydes

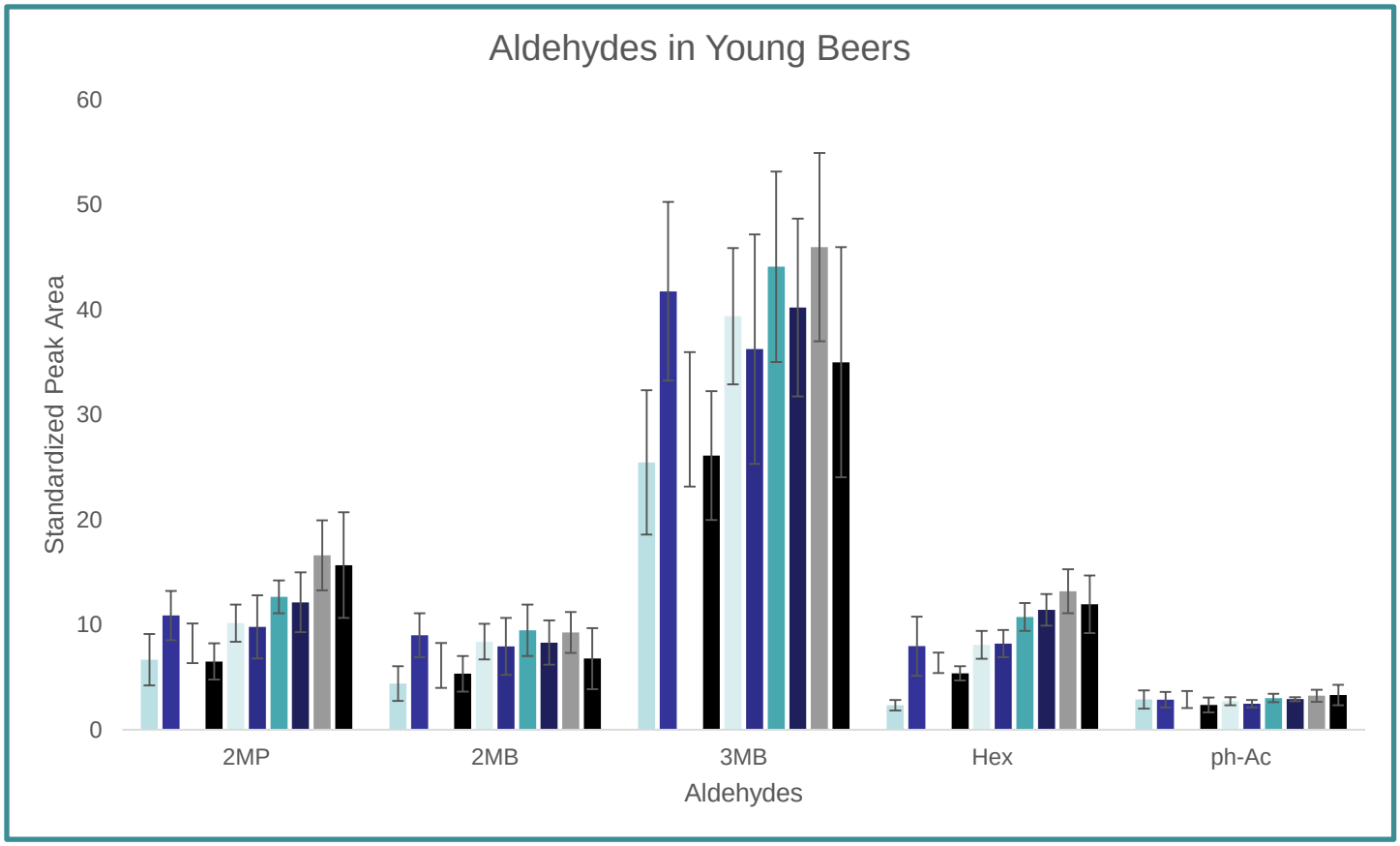




Chromatograms of aldehydes of interest (SIM 181m/z)

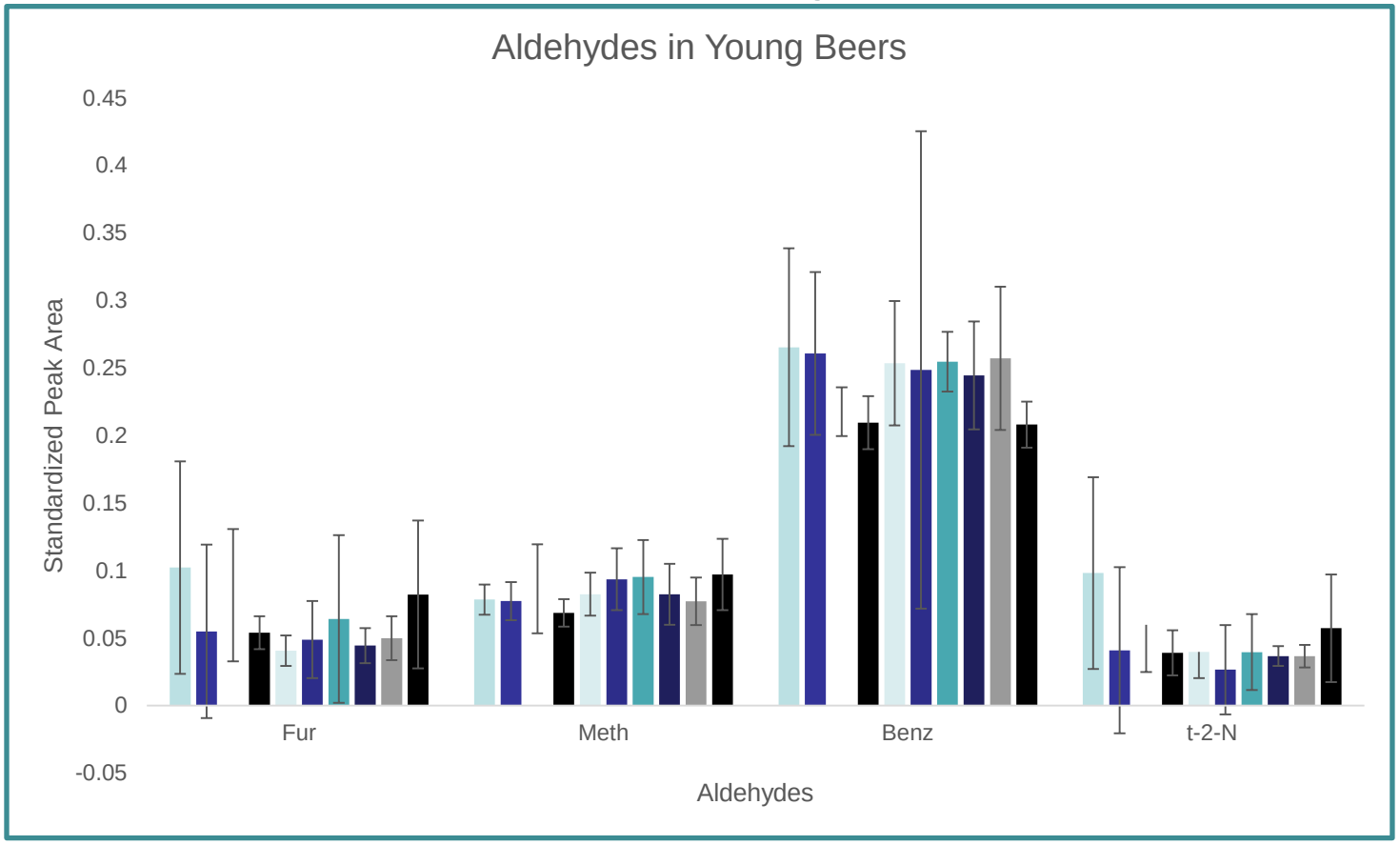
Results

GC and aldehydes



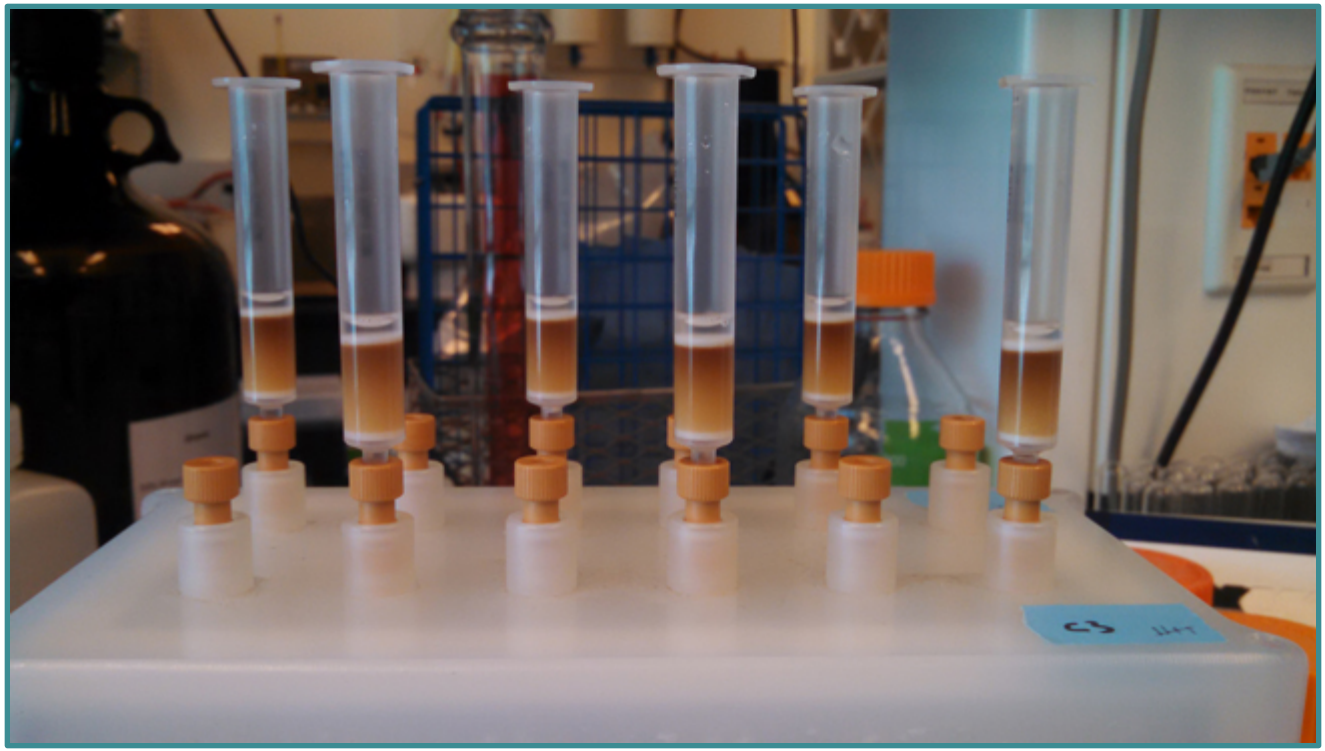
Results

GC and aldehydes



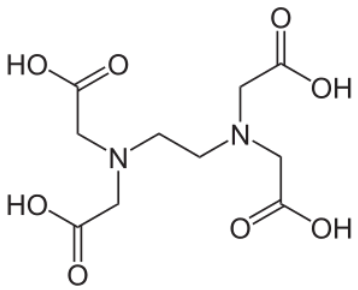
Results

Iso-α-acid analysis



Results

Iso-α-acid analysis



EDTA 0.1M (1 mL/L)

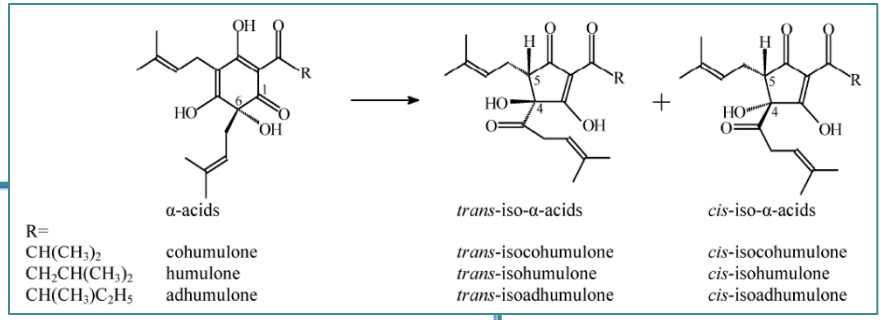
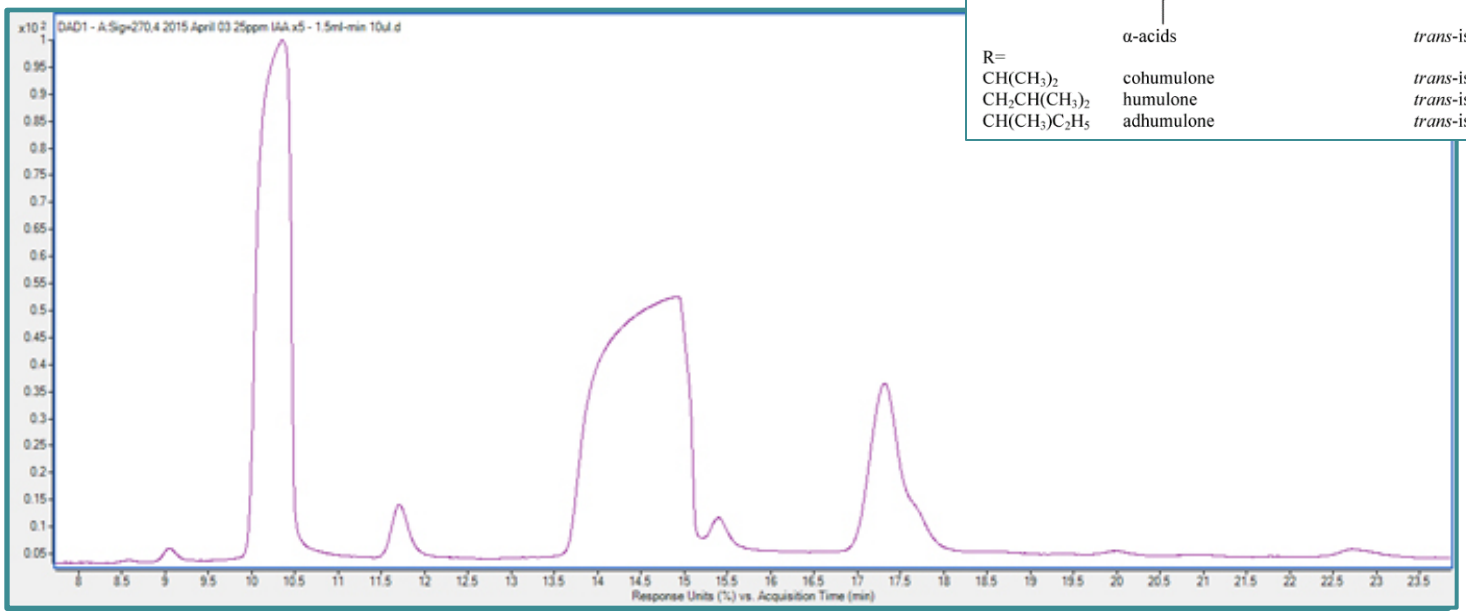


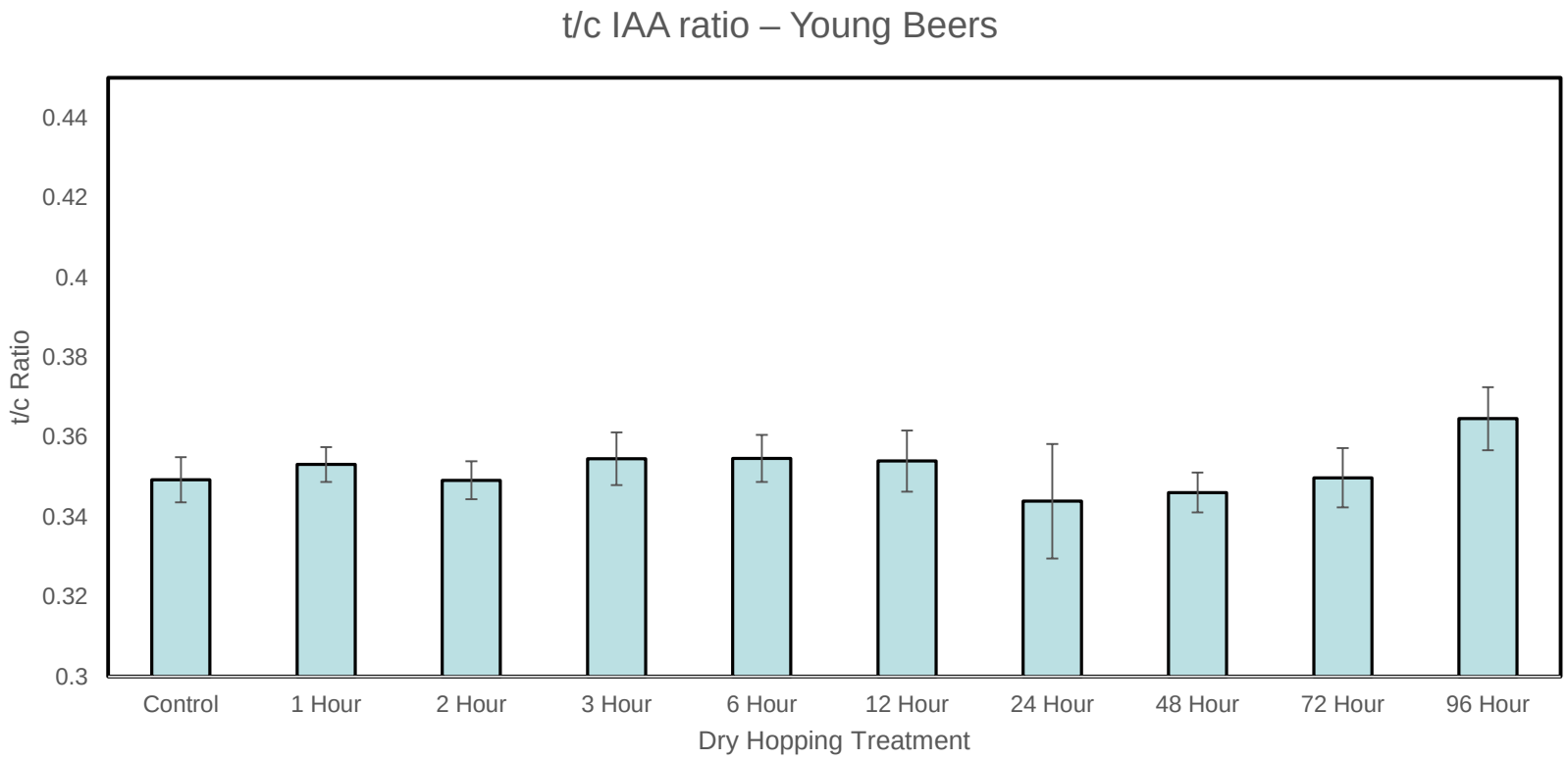
Image credit: Jaskula et al. 2007



Chromatogram of successful separation of all six acids in beer sample.

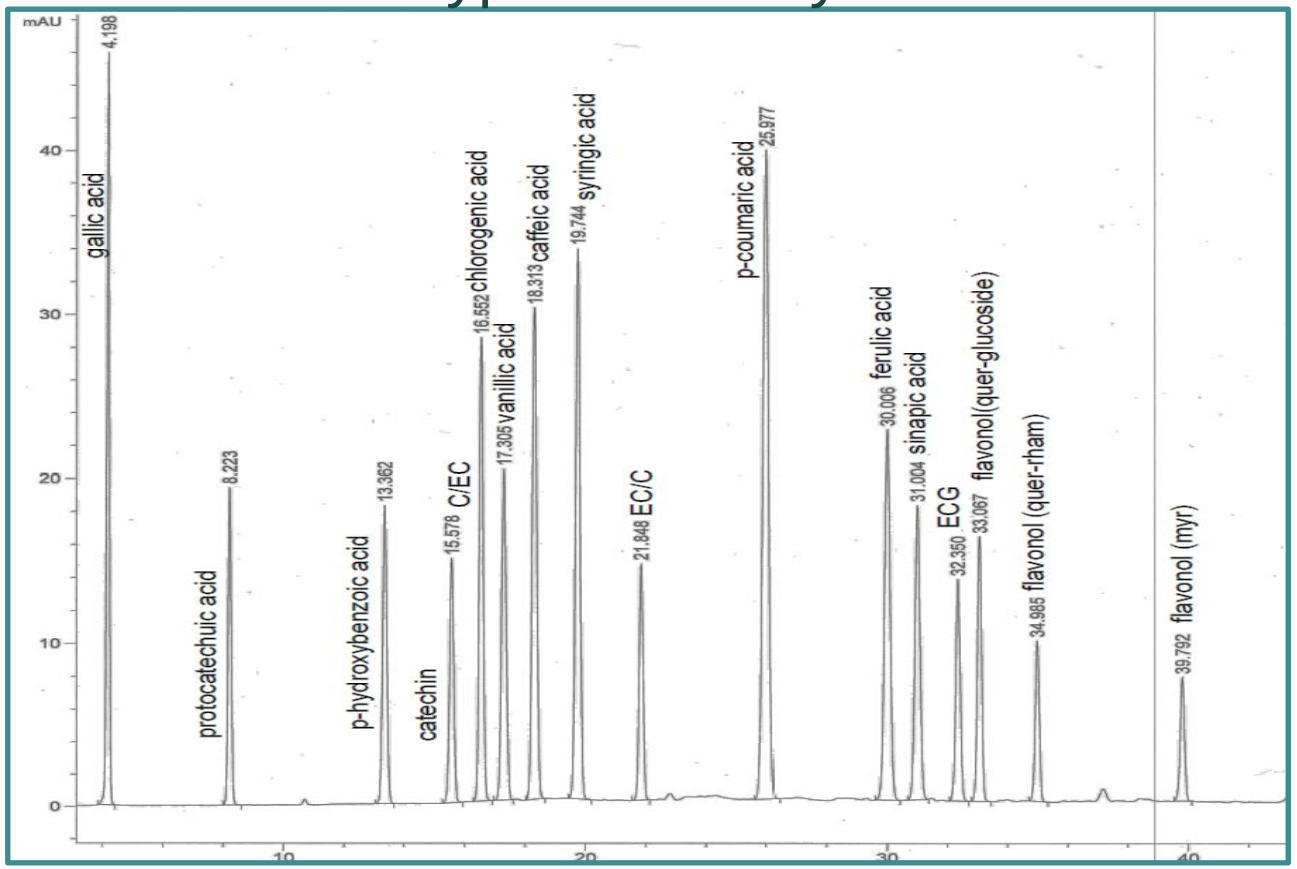
Results

Iso-α-acid analysis



Results

Polyphenol analysis



Chromatogram showing polyphenols of interest

Results

Descriptive analysis

DA Design

- Modified ballot design
- Treatments evaluated in triplicate
- 10 treatments x 3 dry hop reps x 3 sensory reps = **90 beers**
- DA done in two weeks
- Thank you panelists!

Results

Descriptive analysis

Attributes

- Pine
- Grapefruit
- Pineapple
- Citrus
- Stone Fruit
- Dried Fruit
- Cedar
- Floral
- Passion fruit
- Herbal
- Onion/Garlic
- Earthy
- Vegetal

Expectations

- Correlations between sensory and chemical data
- Lower t/c ratios in aged beer with shorter dry hop time
- Changes in aldehyde profiles indicating lipid oxidation and deterioration of flavor compounds
- Correlation between polyphenol concentrations and aging markers

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THANK YOU!

Questions?