Use of a Field-portable GCMS in a Brewing Environment

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MOUNT ST. MARY'S UNIVERSITY

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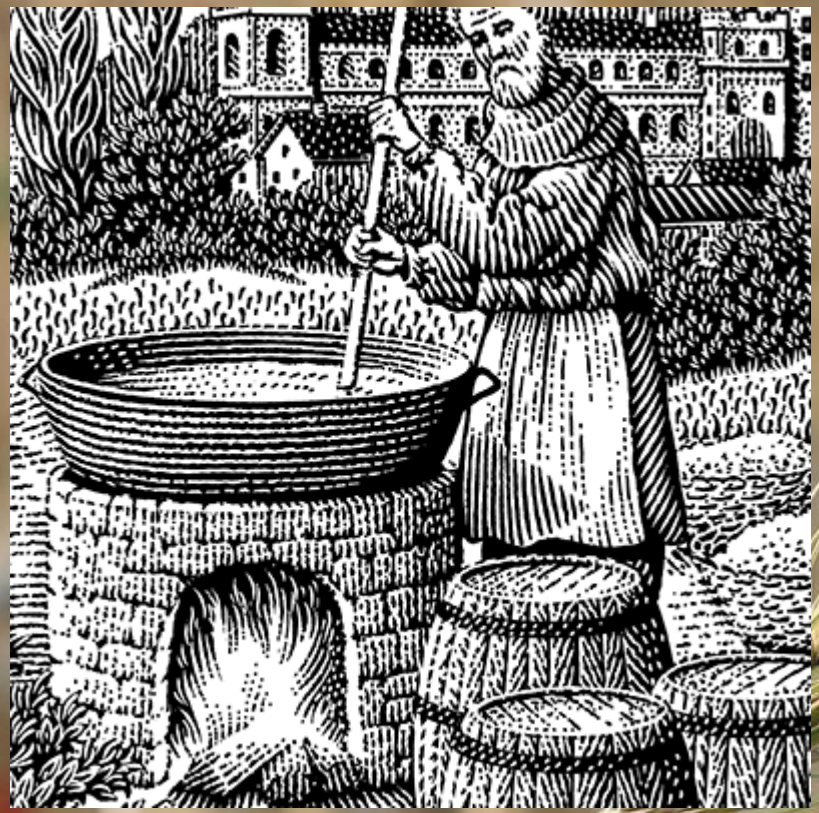

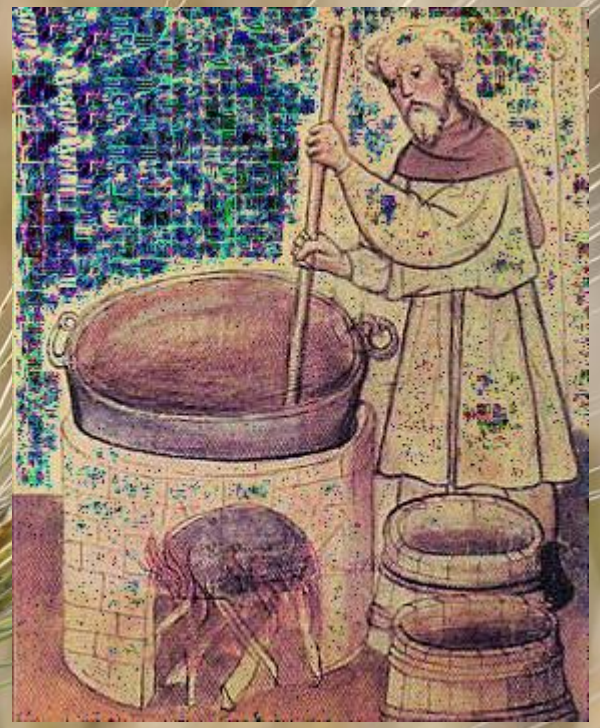

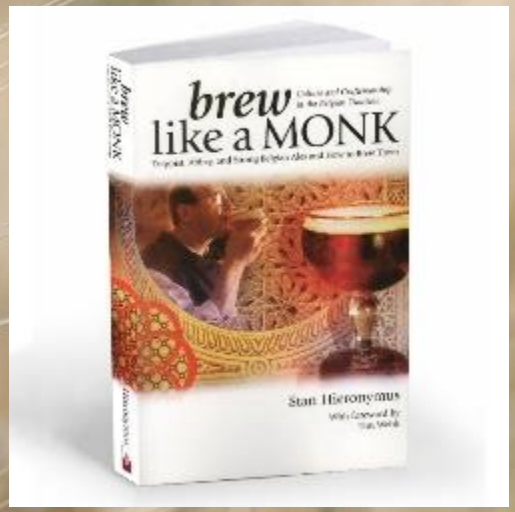

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Brewing Science

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http://www.greatnorthwestwine.com/2013/08/02/osu-fermentation-science/

Brewing Science

- Chemistry – Analytical and instrumental analysis
  - pH
  - Water quality
  - Headspace analysis
- Biology –
  - Yeast
  - Germination
  - Genetics
- Psychology
  - Alcohol and development
  - Perception and marketing

Brewing Process

Malt
Mill
Mash
Sparge
Boil
Hop
Fine
Oxygenate
Pitch
Ferment
Age
Filter
Keg

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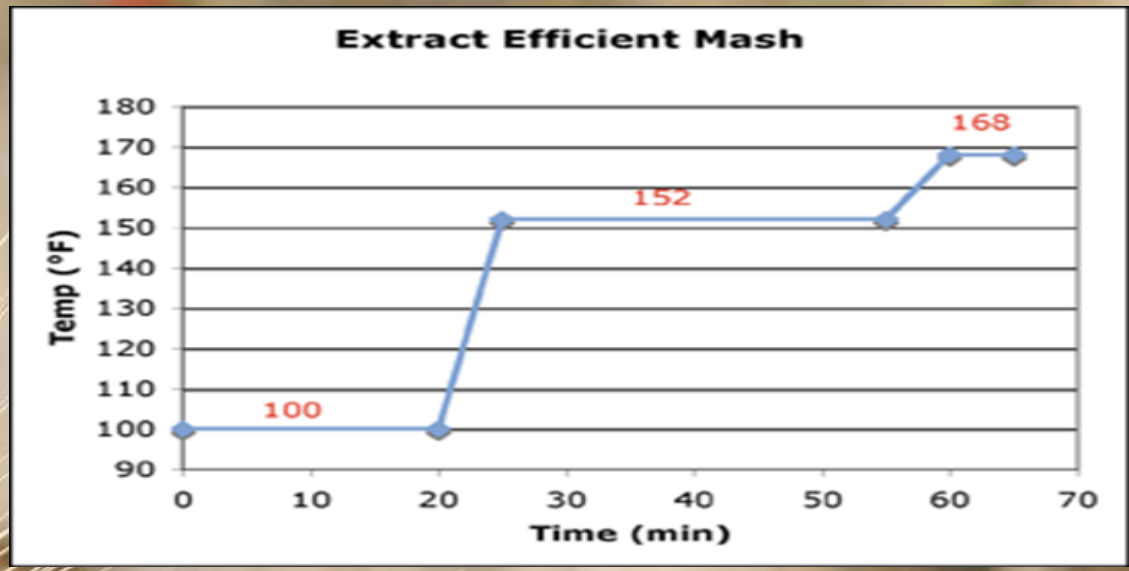
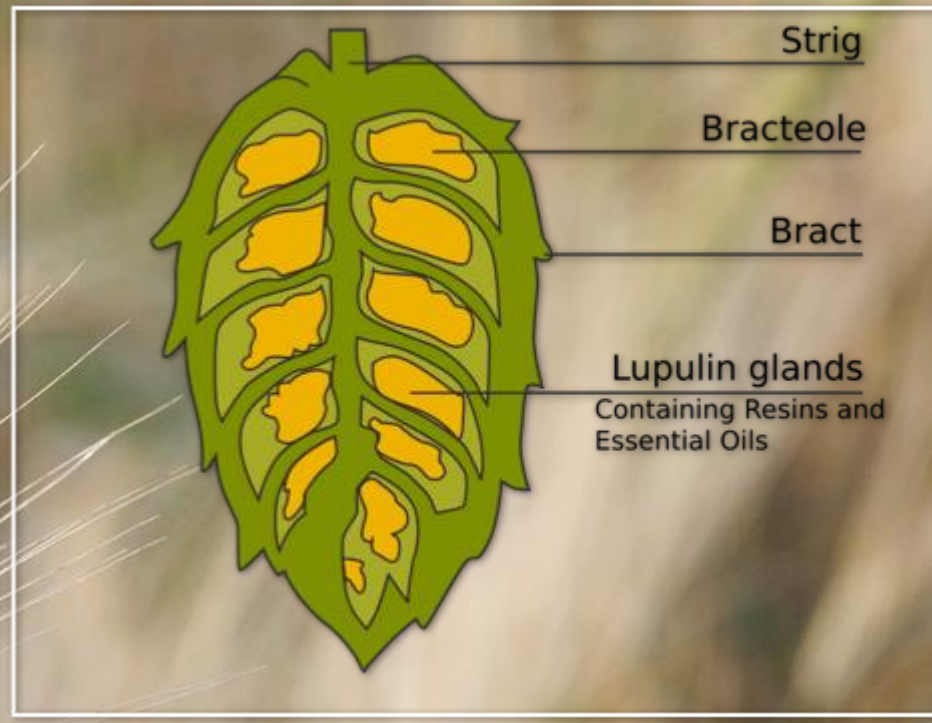
Step mashing

- Progressive increase in temperature, with several "resting" points. Used to create a greater variety of beer types and beers with distinctive flavors
- Acid Rest- First rest in the mashing process. Purpose is to lower the pH and also to break down beta glucans to reduce haze
- Protein Rest- Proteinase breaks down long chained proteins into medium sized chains. Peptidase breaks down short chain proteins into their component form
- Starch Conversion - The starch conversion rest is required in the brewing process. It occurs when two enzymes, known as diastatic enzymes "attack" the starch chains. Beta-amylase cuts off the last two sugar residues from the starch molecule, resulting in maltose



Hops

- British plant which began being used about 1000 years ago
- Before hops brewers used gruit
  - Combinations of herbs
  - Sweet gale, mugwort, yarrow, ground ivy, horeground, and heather but the combination of them varied between each brewer
- Hops began being used because they were taxed less than gruit and provided consistency which gruit could not



Hops

- Hops are grown on vines-like wood stalks called bines
- An acre of hops require about thirty inches of rain during the season but can grow up to 20 feet tall in as little as six weeks.

Hops

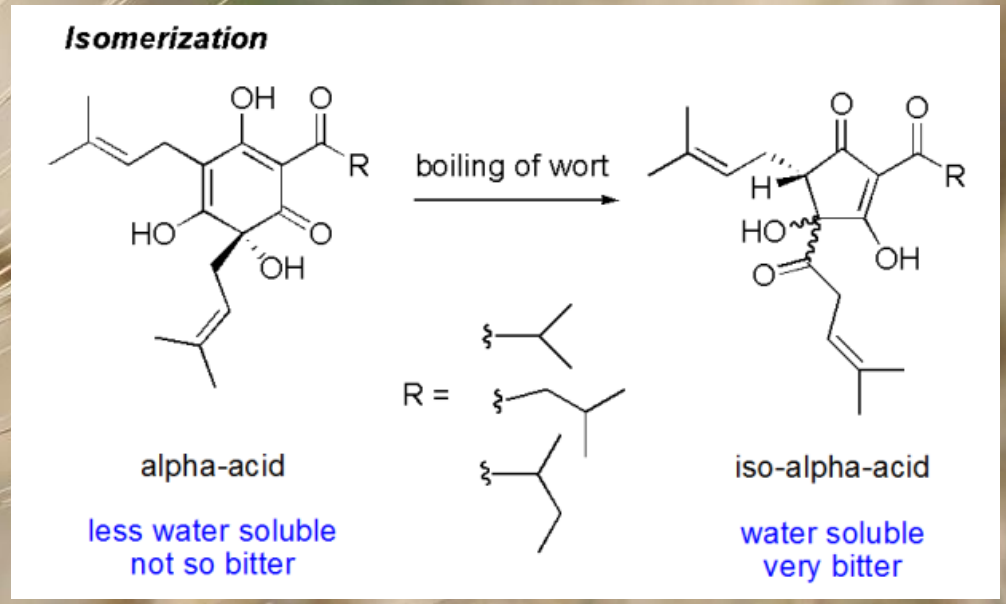
- Alpha Acids
  - Affects the bitterness of beer
  - Components of Alpha Acids
    - Humulone, cohumulone, and adhumulone
- Beta Acids
  - Softer resins which would boil off faster than alpha acids
  - Provide the aroma of the beer
  - Components
    - Lupulone, colupulone, and adlupulone.
  - Beta acids take much more time to break down than alpha acids so they can play an important role on aging and lagering of the beer.

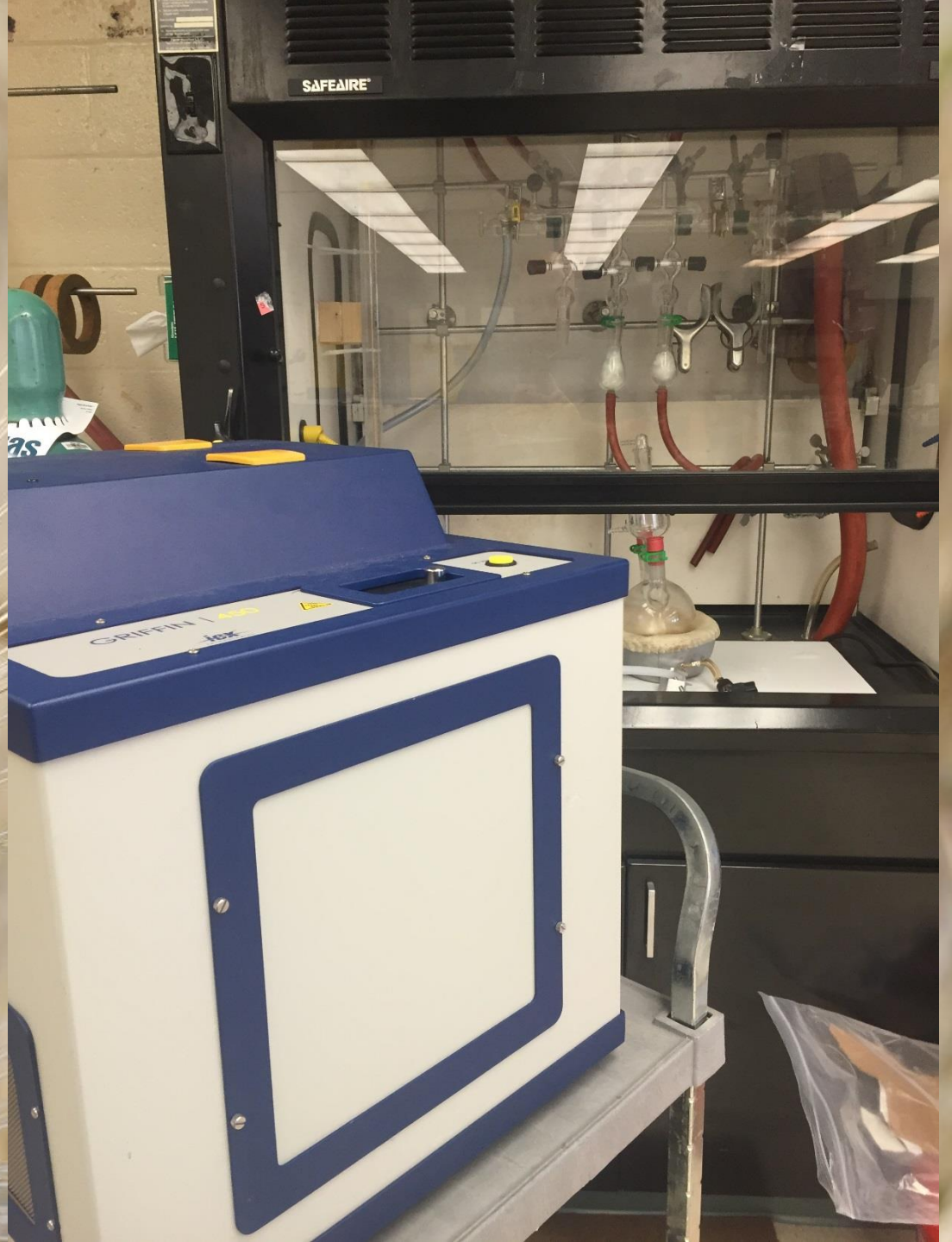
Ultra	2.0 – 3.5%
Saaz (US)	3.0 – 4.5%
Liberty	3.0 – 5.0%
Tettnang (US)	4.0 – 5.0%
Crystal	3.5 – 5.5%
Hallertau (US)	3.5 – 5.5%
Fuggle (US)	4.0 – 5.5%
Glacier	5.5 – 5.5%
Golding (US)	4.0 – 6.0%
Willamette	4.0 – 6.0%
Vanguard	5.5 – 6.0%
Ahtanum™	5.7 – 6.3%
Mt. Hood	4.0 – 7.0%
Cascade	4.5 – 7.0%
Santiam	5.0 – 7.0%
Delta	5.5 – 7.0%
Cluster	5.5 – 8.5%
Sterling	6.0 – 9.0%
Palisade®	5.5 – 9.5%
Perle (US)	7.0 – 9.5%
Brewer's Gold (US)	8.0 – 10.0%

Northern Brewer (US)	8.0 – 10.0%
Amarillo®	8.0 – 11.0%
Centennial	9.5 – 11.5%
Citra®	11.0 – 13.0%
Horizon	11.0 – 13.0%
Mosaic™	11.5 – 13.5%
Galena	11.5 – 13.5%
Nugget	11.5 – 14.0%
Chinook	12.0 – 14.0%
Magnum (US)	12.0 – 14.0%
Simcoe®	12.0 – 14.0%
Chelan	12.0 – 14.5%
Super Galena	13.0 – 16.0%
El Dorado®	14.0 – 16.0%
Columbus/Tomahawk®/Zeus	14.5 – 16.5%
Millennium	14.5 – 16.5%
Newport	13.5 – 17.0%
Bravo	14.5 – 17.5%
Warrior®	15.0 – 18.0%
Summit™	16.0 – 18.0%
Apollo	16.0 – 20.0%

Isomerization

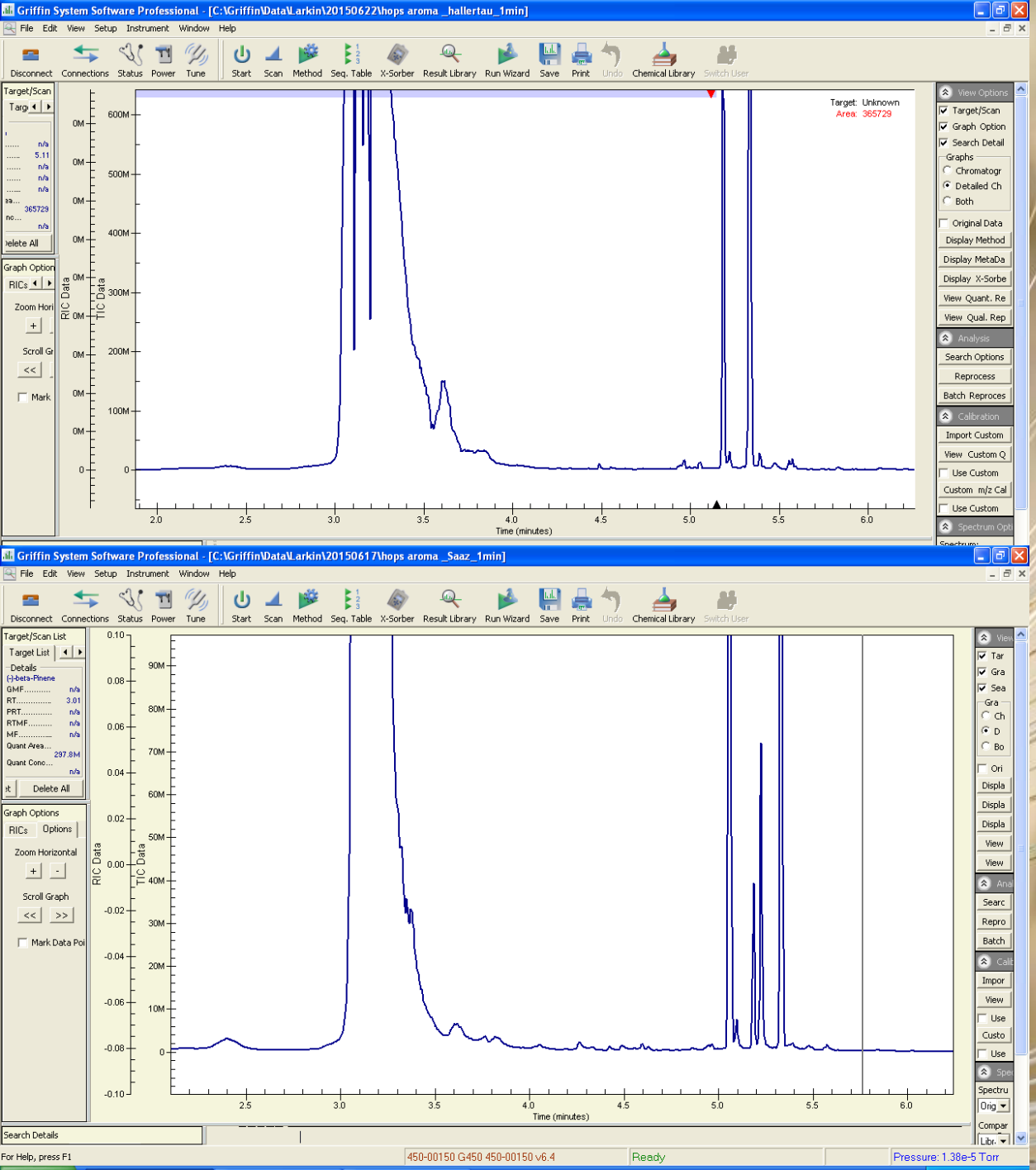
- Isomerization is a chemical process in which a compound is changed into another form with the same chemical composition but a different structure.
- Create a cis- and trans- isohumulone.
- The isomerized acids, however, are what provides the bitterness to the beer.
- The longer the humulones are able to isomerize means the more bitterness they are able to provide for the beer.




SAFEAIRE
GRIFFIN

Compounds	RI
1	*2*
Methyl hexanoate	905
α-Thujene	931
α-Pinene	939
β-Pinene	980
Myrcene	**991**
Butanoic acid butyl ester	993
α-Phellandrene	1003
p-Mentha-1(7),8-diene	1004
p-Cymene	1025
Methyl heptanoate	1026
(E)–β- Ocimene	1050
Terpinolene	1089
2-Nonanone	1090
Linalool	1097
n-Nonanal	1101
Methyl 6-methylheptanoate	1115
Methyl octanoate	1127
n-Decanal	1220
2-Undecanone	1294
n-Tridecane	1300
Methyl geranate	1323
Methyl decanoate	1326
δ-Elemene	1339
α-Cubebene	1351
α-Ylangene	1375
α-Copaene	1376
l-Tridecene	1385
β-Elemene	1391
n-Tetradecane	1400
α-Gurjunene	1409
(E)-α-Bergamotene	1413
β-Caryophyllene	**1418**
β-Ylangene	1421
β-Gurjunene	1432
γ-Elemene	1433
(E)-α-Bergamotene	1435
α-Guaiene	1438
Aromadendrene	1439
α-Humulene	**1454**
(E)-β-Farnesene	**1457**
(Z)-Muurola-4(14),5-diene	1460
Alloaromadendrene	1461
α-Acoradiene	1466
γ-Gurjunene	1473
γ-Muurolene	1477
2-Tridecanone	1477
γ-Curcumene	1481
ar-Curcumene	1483

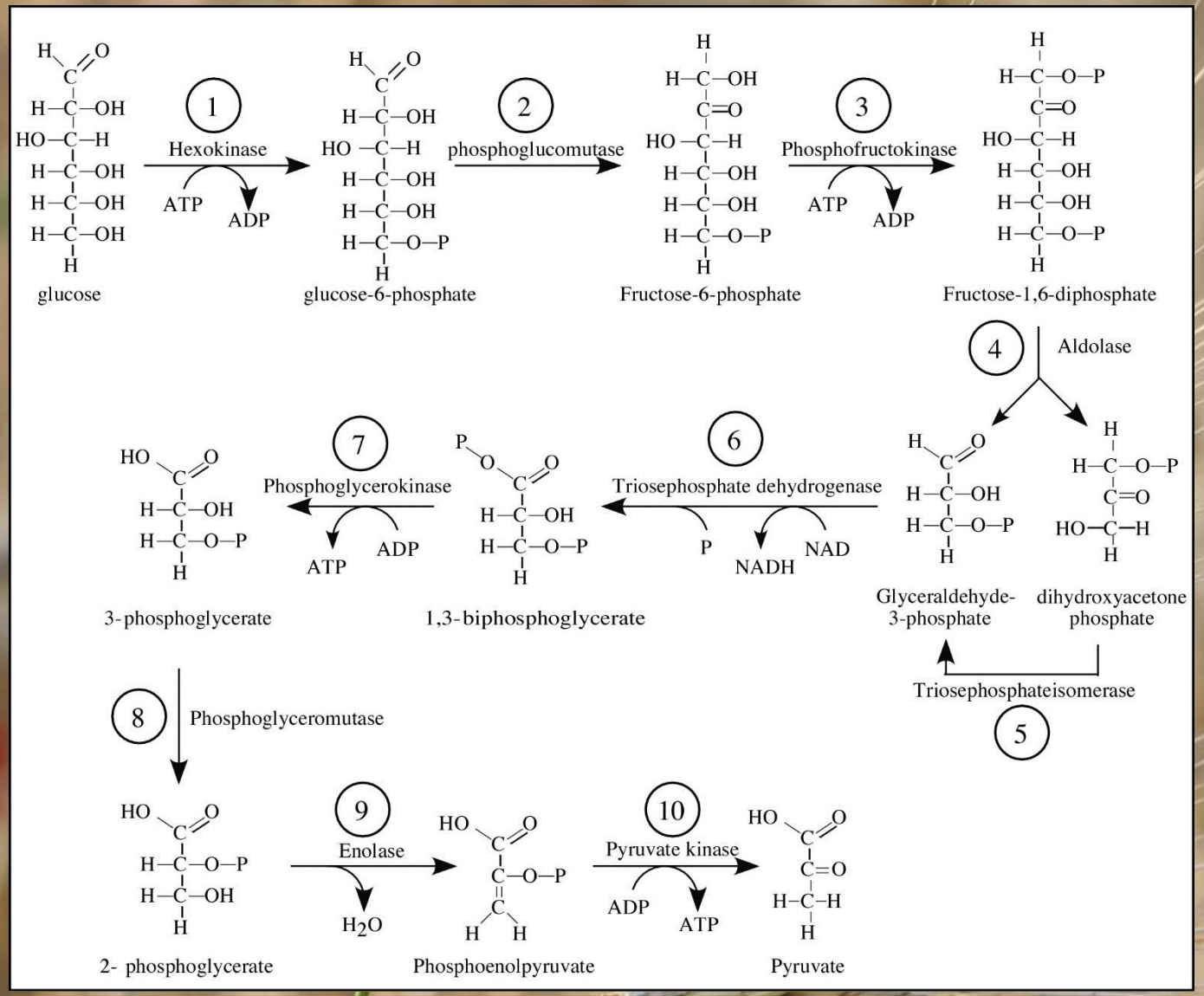
Chemical composition of essential oils of hops (*Humulus lupulus* L.) growing wild in Aukstaitija, *Chemija*., 2004 T. 15 Nr. 2. P.31-36



- Hallertau
- Saaz

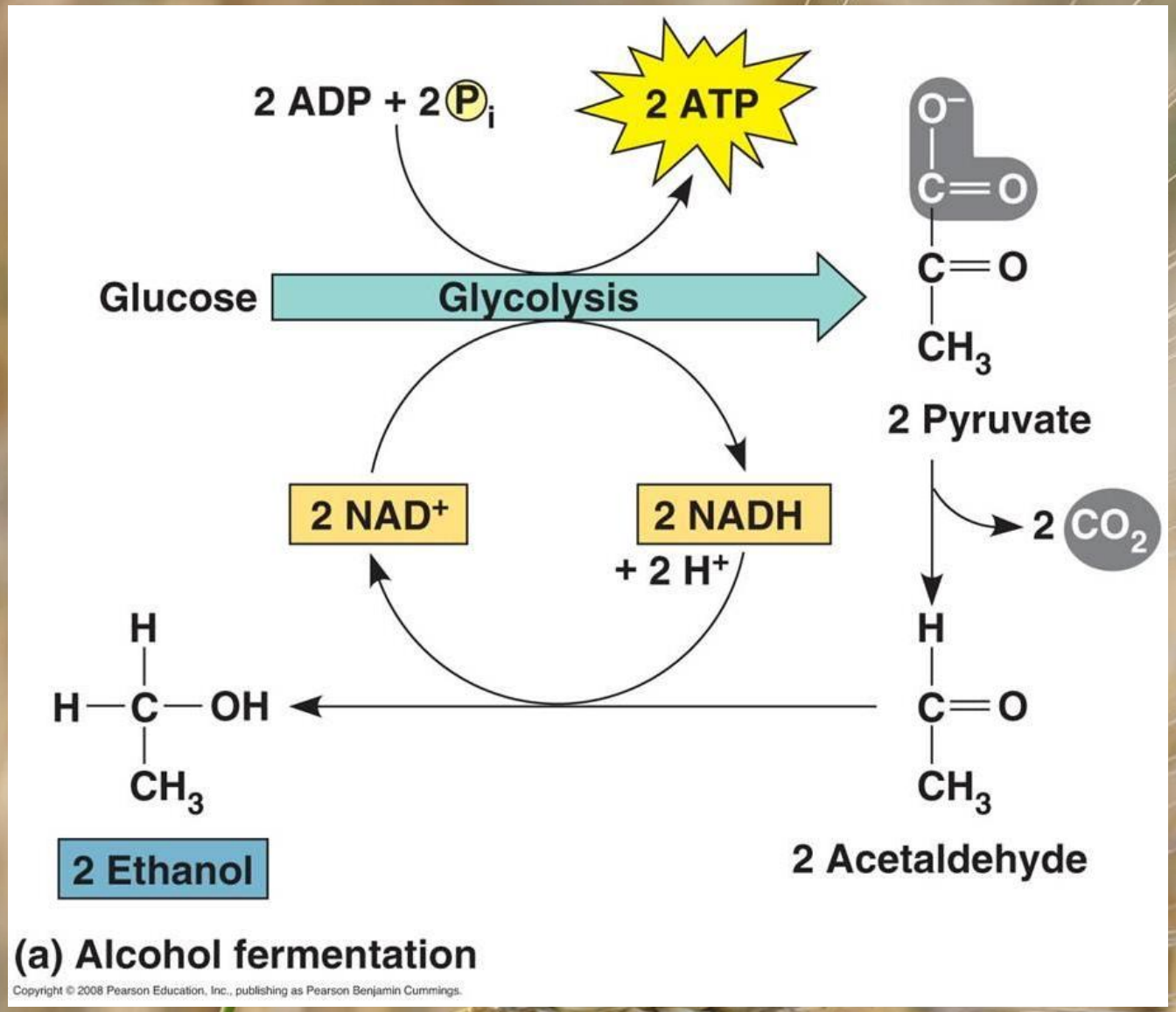
- 1 minute Xsorber sample collection of headspace of ground hops pellets
- Compared to each other and on the vine flowers

Glycolysis



- Presence of zinc
- Redox reactions with NAD
- Formation of pyruvic acid

Fermentation



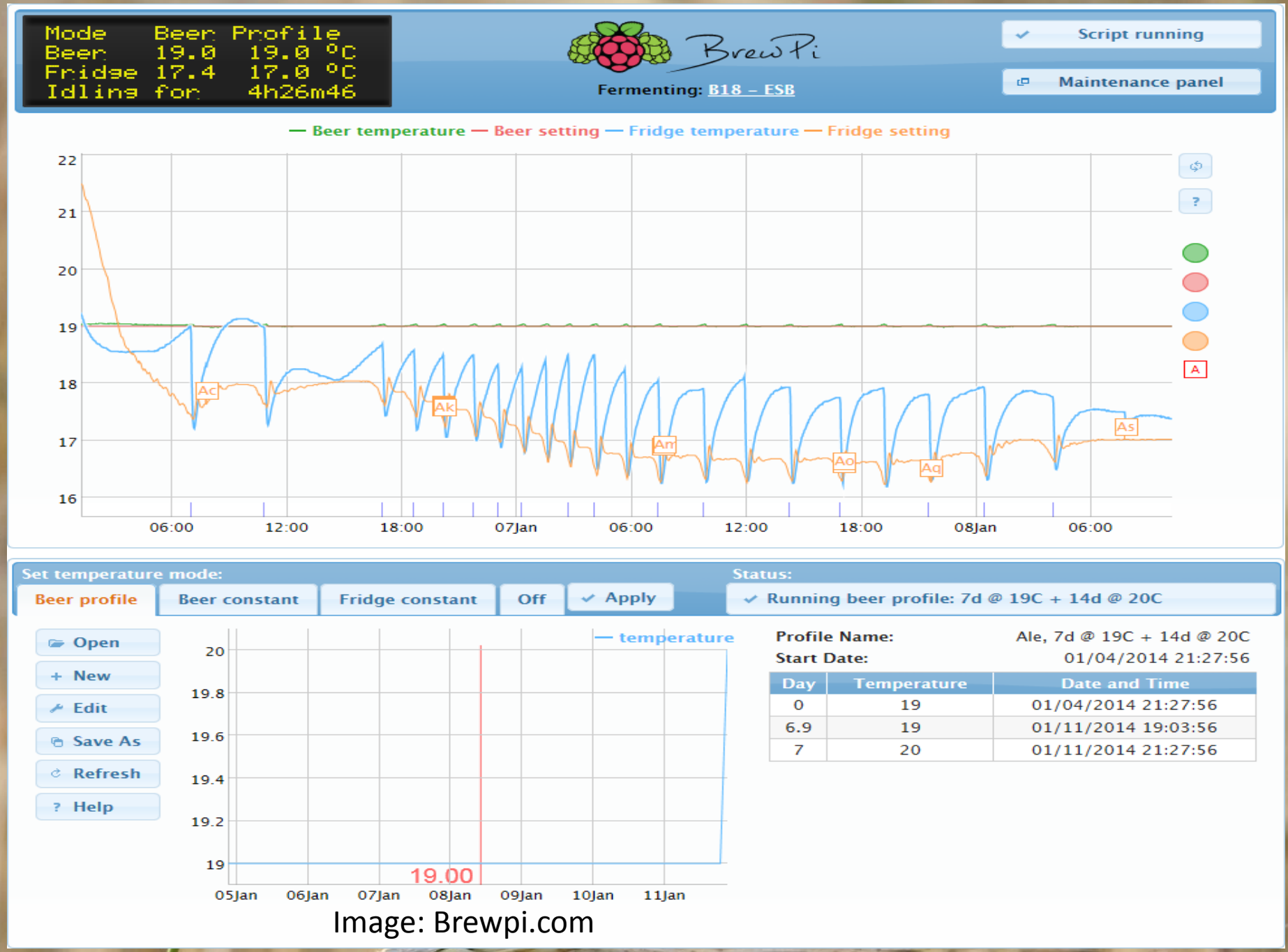


Image: Brewpi.com

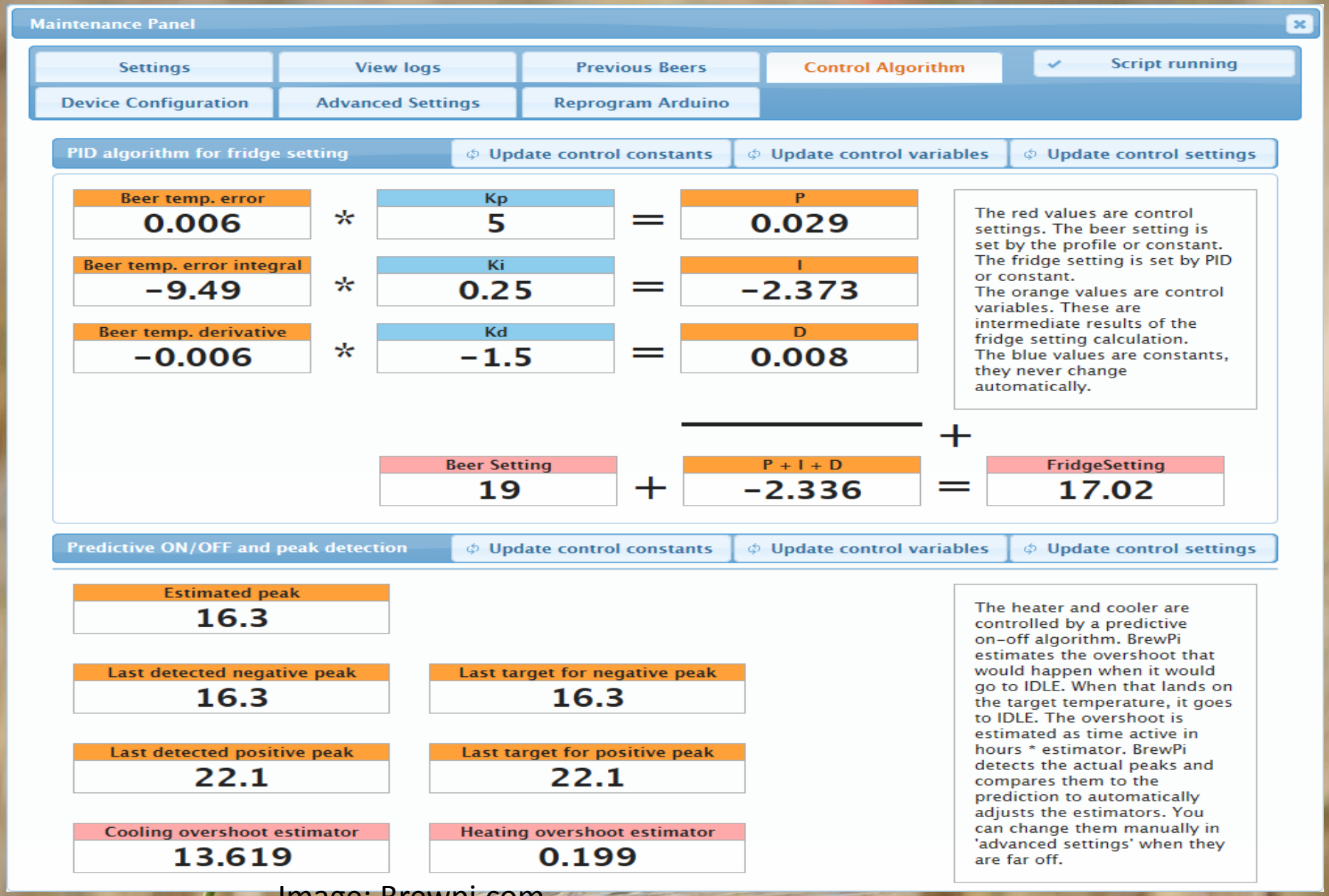
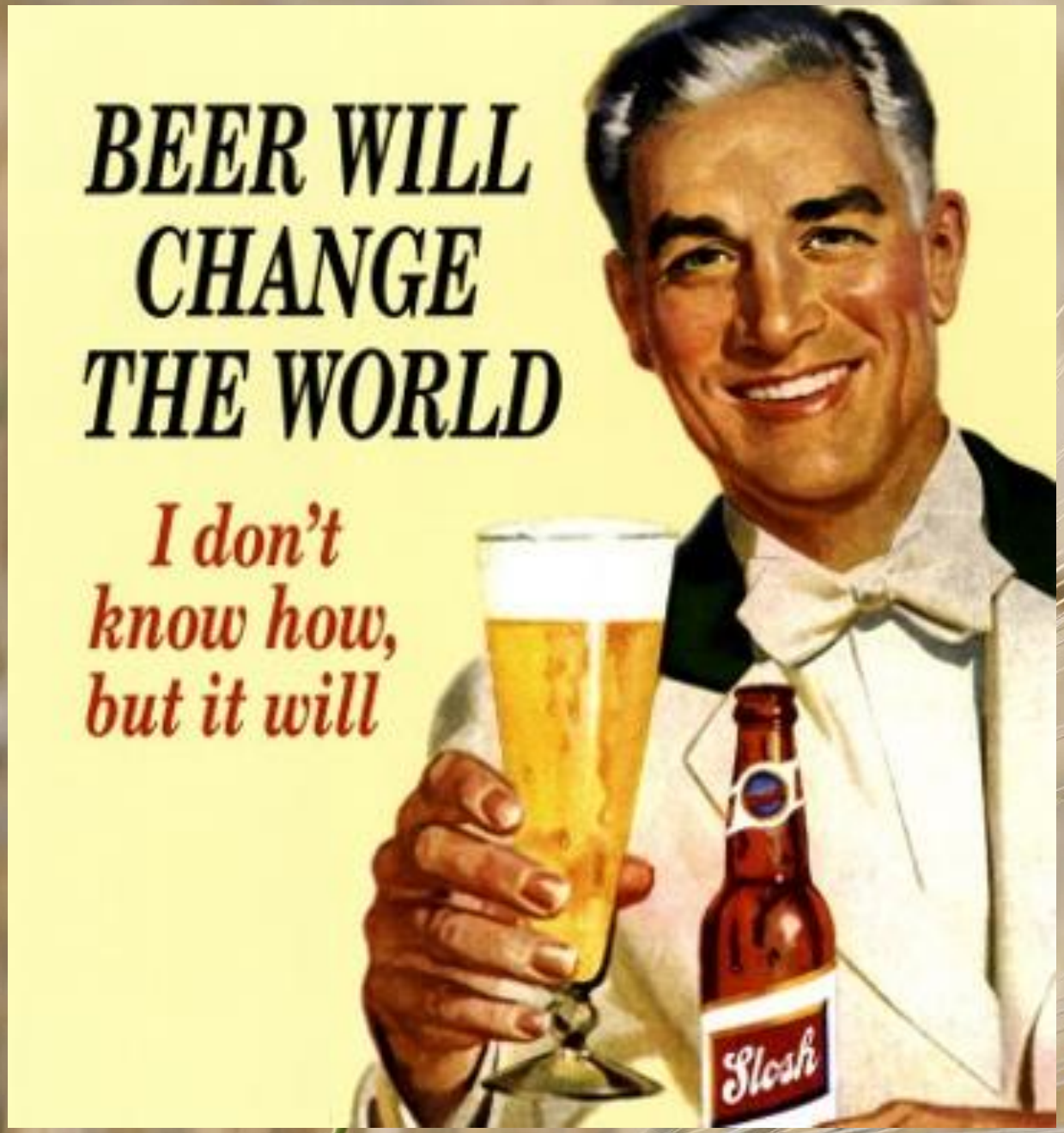


Image: Brewpi.com


180QT
180QT
180QT
AmeriGas


GIANTS


2015 Special Edition
PRESIDENTIAL ALE
IRISH RED ALE



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How Does Water Affect Beer?

- Simple answer: Taste and Aroma
- How? Different chemical profiles.
- The source of water can result in an altered chemical composition
- Water also differs geographically which allows certain beers to be made better in certain regions
  - Hard water in Dublin results in Guinness
  - Soft water in Pilsen Region of Czech Rep. results in Pilsner

How it Affects Beer

- Mashing requires a certain pH or the flavor is affected
  - Generally between pH 5.2-5.5
- Alkalinity affects mash pH affects fermentation pH affects beer pH
- Most tap waters are high in alkalinity (pH 7+) and most grains are slightly acidic so they balance out in the mash
  - Lighter grains have lower acidity – require more additives to help bring pH down
  - Dark grains have higher acidity – require less additives
- Beer with a higher pH results in a “lifeless” beer as it is still drinkable but missing some of the finer flavors and aromas found in a beer made with correct pH.

How to Help Conserve Water

- Buy from breweries that have environmental sustainability programs and/or water conservation plans
- MillerCoor's
  - Uses 3.4 barrels of water/1 barrel of beer, cleaning bottles with air, doesn't use water-based solvents for packaging
- Long Trail Brewing Co.
  - uses 2 gal water/1 gal beer by capturing and reusing steam in a Heat Recovery System
- Sierra Nevada
  - Uses drip irrigation in hop fields and maintains own wastewater plant
- New Belgium Brewing Co.
  - Eco-friendly brewery, harvests energy from treating wastewater to power brewery, harvests 14% of their own electricity.
- Buy aluminum cans or kegs
- Recycle!