Water
(and context)

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Context for why we care about water

- Malting
- Mashing
- Boiling
- Fermenting
- Yes, pretty much everything

Quick outline of the brewing process

- Malting barley:
  - Harvested, dormant for months
  - Steeped in water for ~ 24-48 hrs
  - Germination begins, “modifies” entire grain
  - Breaks up starch “matrix,” activates proteolytic and amylase enzymes
  - Dried (to ~ 10% moisture) then kilned to desired color and flavor

Quick outline of the brewing process

- The mash:
  - Malt soaked in water ~ 65C
  - Amylase breaks off simpler sugars from starches
  - β-amylase breaks off monosaccharide units (mostly glucose), denatures rapidly @ 70C
  - α-amylase breaks of longer chains (maltose, maltotriose), denatures rapidly @ 75C

Sugar solution (wort) is boiled, hops added for bitterness and flavor

Quick outline of the brewing process

- Boil 60+ minutes to sterilize, extract α-acids from hops (bitterness), drive off DMS
- Rapidly chill to pitching temperature
- Aerate well
- Pitch appropriate yeast
  - Or stir with magic wooden spoon ….

Some advances (?) in brewing practices

- c 500-present: monastery breweries
- c 1400: Guild of Brewers founded in Koln
- c 1500: German monks begin “lagering” - storing beer in cold caves
- c 1700-1850: technology for drying/kilning of malt advances from the smoky dark
- C 1845: Gabriel Sedlmayer isolates first pure lager yeast strain

Danger of so much effort spent propagating yeast …

Development of beer styles

- Amylase enzymes have both temperature and pH sensitivity
  - Early temperature control was shockingly good, but largely learned by trial and error
  - pH issues less well understood, but nature makes life fairly easy:
    - Enzymatic degradation of phytin in mash forms phytic acid
    - Phytic acid reacts with Ca^2 to form calcium phosphate, release hydrogen ions
    - So pH lowers to ideal 5.2 or so range, unless …
      - lots of alkalinity/hardness

Development of beer styles

- Premier example of water chemistry dictating beer style is …

  Czech Pilsner

Pilsen water profile:

bicarbonate	15 ppm
sulfate	5 ppm
calcium	7 ppm

Very soft, almost no buffering, so can make very light beers with no issues! Low sulfate so high bitterness is still very soft, smooth.

Development of beer styles

- Munich water profile:

bicarbonate	150 ppm
sulfate	10 ppm
calcium	75 ppm

So favors darker grains (with natural acidity keeping the mash pH in check)

Took almost until 20th century for reasonable Munich light lagers to compete with Czech Pils. Usually low bitterness levels to avoid harshness.

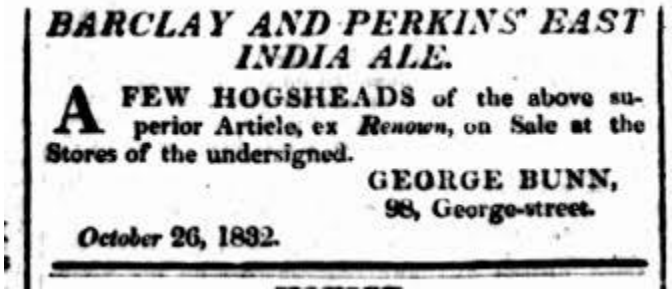
Development of beer styles

- Dublin water profile:
  - bicarbonate 125 ppm
  - sulfate 55 ppm
  - calcium 120 ppm

  Can make darker beers easily, will have a bitter edge due to high sulfate – big roasty stouts are ideal.

Development of beer styles

- Burton water profile:
  - bicarbonate 260 ppm
  - sulfate 450 ppm (!)
  - calcium 275 ppm


BARCLAY AND PERKINS' EAST INDIA ALE.

A FEW HOGSHEADS of the above superior Article, ex *Renown*, on Sale at the Stores of the undersigned.

GEORGE BUNN,
98, George-street.

October 26, 1832.

Can make pale beers with no pH issues, very prominent bitterness – IPA is a natural

BAD example: Dortmund!!!!

BJCP Written Exam question T8:

Discuss the importance of water characteristics in the brewing process and how water has played a role in the development of at least four distinct world beer styles. Address the following topics:

50 %: Describe the importance of water characteristics in the brewing process

50 %: Describe the role in the development of beer styles.

Details on water relevant for exam

1. Why do we care?

- Beer is 85 – 90% water
- Water has dissolved minerals and ions
  - Affect flavor
  - Affect pH
  - Essential for yeast health
- Water qualities vary by region & source
- Classic beer styles were influenced by the local water !!!!!

Details on water relevant for exam

2. Basics

- Should taste and smell “good.”
- Low in iron/other metals (for flavor and yeast health).
- If municipal water, remove chlorine to avoid development of chlorophenols in fermentation:
  - Preboil for free chlorine (Cleveland).
  - Charcoal filter or Campden (Potassium Metabilsulfite) if chloramines (good for low oxygen brewing, too.)

Details on water relevant for exam

3. Hardness

- Hardness refers to total amount of dissolved mineral salts.
- Roughly grouped as “soft” (0-60 mg/l), 60-120 “moderately hard,” 120+ “hard”
- Water hardness due to carbonate/bicarbonate is usually broken down as
  - Temporary Hardness which can be removed by boiling/precipitation (w/ slaked lime?)
  - Permanent Hardness (stuck with it).

Details on water relevant for exam

4. Alkalinity

- Alkalinity is a measurement of buffering ability – i.e. ability to neutralize acids = resistance to changes in pH.
- Water Alkalinity usually expressed as PPM of Bicarbonate (HCO_3) or Calcium Carbonate ($CaCO_3$).
- Residual Alkalinity (RA) measures how much resistance you'll have to natural mash acidification (keeps pH from dropping to 5.2 or so range).
- Higher RA is typically better for darker beers, lower RA for lighter beers.
- Residual Alkalinity can be "neutralized", if needed, by adding acid to mash water (phosphoric, lactic).

Details on water relevant for exam

5. Important ions:

- Salts are just soluble ions (positively charged cations w/ negatively charged anions).
- Cations:
  - Calcium Ca++ (biggest part of hardness & alkalinity, needed for yeast health (20 mg/l?)
  - Magnesium Mg++ (second biggest part of hardness, necessary for yeast health, can add “roundness” @ 10-25 mg
  - Sodium Na+ (adds to malt perception at low levels, salty flavor at > 50 or so mg/l.

Details on water relevant for exam

5. Important ions:

- Salts are just soluble ions (positively charged cations w/ negatively charged anions).
- Anions:
  - Carbonate/Bicarbonate HCO3-/HCO3- - (Expressed as alkalinity/temp hardness; can add to harshness; typically counteracted by dark malts or acid.)
  - Chloride Cl- (Can add to fullness, perception of sweetness.)
  - Sufate SO4- - (Adds fullness, perception of bitterness.)

Return of development of beer styles

- Cleveland water report:
- pH 7.0-7.6
- Alkalinity: 72-85
- Phosphate as P: 0.8-1.3
- Hardness: 114-118
- Chloride: 18 (rises in winter from road salt)
- Total dissolved solids: 175
- Calcium: 30.5
- Magnesium: 8.8
  - Moderately hard ….

What works best in Cleveland?

- 2013 local GABF winners:
  - Kellerbier: Bronze, Progress Pilsner, Market Garden Brewery, Cleveland, OH
  - Barrel-aged Strong Stout: Bronze, Barrel Aged BORIS The CrusherHoppin' Frog Brewing Co.
  - Fresh Hop Ale: Silver, Trail Head, Fat Heads Brewery, Middleburg Hts OH
  - Schwarzbier: Silver, Black Knight, Fat Heads Brewery & Saloon, North Olmsted, OH
  - Imperial India Pale Ale: Gold, Hop JuJu, Fat Heads Brewery, Middleburg Heights, OH

Interested in more?

- Beer Judge Certification Program (bjcp.org)
- SNOBs (Society of Northeast Ohio Brewers) www.beersnobs.org (NOT snobs.org!)

S. N. O. B.
SOCIETY OF NORTHEAST OHIO BREWERS
CLEVELAND OHIO
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