Intro to Brewing Water 2

Brighten up your beer through water and pH adjustment

GTA Brews – January 2017

Does Water Chemistry Matter?

- Yes, but can only make a good beer great
- There are some things you should master first:
  - Fermentation and yeast health
  - Packaging and sanitation
- Beer is 95% water
- Water composition influences flavour expression and certain yeast behaviour
- Brulosophy water XBMTs have been significant

Does Water Chemistry Matter?

- “Water Chemistry” is a vague term
- Refers to combination of:
  - Mash pH adjustment
  - Mineral concentration adjustment

Mash pH Adjustment

- Briefly, pH is:
  - Concentration of H+ ions (exponential scale)
  - Lower is more acidic, higher is more basic
  - 7.0 pH is the middle
- Tap water is usually around 6.8 to 7.8
  - Drops when you add grain, salts, or acid
- Mash pH should be 5.2 – ~5.5 pH
- Beer pH is usually 4.0 – 4.4 pH

Mash pH Adjustment

- With mash pH in range:
  - Hop bitterness is more pleasant and doesn't linger
  - Improved break formation
  - Enzymatic activity in the mash is increased
  - Beer is crisper, more fresh and shows more character
- Measured at room temp (20°C – 25°C)
  - pH reads 0.2-0.3 pH lower at mash temp
- Read this Braukaiser.com post for more detail

Mineral Concentration Adjustment

- Common brewing minerals
  - Cations: **Calcium (Ca)**, Magnesium (Mg), and Sodium (Na)
  - Anions: Bicarbonate (HCO_3), **Sulfate (SO_4)**, and **Chloride (Cl)**
- Calcium (Ca) affects “everything”
  - Lowers mash pH
  - Promotes flocculation of yeast and protein
  - Limits extraction of tannins (astringency)

Mineral Concentration Adjustment

- Usually Calcium (Ca) is added as gypsum ($CaSO_4$) and/or Calcium Chloride (CaCl)
- Sulfate (SO_4) affects perception of bitterness
  - Helps give the beer a drier and crisper impression.
- Chloride (Cl) affects perception of sweetness and body
- Choose ratio (SO_4:Cl) for desired result
  - “Seasoning level” matters
  - Experiment to find your preference

Mineral Concentration Adjustment

- Bicarbonate (HCO_3) helps determine alkalinity
  - Acts as a buffer working against acid additions
  - Can be good to balance against acidic malt
- Magnesium (Mg) and Sodium (Na)
  - Usually you don't aim to adjust these
  - Track them to make sure they are in range

Brewing Water Target Ranges

- Calcium (Ca) 50-150 ppm
  - Less than this is okay for lagers
- Sulfate (SO_4) 0-350 ppm
  - More than this becomes harsh and astringent
- Chloride (Cl) 10-100 ppm
  - Closer to 50 ppm when high sulfate
- Bicarbonate (HCO_3) <50 ppm
  - May need acid or acidic malt to achieve this

Toronto Water Profile

- GTA Brews Toronto Water Report Page
- Calcium (Ca) - 36 ppm
  - Note that this is <50 ppm
- Chloride (Cl) - 26 ppm
- Sulfate (SO_4) - 26 ppm
- Total Alkalinity - 88 ppm
- Magnesium (Mg) - 9 ppm
- Sodium (Na) - 15 ppm

What Determines Mash pH

- Balancing act between
  - Alkaline: water
  - Acidic: malts, added salts, and acid additions
- Highly alkaline water needs additional acidic additions (usually more lactic acid)
- Thinner mash usually means higher pH
- Calcium has a limited effect on mash pH
- Roast and crystal malts are more acidic

What Do You Need

- pH Meter
  - Omega PHH-7011 $133 CAD
  - Milwaukee MW102 (hard to find probes in CAD)
  - Generally: Reliable brand, 0.01 pH accuracy, probes are available
- Scale with 0.1 g resolution (preferably 0.01g)
- Salts and acid
- DO NOT USE
  - 5.2 Stabilizer or pH strips

My Approach

- Pick your software
  - Bru'n Water and Brewer's Friend are both great
  - I use Bru'n Water
- Decide on a mineral profile
  - More than 50 ppm Calcium
  - High sulfate for hoppy/bitter beers (SO_4:Cl > 2)
  - Start balanced for most beers (SO_4:Cl ~ 1.3)
  - More chloride for sweet/malty beers (SO_4:Cl < 0.5)
- Add enough acid to hit desired mash pH

My Approach

- Avoid adding alkalinity in dark beers by mashing thinner
  - Opt for Pickling Lime ($Ca(OH)_3$) over Chalk ($CaCO_3$) if you need to add alkalinity, chalk doesn't dissolve
- Use lactic acid instead of acid malt
  - Phosphoric works great if you can get it
- I aim every beer at 5.2 pH, but accept anything under 5.4 pH

My Approach

- Start with preset profiles when not sure
  - Use the colour and balance to determine which
- Avoid using historical brewing water profiles
  - Most breweries treated their water in some way
- If you do none of this, at least do campden!

Bru'n Water Setup (Toronto)

Water Report Input

Hover cursor over cells w/ red corner marks to display information

Cations	Enter Ion Concentrations from Water Report (mg/L or ppm)		Anions
Calcium (Ca)	35.9	106.2	Bicarbonate (HCO_3)
Magnesium (Mg)	9.1	0.1	Carbonate (CO_3)
Sodium (Na)	13.5	26.3	Sulfate (SO_4)
		25.0	Chloride (Cl)
Optional Inputs (not required, but may improve ion balance)		0.0	Nitrate (NO_3)
Potassium (K)	0.0	0.0	Nitrite (NO_2)
Iron (Fe)	0.0	0.0	Fluoride (F)

If water report provides only **Total Alkalinity** or **Temporary Hardness** (as $CaCO_3$), use the calculator below to estimate the Bicarbonate and Carbonate concentrations. Insert the estimated Bicarbonate and Carbonate results in the table above.

Reported Total Alkalinity or Temporary Hardness (as CaCO3) (mg/L or ppm)	Reported or Measured Water pH	Estimated Bicarbonate Concentration (ppm)	Estimated Carbonate Concentration (ppm)
87.3	7.5	106.2	0.2

Example 1. Robust Porter

Grain Bill Input

Hover cursor over cells w/ red corner marks to display helpful information

Grains	Grain Type	Quantity (lb)	Quantity (oz)	Color (L)	Percentage of Grain Bill
Maris Otter	Base Malt	9.0	0.0	3.5	70.6
Munich I	Base Malt	1.5	0.0	6.5	11.8
Crystal II	Crystal Malt	0.0	14.0	65	6.9
Chocolate Malt	Roast Malt	0.0	12.0	450	5.9
Black Patent	Roast Malt	0.0	10.0	550	4.9
	Base Malt	0.0	0.0	0	0.0

Water Profile Adjustment Calculator

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Desired Water Profile	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
Black Full	50	5	33	35	45	140
Existing Water Profile	36	9	14	26	25	107

Water Additions

Minerals	Addition (gram/gal)
Gypsum ($CaSO_4 \times 2H_2O$)	0.10
Calcium Chloride ($CaCl_2$)	0.20

Example 1. Robust Porter

Actual Finished Water Adjustment (ppm)	25	0	0	15	34	0						Finished SO_4/Cl Ratio
Mashing Water Profile	61	9	14	41	59	107						0.7
Overall Finished Water Profile	61	9	14	41	59	NA						
							Total Water Additions				**Total Batch Volume**	
Estimated Mash pH	5.17	This pH value is NOT VALID until the grain information is properly entered for the beer on the **Grain Bill Input** sheet.					**Mash**		**Sparge**			
Water Additions							Water Volume (gal)	4.90	Water Volume (gal)	4.00	Water Volume (gal)	6.00
Minerals	Addition (gram/gal)	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)	Total Mineral Additions (grams)		Total Mineral Additions (grams)		
Gypsum ($CaSO_4 \times 2H_2O$)	0.10	6.2			14.7			0.49		0.4		
Calcium Chloride ($CaCl_2$)	0.20	19.1				33.8		0.98		0.8	Anhydrous	What form of
Epsom Salt ($MgSO_4 \times 7H_2O$)	0.00		0.0		0.0			0.00		0.0	10.0	Liquid $CaCl_2$
Magnesium Chloride ($MgCl_2 \times 6H_2O$)	0.00		0.0			0.0		0.00		0.0		Liquid $CaCl_2$ Solutio
Canning Salt (NaCl)	0.00			0.0		0.0		0.00		0.0		
Baking Soda ($NaHCO_3$)	0.00			0.0			0.0	0.00		Not Recommended	No	Add Sparging additions to t
Chalk ($CaCO_3$)	0.00	0.0					0.0	0.00		Not Recommended	No	Add Hardnes
Pickling Lime ($Ca(OH)_2$)	0.00	0.0					0.0	0.00		Not Recommended	No	Add $CaSO_4$ & & Lime in Spa
Acids	Addition				Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)					
Mash	(mL/gal)	**Mash** Acid Strength parameters are entered **below**						Total Acid Addition (ml)				Acid Anion Concentrat
Lactic	0.00	Strength	88.0	%	0.0	0.0	0.0	0.0				
	(mL/gal)							Total Acid Addition (ml)				
Phosphoric	0.00	Strength	10.0	%	0.0	0.0	0.0	0.0				
Sparge		**Sparge** Acid Strength parameters are entered on the **Sparge Acidication** sheet								Total Acid Addition (ml)		
Lactic		Strength	88.0	%	0.0	0.0				2.1	143	(ppm) Lacta
										Total Acid Addition (ml)		
		Strength			0.0	0.0				0.0		

Example 1. Robust Porter

Water Adjustment Summary

Hover cursor over cells w/ red corner marks to display helpful information

Black Full	Calcium (ppm)	Magnesium (ppm)	Sodium (ppm)	Sulfate (ppm)	Chloride (ppm)	Bicarbonate (ppm)
Existing Water Profile	36	9	14	26	25	107
Mashing Water Profile	61	9	14	41	59	107
Finished Water Profile	61	9	14	41	59	NA
Recommended Ranges	20 to 150	0 to 30	0 to 150	0 to 350	0 to 100	as needed

Mash Parameters					
Batch Volume (gallons)	6.00	Hardness (ppm as $CaCO_3$)	190	RA (ppm as $CaCO_3$)	38
Estimated Mash pH	5.17	Alkalinity (ppm as $CaCO_3$)	87	SO_4/Cl Ratio	0.7

Additions	Total Mash Water Vol (gal)	4.90	Total Sparge Water Vol (gal)	4.00
	Mash Dilution Vol (gal)	0.00	Sparge Dilution Vol (gal)	0.00

Minerals	Mash Water Additions (grams)	Sparge Water Additions (grams)
Gypsum ($CaSO_4 \times 2H_2O$)	0.5	0.4
Calcium Chloride ($CaCl_2$) Anhydrous	1.0	0.8
Epsom Salt ($MgSO_4 \times 7H_2O$)	0.0	0.0
Magnesium Chloride ($MgCl_2$)	0.0	0.0
Canning Salt (NaCl)	0.0	0.0
Baking Soda ($NaHCO_3$)	0.0	Not Recommended
Chalk ($CaCO_3$)	0.0	Not Recommended
Pickling Lime ($Ca(OH)_2$)	0.0	Not Recommended
Acids		
	0.0 (ml)	
	0.0 (ml)	
Lactic 88.00 %		2.1 (ml)
		0.0 (ml)

64 (ppm) Lactate added to water Expected to be under taste threshold

Example 2. Munich Helles

- Recipe: 8.5 lbs Pilsner (2L), 1 lbs Vienna (3.5L), 1.50 qt/lbs, 3.69 gal strike, 5.31 gal sparge
- Light touch, bit more sulfate, mostly balanced
  - SO_4:Cl = 1.5
- Result: Ca = 54.2 ppm, SO4 = 56.9 ppm, Cl = 39.1 ppm, mash pH = 5.32 pH
- Additions: $CaSO_4$ sparge 0.7 g strike 1.1 g, CaCl strike 0.4 g sparge 0.5 g, lactic strike 3.7 mL sparge 2.2 mL

Example 3. IPA

- Recipe: 10 lbs 2 Row (2L), 1 lbs Munich I (6L), 0.5 lbs Wheat (2L), 1.50 qt/lbs, 4.43 gal strike, 4.31 gal sparge
- More sulfate accentuate dryness
  - SO_4:Cl = 3.0
- Result: Ca = 101.9 ppm, SO4 = 154.2 ppm, Cl = 51.8 ppm, mash pH = 5.38 pH

Example 3. IPA

- Additions: $CaSO_4$ sparge 3.8 g strike 3.7 g, CaCl strike 0.9 g sparge 0.9 g, lactic strike 2.9 mL sparge 1.8 mL
- Mash pH measured 5.74 pH, added 1.5 mL more acid, got 5.52 pH
  - This is why you need a meter

Example 4. Doppelbock

- Recipe: 13 lbs Munich I (6L), 3 lbs Munich II (10L), 2 lbs Caramunich III (65L), 0.5 lbs Melanoidin (20L), 1.50 qt/lbs, 7.07 gal strike, 3.03 gal sparge
- Low pH, more chloride, watch out for crystal
  - SO_4:Cl = 0.8
- Result: Ca = 55.2 ppm, SO4 = 42.1 ppm, Cl = 51.8 ppm, mash pH = 5.49 pH

Example 4. Doppelbock

- Additions: $CaSO_4$ sparge 0.7 g strike 0.3 g, CaCl strike 1.4 g sparge 0.6 g, lactic strike **0 mL** sparge 1.2 mL
- Mash pH measured 5.29 pH, closer to real target

Questions?

- Further Reading
  - GTA Brews Toronto Water Report Page
  - Bru'n Water – Water Knowledge
  - Water Book – By John Palmer and Colin Kaminski
  - Braukaiser - Mash pH Control
  - Scrappy Hound Brewing – Brewing Water
  - Toronto Water Reports