

Importance of Trace Minerals In Brewing



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MBAA Southern California
June 3, 2023
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As brewers, we make wort.

We rely on yeast to turn wort into beer.

Trace metals, such as calcium, magnesium, zinc, iron, and copper are essential to the growth and health of yeast, which in turn are crucial for the fermentation process.



Happy yeast cells make good beer.

In this presentation, we will explore the importance of some trace minerals in brewing, including their role in yeast health, flavor development, and beer quality.



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WHERE DO THESE MINERALS COME FROM

■ Brewing Water

- Always have a water analysis
- Understand where your water comes from
- Does the source change?
 - many municipal supplies have multiple sources
 - these sources can change often
 - profiles can change seasonally



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WHERE DO THESE MINERALS COME FROM

- Raw materials
 - Barley
 - Hops
 - Yeast Nutrients
 - Adjuncts



WHERE DO THESE MINERALS COME FROM

- Picked up in process
 - raw materials are agriculture products
 - dirt, pesticides, etc.
 - pipes, tanks, processing equipment
 - copper kettles
 - Non-passive stainless tanks and pipes (bad welds)
 - malt roasting
 - Filtration
 - DE - diatomaceous earth filter powder
 - Look for low beer soluble iron grade filter powders



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CALCIUM

- Calcium is important for mash enzyme stability, yeast flocculation and beer stability.
- Without enzymes working as expected, we can't make wort.
- Yeast flocculation – clarity and filtration.
- Calcium reacts with phosphates in the mash and lowers pH.
- Calcium also promotes trub formation in the kettle.



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CALCIUM

- Low calcium can lead to oxalate crystals and gushing in finished beer.
- Ideally 50 – 150 ppm in brewing water will provide enough.
- Beer should have at least 50 ppm of calcium to promote yeast flocculation
- Commonly supplemented with calcium chloride or calcium sulfate



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CALCIUM

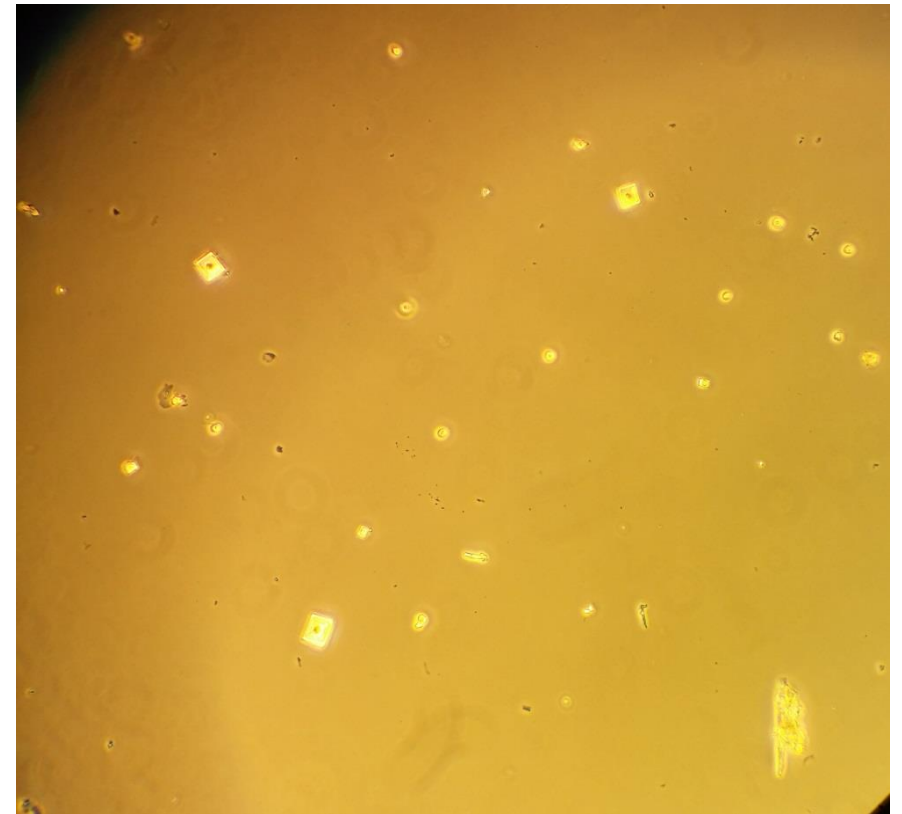
Microscopy showing calcium oxalate crystals in a beer sample.

Calcium oxalate crystals can be formed over time in the finished package if calcium is low. Normally calcium balances oxalic acid and precipitates out oxalate before the beer is finished.

Oxalate crystals are great nucleation sites for CO₂ breakout in beer. When a bottle is opened, carbon dioxide will rapidly come out of solution if calcium oxalate crystals are present

The beer sample was centrifuged and examined microscopically for oxalate crystals. Oxalate crystals were present as well as some filter aids (DE/Perlite).

The octahedral crystal morphology is clearly visible



COPPER

- Copper is an essential element in all forms of life. It acts as a cofactor of some enzymes and is involved in forming proper protein conformations (enzymes).
- Copper react with sulfides and reduces sulfur aroma and flavor in beer. (H₂S – rotten eggs)
- Too much can have a negative impact on flavor
 - oxidation by Haber Weiss Reactions / Reactive Oxygen Species.



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COPPER

- High level are toxic to yeast (>10 ppm)
- Generally copper contact with wort is ok
 - contact with beer is not ok as it is much more acidic.
- Ideally <0.25 ppm in wort



IRON

- As brewers, we want to keep iron out of our process.
- Yeast uses very small amounts of iron as a cofactor in many cellular processes including DNA replication, respiration and lipid synthesis
- Can inhibit saccharification
 - kind of important to brewers
- Unpleasant off flavor at low levels (1-1.5ppm)



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IRON

- Strong beer staling action (Fenton's reaction/ ROS)
 - Causes repeated oxidation reactions in beer
 - Not cleaned well up by yeast
- Levels above 0.2 ppm can cause serious issues
- Contributed by water, raw materials, filter powder and equipment



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IRON

Example of bad welding practices potentially leeching iron into beer

Ferroxyl Testing of Stainless Welds

(ASTM A 380-06, section 7.3.4)

Control – outside of stainless pipe
(slight brown discoloration – dirt)

Test #1 – external pipe weld
blue color change – iron present

Test #2 – external sanitary fitting
blue color change – iron present

Test #3 – Internal sanitary fitting
blue color change – iron present



Procedure: a swab is soaked in the ferroxyl reagent and rubbed on the test area.

Blue color change indicates free iron and risk for iron pickup in beer, no change indicates no free iron.

These welds are examples of improperly purged and cleaned welds. The heat affected zone is indicated by discoloration and is a source for beer soluble iron.

MAGNESIUM

- Magnesium is important for yeast health.
 - Cofactor in over 300 yeast enzymes
 - Increases fermentation rate, increased rate of maltose take-up.
 - Slight increase in ethanol production and attenuation
- Generally, there is enough magnesium in malt
 - a 10P all malt brew brings 70 ppm to wort, minimum for yeast is around 40ppm
 - high gravity and nutrient deficient brews may benefit from supplementation
 - can be supplemented with MgSO₄ – Epsom Salts
- Too much can have a negative impact on flavor (astringency).
- Too much can have a laxative effect (>125 ppm)
- Ideally 0-50 ppm in brewing water



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MAGNESIUM

- Magnesium also lowers mash pH, not as much as calcium
- Magnesium reduces yeast stress
 - Ethanol
 - high gravity / osmotic pressure
 - Poor nutrition
 - Temperature
- Important cofactor for glycolysis – yeast energy source!



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MANGANESE

- Manganese promotes beer staling in a similar fashion to iron and copper (reactive oxygen species)
- Enhances protein solubilization in mash
- Manganese contributed from gains is typically bound up in trub and do not make it through to finished beer.
- Manganese leeches from hops into wort and beer



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POTASSIUM

- Trace amounts are contributed by malt
- Over 10 ppm can interfere with mash enzymes
- Potassium carbonate is used in wine making to balance acidity – no place in beer brewing.



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SODIUM

- Sour / salty taste can accentuate beer flavor
- Over 150ppm have strong metallic flavor
- Generally, limit to 100ppm
- Toxic to yeast in high levels
- Salt / Sodium is part of Gose beer style (250+ppm)
 - Often added post fermentation



ZINC

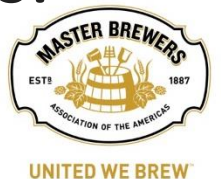
- Wort is deficient in zinc for optimal yeast health.
- Zinc is an important cofactor in over 100 enzymes including alcohol dehydrogenase – reduces acetaldehyde to ethanol during the fermentation.
- Increases fermentation rate and esters – stimulates uptake of maltose
- Important for phospholipids in cell membranes
 - Important for flocculation with Calcium ions, you need both



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ZINC

- The amount needed depends on the yeast strain and contribution from malt, varies by crop year.
- Easily lost in trub
- Zinc / water solution is antibacterial – make it in advance!
- Add it to cooled wort with your yeast to prevent trub losses.



ZINC

- The level of zinc in wort has a huge impact on yeast health.
 - Better flocculation - easier yeast cell collection
 - Lower beer solids – easier filtration or clarification
 - Consistent complete fermentations and RDF numbers
- Generally, ale strains need more zinc than lager strains
 - Ale strains need an additional 0.150 – 0.300 ppm
 - Lager strains need an additional 0.050-0.150ppm

To much zinc and your yeast will floc like peanut butter.

Zinc dosing is somewhat cumulative, and results are best assessed after a few generations.



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SUMMARY

As with many things in brewing,
balance is key.

More is not always better!



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Thank you!

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