LOW-OXYGEN BREWING

Preserves the fresh malt/grain flavor that exists in your malt before you even begin brewing.

Theory

- Ascorbic Acid Oxidase (AAO) is a malt antioxidant that, when preserved, provides glorious fresh-tasting, lingering grain flavor.
- Because it is an antioxidant, any oxygen in the brewing process will destroy AAO and the flavor it provides.
- You can smell it when you dough-in. That wondrous grain aroma you smell is the evaporation of AAO.
- Low oxygen hot-side brewing methods have practically zero odors, preserving the flavor and aroma until you serve the beer.

WHY BREW USING LOW-OX?

- Make authentic Continental style beers
- Obtain that "lingering fresh grain flavor" you only find in fresh Continental styles
- Improve the overall quality, flavor, and freshness of all your beers - even ales
- If DO > 1 ppm throughout entire hot side process, fresh malt flavors are gone.
  < 1 ppm is the “minimal” target
  <= 0.5 ppm is better; lowest possible = best

BACKGROUND INFO ON DISSOLVED OXYGEN (DO)

- Pre-boiling water reduces DO to < 0.5 ppm, but doesn't provide active protection against DO
- Metabisulfite alone doesn't provide enough margin – need to take additional steps for Low Ox brewing.

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Custom Low Ox Mash Tun With Wheels

SOURCES OF D.O.

- Hot Liquor (8-12 ppm)
- Dough-in (1-3 ppm)
- Splashing
- Atmosphere (1-2 ppm per hour)
- Copper, Brass, Aluminum (Brewtan B may help)
- Loose Hose Connections (especially pumps)

WHAT IS LOW OXYGEN BREWING?

- Methods and procedures for each step of the brewing process to reduce/eliminate oxygen uptake
- It's not just eliminating HSA from the boil kettle
- It covers steps you didn't know you needed to worry about
- Just 1ppm DO is all it takes

LOW OXYGEN BREWING PREREQUISITES

- Malt conditioning
- Step mashing; low oxygen infusion step mashing & consistent temperatures; hold temps w/single infusion mash
- Rapidly chill water and wort. This reduces the time and temperature – both are contributors of D.O.
- Can make yeast starters and/or storage & re-pitching; yeast counts; ensure healthy yeast – healthy yeast consumed D.O.
- Ability to control fermentation temperature; monitor progress

- Kegging
- Measure & control pH
- Accurate small scale for measuring metabisulfites
- Eliminate copper, brass, and aluminum (Brewtan B may help if you can't eliminate these metals)
  Note: homebrew "stainless" plate heat exchangers are typically brazed, which will cause oxidation.

STEP BY STEP:

GRAIN PREPARATION

- Use fresh malt.
- Condition malt before crushing.
- Malt starts oxidizing 15 minutes after crushing, so crush immediately before brewing.
- Mill slowly: <100 rpm; 3 rollers is better.

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HOT LIQUOR / BREWING WATER

- RO / distilled water is best (lowest source of metals)
- Use Brewtan B if using tap water (reduces Fenton-type reactions)
- Use sulfite test strips to determine DO reduction at various steps:
  - 5 ppm MetaBiSulfate scavenges 1 ppm O_2
  - Plan out your water treatments/additives
- Chill strike water using your internal HERMS coil (easiest) or external stainless chiller

HOT LIQUOR / BREWING WATER

- Pre-boil HLT water vigorously for 5 minutes to reduce O_2 to < 0.5 ppm
  - Preboiling does not provide active protection against D.O.
  - Metabisulfite (sodium or potassium metabisulfite) will remove O_2 from water. Provides Active protection.
- Chill HLT water to 200°F; add metabisulfite
- Continue chilling water to strike temp
- Alternate de-aeration method: Yeast scavenging using dry bread yeast, dextrose and 2-3 hours

Hot Liquor Tank w/HERMS & Tangential Inlet

All Stainless Counter-flow Wort Chiller

- Keep potassium < 10ppm. This equates to Kmeta max = 30ppm
- If using NaMeta (SMB), then start with ≈35ppm and reduce if possible with experience; GOAL = 0 ppm just before oxygenating wort. Reduce META as you improve your processes.
- But alone, it doesn't provide enough margin. Need to take additional steps for the downstream brewing processes, which we will talk about later.

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ARE YOUR METHODS WORKING?

- Use a DO meter (best, but expensive).
- Or, use sulfite test strips to determine amount of DO being "consumed".
  - Use a pinch of baking soda to increase the pH to >6 (Only add to the sample you have taken – not to the kettle).
  - A 5 ppm drop in sulfites ≈1 ppm drop in DO.
  - Measure sulfite after you add to HLT. As your process absorbs oxygen the sulfite level will drop. Learn where the weak points are in your brewing process.
  - The goal is to have 0 ppm metabisulfite when done (before oxygenation). Additional O_2 is needed to consume the remaining meta when oxygenating chilled wort. So, less residual meta is better.

MASHING

- Bottom fill / underlet
- Stir gently / no splashing
- Use Mash Cap or purge with CO_2 (or N_2)
- Recirculate wort below the liquid surface
- Try a vorlauf pipe (see photo)
- Notice LACK of mash smell - the aromas are staying in the kettle
- Taste the wort!

Vorlauf Pipe

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LAUTERING

- No-sparge is most efficient way to avoid O_2 pickup
- If sparging, treat sparge water same as mash water with metabisulfite
- Purge head space, add gently, or under let water
- Vorlauf pipe can work here, too.
- Add first-wort hops to kettle during lautering
- Use lauter cap in BK or purge headspace to limit O_2 pickup

BOILING

- Heat stress accelerates oxidation
- Limit boil time to 60-70 minutes
- Simmer; not a robust boil
- Partially open BK to limit evaporation to 6-10% without adding too much excess oxygen
- Consider effect on hop utilization – may reduce hops with lower evaporation rates
- With pilsner base malt, if pH ≥ 5.4, evaporation can be 4% - 6% per hr
- Think about eliminating O_2 from hop additions.
  - Purge hop container with CO_2 or N_2, etc.

Post-whirlpool trub cone with trub

- If pH is not <5.1 at end of boil, add lactic acid or saurgut to drop pH
- Improves hot/cold break, reduces lag time and yeast stress.
- Chill wort as quickly as possible after boil

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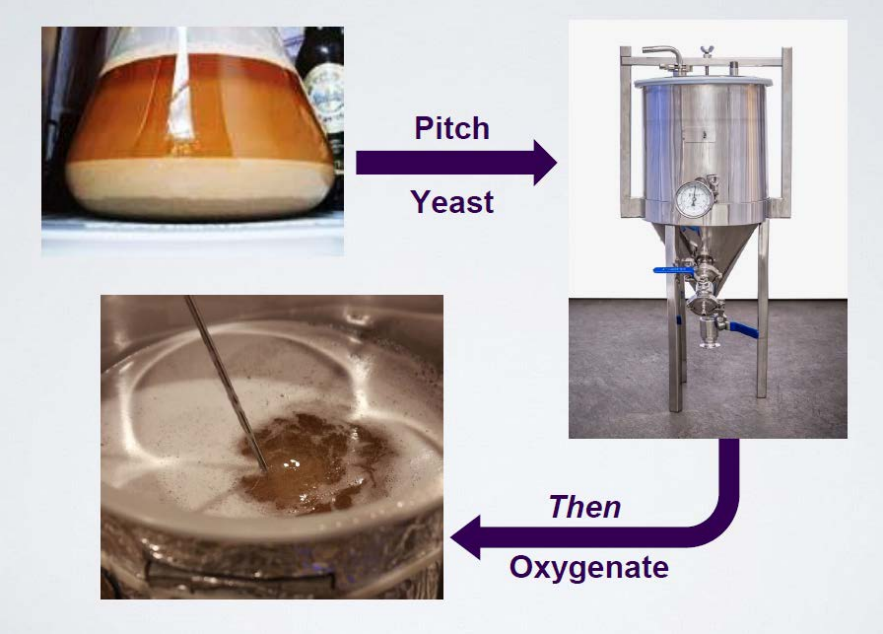
PRIMARY FERMENTATION

- Remove hot break – keep it out of the fermenter: whirlpool in the kettle, etc.
- Pitch yeast first, then oxygenate wort
- Check metabisulfite levels before oxygenating – need to add extra O2 to consume remaining metabisulfite, so there is enough O2 for yeast.
- Don't skimp on pitching rate
  - Ales: 1.7 million cells / ml / °P
  - Lagers: 2.5 million cells / ml / °P
- Lager fermentation schedule – need to start fermentation within 6-8 hours after knockout to prevent oxidation of the AAO.
- Why so long? At high temps, you get oxidation in < 1 minute. At cold temps, it takes much longer. Yeast can consume O2 before oxidation occurs.



- Cool wort to 41-43°F
- Do it quickly – use ice bath, etc. to chill cold liquor even more (if you have a HLT with a HERMS coil, put ice in there and run water through the HERMS coil first).
- Add yeast & oxygenate
- Allow temp to rise to 46-48°F over 48 hrs, then hold
- Diacetyl rest should be unnecessary due to cold fermentation and high pitching rate
  - Taste it to be sure!

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SPUNDING:

- Carbonate beer by sealing fermentation vessel near end of primary fermentation; naturally produced CO_2 stays in
  - Optimal method to maintain low oxygen and protect flavor
- Do fast ferment to predict final gravity
- Target 1% remaining extract before transfer
- Use closed transfer to eliminate O_2 pickup
- Set spunding assembly to achieve proper carbonation for the temperature of the beer
- Cut gas tube as short as possible
- Allow beer to finish fermenting (and lagering) in the spunding vessel

Carbonation Chart For Setting Spunding Valve Pressure:

		Pressure (PSIG)														
		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Temperature (F)	30	1.82	1.92	2.03	2.14	2.23	2.36	2.48	2.60	2.70	2.82	2.93	3.02	3.02	3.02	3.02
	31	1.78	1.88	2.00	2.10	2.20	2.31	2.42	2.54	2.65	2.76	2.86	2.96	2.96	2.96	2.96
	32	1.75	1.85	1.95	2.05	2.15	2.27	2.38	2.48	2.59	2.70	2.80	2.90	3.00	3.11	3.21
	33	1.81	1.81	1.91	2.01	2.10	2.23	2.33	2.43	2.53	2.63	2.74	2.84	2.96	3.06	3.15
	34	1.78	1.78	1.86	1.97	2.06	2.18	2.28	2.38	2.48	2.58	2.69	2.79	2.90	3.00	3.09
	35	1.83	1.83	1.83	1.93	2.02	2.14	2.24	2.34	2.43	2.52	2.63	2.73	2.83	2.93	3.02
	36	1.79	1.79	1.79	1.88	1.98	2.09	2.19	2.29	2.38	2.47	2.57	2.67	2.77	2.86	2.96
	37	1.84	1.84	1.84	1.84	1.94	2.04	2.14	2.24	2.33	2.42	2.52	2.62	2.71	2.80	2.90
	38	1.80	1.80	1.80	1.80	1.90	2.00	2.10	2.20	2.29	2.38	2.48	2.57	2.66	2.75	2.85
	39	1.86	1.86	1.86	1.86	1.86	1.96	2.06	2.15	2.25	2.34	2.43	2.52	2.61	2.70	2.80
	40	1.83	1.83	1.83	1.83	1.83	1.92	2.01	2.10	2.20	2.30	2.39	2.47	2.56	2.65	2.75
	41	1.79	1.79	1.79	1.79	1.79	1.88	1.97	2.06	2.16	2.25	2.34	2.43	2.52	2.60	2.70
	42	1.75	1.75	1.75	1.75	1.75	1.85	1.94	2.02	2.12	2.21	2.30	2.39	2.48	2.56	2.65
	43	1.72	1.72	1.72	1.72	1.72	1.81	1.90	1.99	2.08	2.17	2.26	2.34	2.43	2.52	2.61
	44	1.69	1.69	1.69	1.69	1.69	1.78	1.87	1.95	2.04	2.13	2.22	2.30	2.39	2.47	2.56

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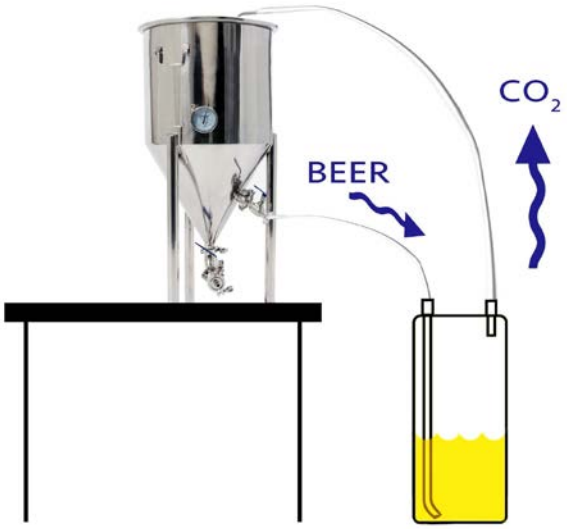
CLOSED TRANSFERS:

- Fill clean corny keg or other vessel to brim with low oxygen sanitizer (e.g., iodophor or Saniclean)
- Push entire volume out with CO_2
- Perform a closed transfer:
  - Fermenter output port to keg liquid out
  - Fermenter blowoff to keg gas-in post



PACKAGING

Keg:

- OPTIONAL – YOU CAN SIMPLY LEAVE YOUR BEER IN THE SPUNDING KEG
- If transferring to a fresh keg do a closed transfer (same concept as the transfer into spunding keg)

Bottling:

- Ferment to final gravity and add speise or priming sugar to provide active protection
- Counterfill the bottle with CO_2 purge
- Bottle straight from fermenter

CONCLUSION

- You can do this!
- Achieve that elusive "fresh, lingering malt flavor"
- Enhance and improve all malt flavors, reduce/eliminate cloying tastes

FURTHER READING

- www.lowoxygenbrewing.com
- www.stouttanks.com

CREDITS

- Low Oxygen Brewing website by Bryan Rabe and Derek Scott (lowoxygenbrewing.com)
- April 2016 Paper "On Brewing Bavarian Helles: Adapting to Low Oxygen Brewing" by the German Brewing Team (germanbrewing.net)