

BREWHOUSE PROCESS CONTROL FOR FLAVOR STABILITY : MILLING & MASHING

Milling

Milling under N₂/CO₂ (+)

Malt purged of entrained O₂ before mashing (+)

Avoiding embryo damage to prevent release of LOX.....discard in spent grains.

Adjuncts with high melanoidin contentevaluate whether antioxidants outweigh prooxidants.

Hammer vs. Roller milling.....former releases more of LOX...not shown to be of practical importance.

Use of CO₂ purges at point of blending grist & water (+)

Carling: infusion leads to better flavor stability than decoction brewing (+)

Higher malt beers have slower rate of development of HMF & furfural staling indices...believe due to high [catechins] (+)

Mashing

Adding sulfite to mash (+)

Gentle mash transfers, introduction (+)

Percent malt increases EA value (+)

Biological mash acidification (+)

De-aerated mash-in water (+)

Lower mash-in temperatures increase LOX activity (-)

Mashing optimized by ESR for peroxidase activity to degrade H₂O₂ (+)

Higher extraction of LOX activity at 40°C vs. 60-65°C (-) use 62°C.

Acidified mashes (5.0 vs. 5.6) slows LOX activity (+) e.g. use 5.2.

Use of fewest vessels possible to limit oxygen exposure (+).... decoction may not be optimal.

Excessive turbulence (-) during mash mixing/conversion

CO₂ purging slows LOX activity during mashing (+)

Indices of mash oxidation: i) [Free thiols] as are lost by oxidation, ii) [hydroperoxides] as are formed by oxidation, iii) redox potential.

Bottom inlet for mash, lautering or kettle (+)

Mash tun rotation speed (-)...better stability at 300 vs. 600 ppm.

AJL recommend improving flavor stability by:
 a) increasing mash-in temp from 45°C to 60°C
 b) adding SO₂ to mash
 c) adding SO₂ to filtered beer
 d) pitching with highly vital/viable yeast
 e) targeting wort DO of 7.5 vs. 10 ppm DO - wort OG not given.

EFFECT ON BEER FLAVOR STABILITY

Bottom entry mash-in systems decreases D.O. level (+)...CB claims only a 7-15% decrease in staling by practicing bottom filling, CO₂ purging of grist, gentle transfers, etc....most oxidation occurs post-brewhouse!!!!

Use of deaerated mash-in water and flushing grist with inert gas to minimize most sensitive phase of LOX activity.

Strike mash-in at highest possible temp to inactivate LOX, assuming good homogeneity.

Avoid splashing in the mash-tun...do not start blades until mash is at higher level than blades.

Keep brewing water iron to <0.2 ppm.

SAB & Brewhouse ESR Findings: improve beer flavor stability by:

- continuous, not batch sparge (avoids bed drying and oxygen ingress)
- controlling run off times...too long will reduce levels of polyphenol and anthocyanogen antioxidants
- elimination of underback occupancy practices
- better removal of cold break, especially in the presence of wort DO before yeast kicks in, as are high in prooxidants
- avoid whirlpool delays & high residence times
- avoid prolonged mash tun or to boil delays
- avoid extended boils.
- higher malt: adjunct ratios preserve/increase EA of wort.

Bleed air from lines before transfer (+)

Mashing under nitrogen (+)

In mash-tun, use lower speed "folding" until ramp-up.

Use of highest practical temp to inactivate LOX (+)

Lower pH's to 5.1reduce LOX activity...CB warns superoxide radicals more harmful at lower pHs.

Addition of **gallotannins** to mash-in liquor (as low as 2.5 g/hL) and/or sparge water improves wort runoff rates during lautering....also improves flavor stability & physical stability.

Decrease LOX activity by higher mash-in temperatures or by lowering pH to slow activity during mashing.

Use of stainless steel vessels (+)....no leaching of Cu⁺ as prooxidant....watch out for sulfur problems though!!!!

Gentle beer transfers/fills (+), variable speed rakes (+), gentle pumps (+), minimum wort recirculation (+)soothing music in the brewhouse.....

Up to 15% of malt lipids are oxidized during mashing!

Design and operate to minimize DO/air entrapment....minimal impact on flavor stability.

Higher beer ESR lags at higher mash-in temps e.g. 60°C better than 55°C (+)

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