Beer (In)Stability, Oxidation, and Freshness

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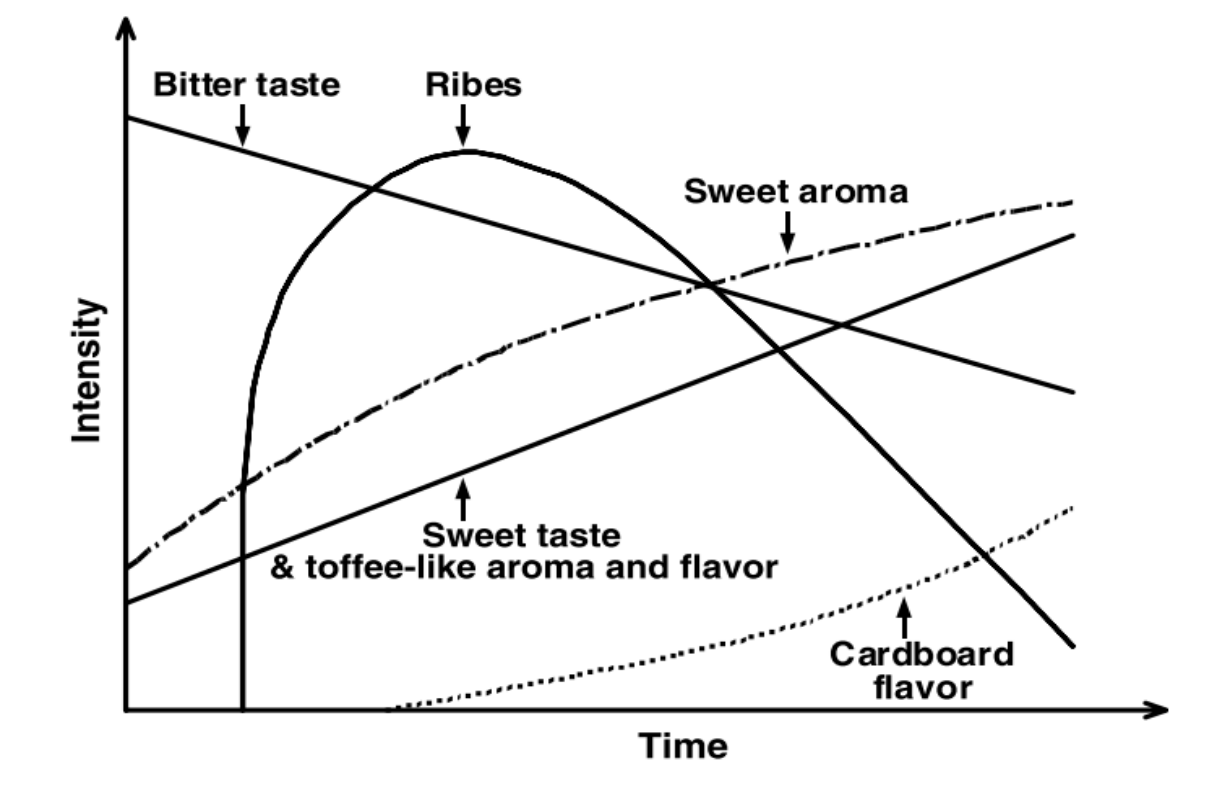
Beer Instability

- Any change in Beer Appearance or Taste over Time
- Usually (but not always) a Negative
- The Opposite of “Fresh”

Notional Timeline of Beer Sensory Changes



There are hundreds of elements and compounds in malt, wort, and beer, interacting with each other and changing flavors. Many are not understood, and from a practical standpoint, most cannot be influenced. But some can…

Addressable Causes of Instability

- Oxidation
- Temperature
- Light Exposure
- Metals
- Vibration

Oxidation (& Oxygenation) Symptoms and Specific Causes

- Acetaldehyde (unripe apple/solvent)
  - Oxidation of Ethanol
- Diacetyl (buttery)
  - Oxidation of excess α-acetolactate from yeast
- Trans-2-nonenal (papery)
  - Enzymatic oxidation of Lipids by Lipoxygenase (LOX), both from malt
  - Non-enzymatic oxidation of linoleic acid (from malt)
- Lost Bitterness, with Added Harshness and Maltiness
  - Oxidative Decomposition of Iso-Alpha Acids and subsequent production of certain Aldehydes
- Acetic Acid (vinegar)
  - Produced by Spoilage Microbes in presence of O_2
- Sherry, Ribes (blackcurrant), Caramel, and Toffee
  - Known to be increased by oxygen; mechanisms unclear

Oxidation Timing and Severity

- Exposure of Crushed Grains, Wort, or Beer to Air (Oxygen) Other Than at Yeast Pitch
- **Cold Side Aeration is Most Harmful, but…**
  - Hot Side Aeration is Real
- Long Exposure is Worse than Short Exposure, but…
  - Oxidation is *Additive*
- It's not Binary (i.e. oxidized/not oxidized)
  - All Beer has some Level of Oxidation
  - Less is better than more

Minimizing Oxidation (and Oxygenation) Effects

- Crush Grains close to Dough-In
- Treat Mash/Sparge Water with Metabisulfite
- Underlet and Cap Mash

"LODO" techniques

- Vorlauf (to minimize lipids)
- Sanitation
- **Avoid Cold Crashing in Fermenter unless set up to prevent suck-back, e.g. pressurized**
- Avoid Secondary Fermenters where possible
- **Closed, Purged Transfers of Finished Beer**
- Minimize Headspace if Bottling

In General, Avoid O2 Except at Yeast Pitch

Impact of Temperature: Thermal Load

Thermal Load: the thermal stress the mash/wort/beer is subjected to during the brewing process.

- Boiling produces Aldehydes
  - Longer/Harder Boils Produce More
- Shorter/Gentler Boils can result in Fresher Tasting Beer

Impact of Temperature: Transport and Storage

Rule of Thumb: for every increase of 10°C, chemical reactions (including staling reactions) go 2-3 times faster.

Suppose a particular beer would have a shelf life of 12 months at 5°C. Apply a 3 times faster per 10°C rule:

Temperature	Shelf Life
5C (41F)	12 Months (assumed baseline)
15C (59F)	4 months
25C (77F)	40 days
35C (95F)	13 days
45C (113F)	4 days

Keep Finished Beer Cold

Light Exposure

- Skunking (3-methyl-2-butene-thiol)
  - Caused by light (Ultraviolet/Blue/Green) striking Isohumulones from hops. Catalyzed by Riboflavin from yeast.
  - Prevention:
    - Use Brown Bottles. Thicker glass helps too.
    - Store bottles in dark areas
    - Bitter with Tetra Iso-Extract (light doesn't degrade)

Avoid Light, Especially Sunlight

Impact of Metals

- Some Heavy Metals promote Oxidative Reactions
  - Iron
  - Copper
  - Manganese
- Avoid H_2O with detectable levels of these Metals
- Stainless Chillers Better than Copper

Heavy Metal Music Good. Heavy Metal Beer Bad.

Impact of Vibration

- Vibration (e.g. during packaging / transportation) has been shown to affect beer quality
- May increase reaction rates through higher molecular energy
- Research shows Vibration seems to have significant impact when combined with high temperatures.

Keep Beer Cold and Don't Shake It Up

Freshness: Key Takeaways

- Do short boils (but consistent with bittering needed and DMS boil off)
- Avoid Oxygen Except at Yeast Pitch
- Do closed transfers into purged vessels if possible
- Keep Finished Beer Cold
- Keep Finished Beer away from Light
- Avoid Iron, Copper, and Manganese
- Avoid Vibration