

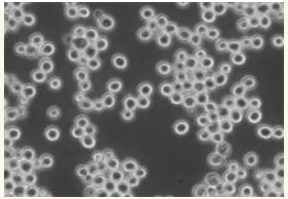


# Versuchs- und Lehranstalt für Brauerei in Berlin (VLB) e.V.

Flavor Stability: Unlocking the Secret to Lasting Beer Taste

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**Research and Teaching Institute for Brewing in Berlin (VLB)**

# VLB – Serving the brewing industry for over 140 years

+ Founded by the brewing and malting industry in **1883**
+ The VLB is an **independent members' association** with around 370 members (mostly companies)
+ Aim of the registered association is to **promote science and education** in the brewing and beverage industry and in biotechnology
+ The VLB receives no regular public funding
+ Long-term co-operation with the **Technische Universität Berlin** in the field of brewing science
+ About **135 employees**
+ Located in **Berlin**

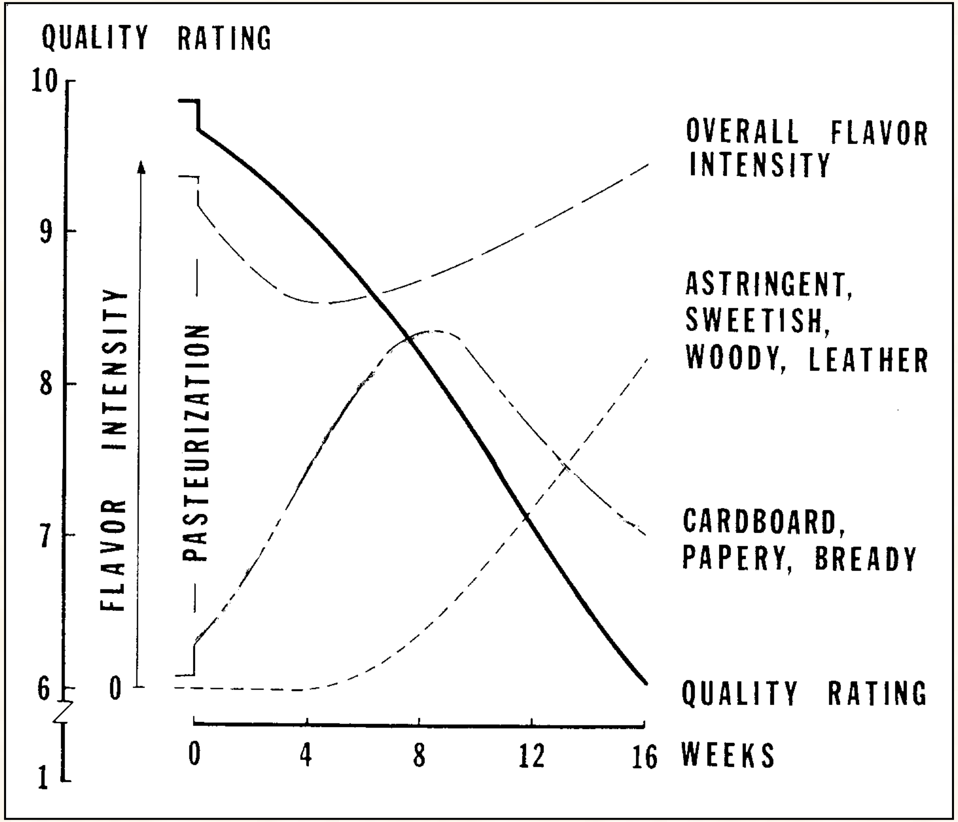
*VLB co-founder Privy Councillor Prof. Dr. Max Delbrück (1850-1919)*


*Transport pool of the VLB Hochschulbrauerei around 1930*

# Stability

- Microbiological stability: Absence of any critical germ in the beer, e. g. spoilage bacteria
- Non-biological stability: Resistance of a beer against haze formation that is not originated from microbiological contaminations
- Flavor stability: Ability of the beer to keep its fresh, pure flavor as long as possible after filling; stability against the formation of stale flavor carbonyls
- Foam stability (Head retention): Ability of the beer to keep the head as long as possible

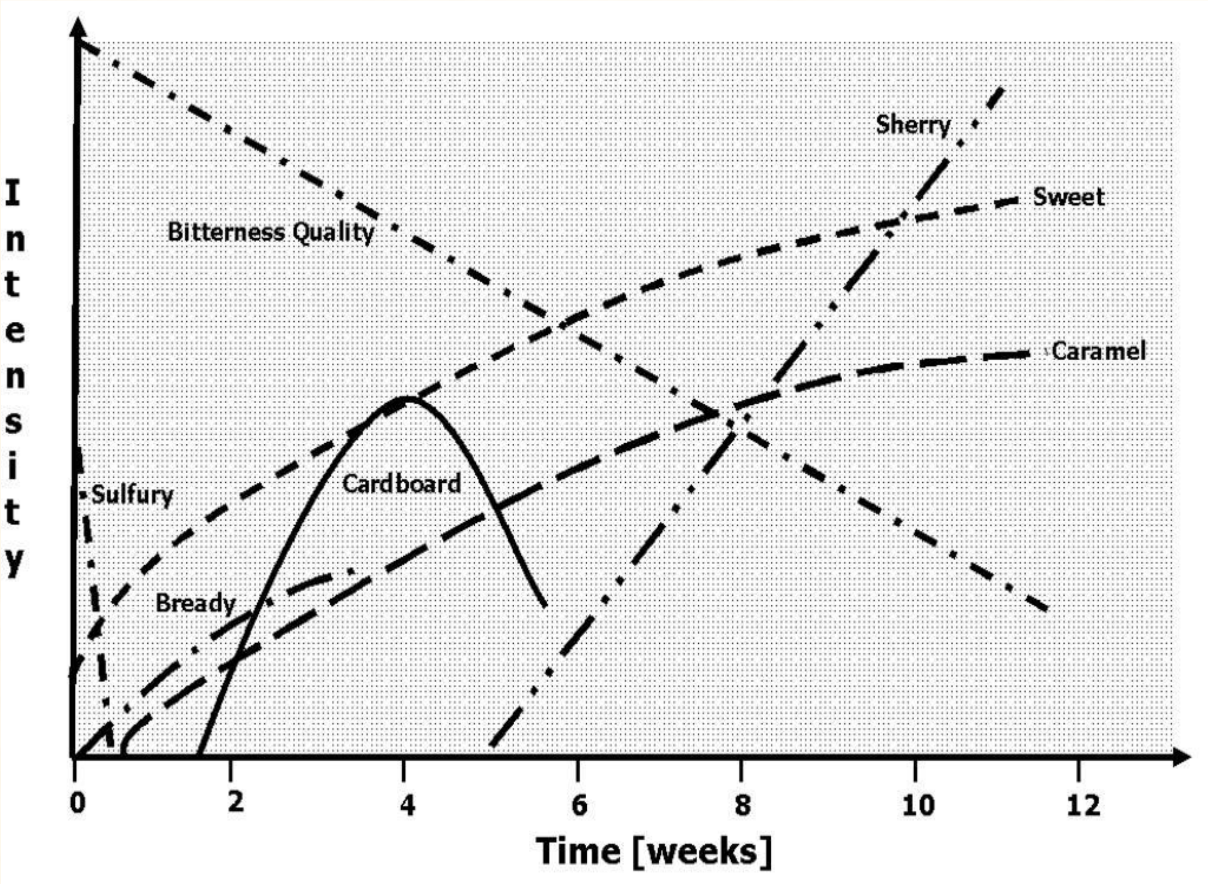
# Flavour Change during Staling






Meilgaard (1972)

# Flavour Change during Staling






Zufall, EBC 2005

# Flavour of Some Carbonyls

| Compound | Threshold [ppm] | Description |
|---|---|---|
| Acetaldehyde | 25 | Green leaves, fruity |
| Furfural | 150 | Paper, husk |
| n-Hexanal | 0.35 | Bitter, vinous |
| 2*E*-Hexenal | 0.6 | Bitter, astringent, green leaves |
| 3*Z*-Hexenal | 0.02 | Green leaves, freshly cut grass |
| 5-Methylfurfural | 20 | Almonds, burnt/phenolic |
| n-Heptanal | 0.075 | Vinous, bitter, very unpleasant |
| n-Octanal | 0.04 | Orange peel, bitter, vinous |
| 2*E*-Octenal | 0.0002 | Bitter, stale |
| 2*E*-Nonenal | 0.00011 | Papery (cardboard), oxidized, stale |
| 2*E*,4*E*-Nonadienal | 0.0005 | Oily, rancid |
| 2*E*-Decenal | 0.001 | Bitter, rancid, stale |
| 2*E*,4*E*-Decadienal | 0.0003 | Oily, deep-fried |

Meilgaard (1975)

# Possible Pathways for Flavour Change

1. Oxidation of higher alcohols
2. Oxidative degradation of isohumulones
3. Maillard reaction and Strecker degradation
4. Aldol condensation
5. Secondary autoxidation of aldehydes
6. Autoxidation of polyunsaturated fatty acids
7. Enyzmatic oxidation of polyunsaturated fatty acids by lipoxygenases
8. Photooxidation of polyunsaturated fatty acids

➔ Oxidative and non-oxidative staling

➔ Oxygen strongest influence on staling

*„Über den Verlauf der Alterung **entstehen** zum einen in chemischen Reaktionen (wie z.B. Maillard-Reaktion, Strecker-Reaktion, Lipidoxidation) Aromastoffe, die das Gesamtaroma des Bieres negativ beeinflussen [3, 4], zum anderen werden positive Stoffe **abgebaut** und so den sensorischen Alterungseindruck maskierende Effekte vermindert (z. B. Acetatester) [5].“*

Lehnhardt, F.: Aussagekraft der forcierten Alterung, BRAUWELT 21-22, 2019, S. 607-610

# Pathways of Flavour Change /

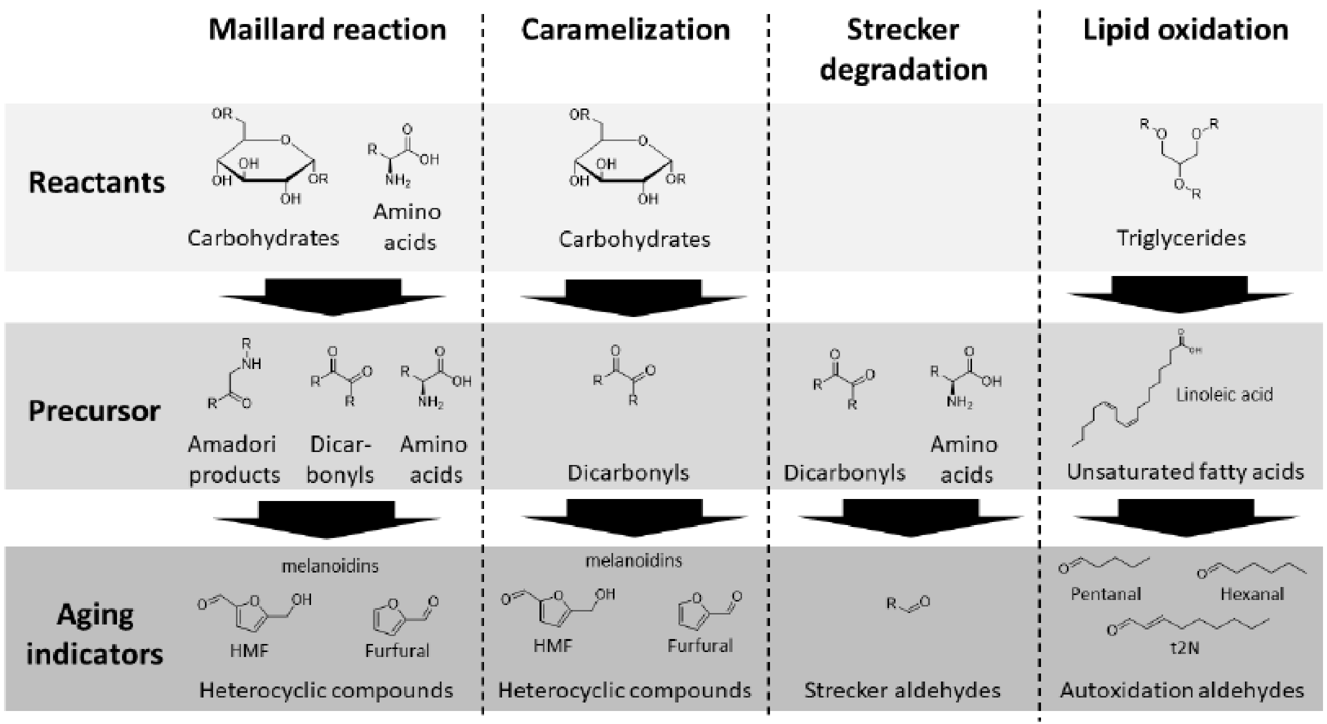



**Figure 1.** Overview of selected aging-relevant reactions and their key reactants, precursors, and aging indicators.

Source: Nobis et al.: The Influence of proteolytic Malt Modification on the Ageing Potential of final Wort (Foods **2021**, 10, 2320. https://doi.org/10.3390/foods10102320)

# Influencing factors for flavour change

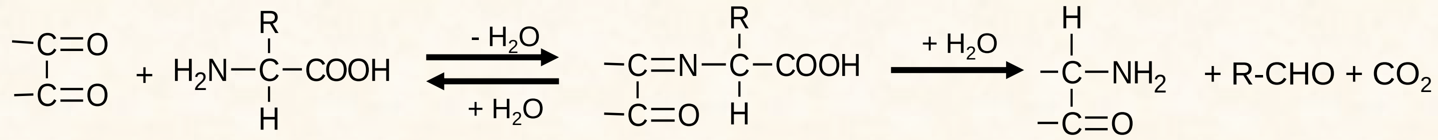
+ **Oxidation**
    - ➔ high oxygen content in wort and beer
+ **Thermal influences**
    - ➔ Long boiling times, pasteurisation, high storage temperatures
+ **FAN**
    - ➔ Increase via Strecker Degradation
+ **Influence of light** (wave length of 350-500nm)

    light-struck flavour

# Influence FAN

# FORMATION OF ALDEHYDES

## Strecker degradation



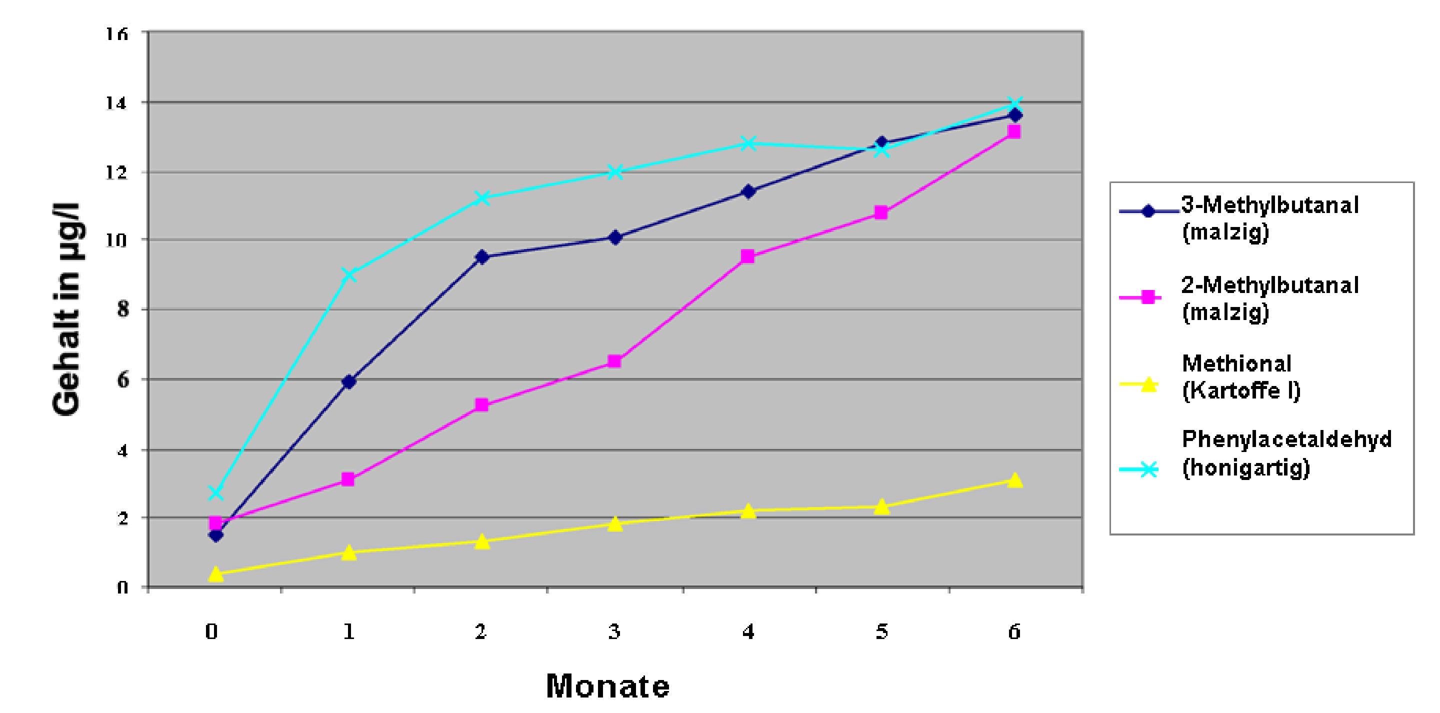

**α-Diketone** **Amino acid** **Amino ketone** **Aldehyde**

Condensation

**Melanoidins**

| Amino acid | Corresponding aldehyde |
|---|---|
| Alanine | Acetaldehyde |
| Leucine | 3-Methylbutanal |
| Isoleucine | 2-Methylbutanal |
| Phenylalanine | 2-Phenylethanal |
| Valine | 2-Methylpropanal |
| Methionine | Methional |
| Glycine | Formaldehyde |

# Streckeraldehydes during storage



# Influence TBI

# Thermal Stress

TBI (Thiobarbituric Acid Index )- heat indicator

- thermal stress to which malt, wort, and beer are exposed
- photometric measurement of yellowing after the reaction with an acetic acid/thiobarbituric acid solution.
- reaction indicates the presence of Maillard reaction products, as well as 5-hydroxy-methylfurfural (HMF)

- Reduce possible boiling and heating times
- gentle  boiling, hot holding time, pasteurisation etc.

# Influence Oxygen

# Oxidation is intensified by

+ Temperature
+ pH

+ But also co-factors like iron (Fe) and copper (Cu) – uptake from Kieselguhr

# Technological Approaches

## Raw Materials

- low content of FAN → low level of Strecker aldehydes
- low LOX-activity → low lipid degradation
- low kilning temperatures → low thermal load

## Milling

- long storage of grist → lipid oxidation
- mills run with inert gas ($CO_2$ / $N_2$)

## Mashing

- mashing-in from below → low oxygen uptake
- gentle agitation → low oxygen uptake
- mashing-in >55 °C → lower FAN, lower LOX-activity

# Technological Approaches

Wort Boiling & Whirlpool

- low thermal load → low level of Strecker aldehydes

Fermentation

- promotion of $SO_2$ formation → protection from lipid oxidation

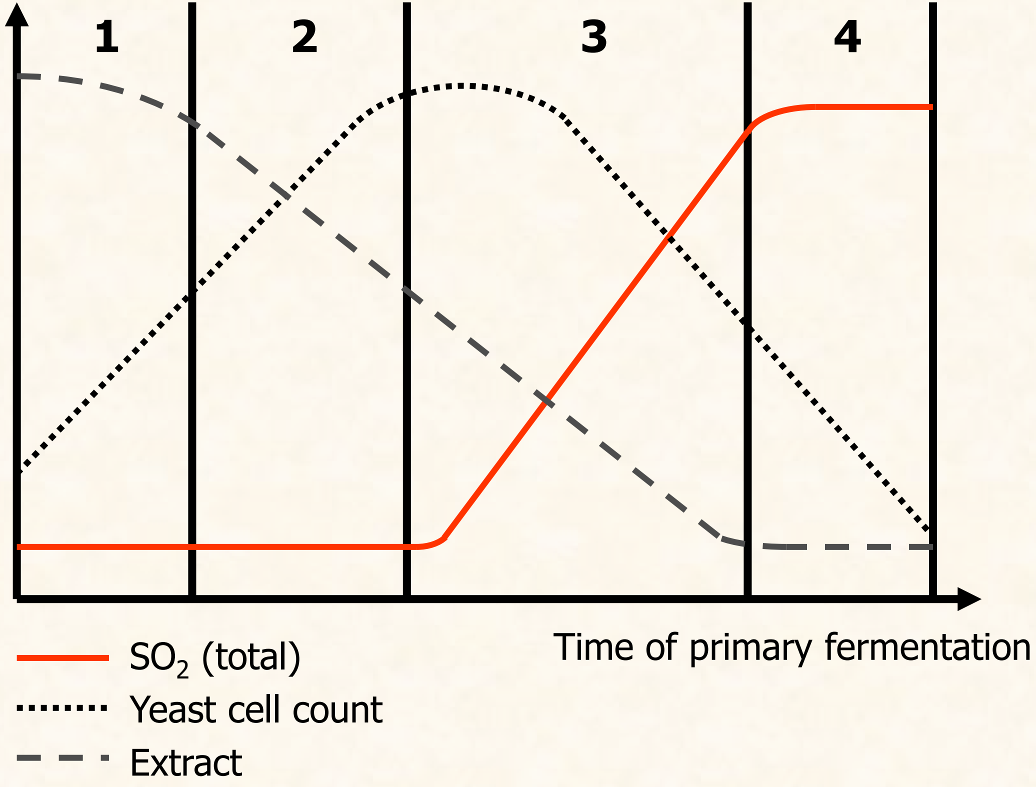
Maturation/Filtration

- pressurizing and emptying of tanks with $CO_2$ → low oxygen uptake
- $CO_2$ gassing of kieselguhr dosing vessel → low oxygen uptake

Filling

- pre-evacuation/purging and pressurizing with $CO_2$ → low oxygen uptake
- bottles: high pressure injection → low oxygen uptake
- cans: bubble breaker and sub lid gassing → low oxygen uptake

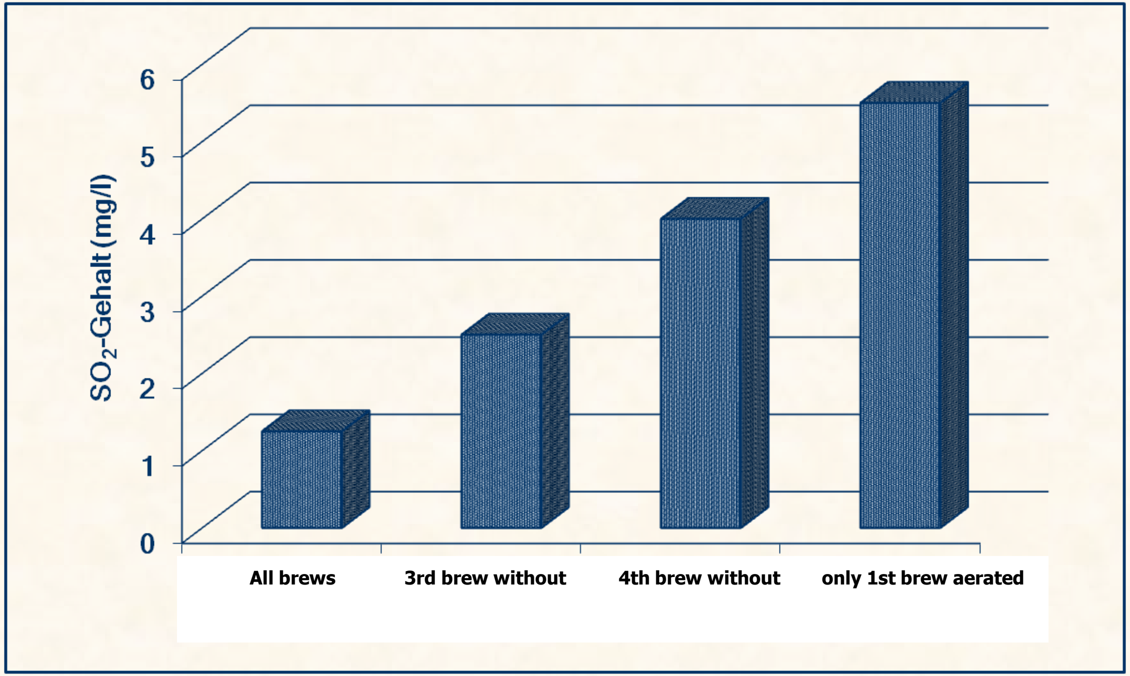
# Phases of $SO_2$- Formation






EBC Proc. 23, 1991

# $SO_2$ -Content depending on Aeration Strategy






Source: C.Tenge

# Pratical part- consulting strategies

# Measurment of TPO

- Where is the $O_2$ right after filling?
  - $O_2$ in the headspace
    ($O_2$ that was not removed by the HPI)
  - $O_2$ dissolved in the beer
    ($O_2$ load of the beer at filler inlet &
    $O_2$ picked up during filling)

# Oxygen in bottle filling

- **TPO in bottles**
  - Air in head space after filling
    - **High Pressure Injection (HPI)**

- 0,5 l NRW:
  - brim full: 520 ml
  - filling volume: 500 ml
  
  ⇨ head space: 20 ml

- Oxygen at 20 °C and 1013 hPa:
  - 1 ml contains 0,21 ml $O_2$ = 0,28 mg $O_2$/ml air

- 20 ml head space * 0,28 mg $O_2$/ml air ⇨ 5,6 mg $O_2$ in head space

- Worst case scenario: *>11,2 mg/l TPO*

ca. 11 000 bis 12 000 ppb !!!

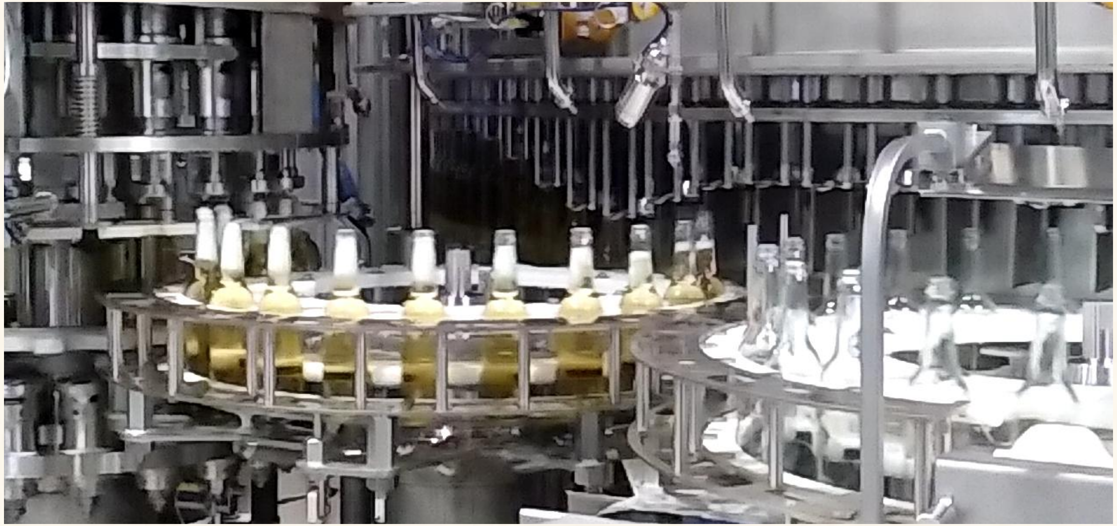
# Oxygen in bottle filling

| Oxygen DO | |
|---|---|
| BBT | 25 ppb |
| First bottle | 1020 ppb |
| After 1000 bottles | 1069 ppb |

# Adjustment of HPI

able 4: TPO after HPI adjustment

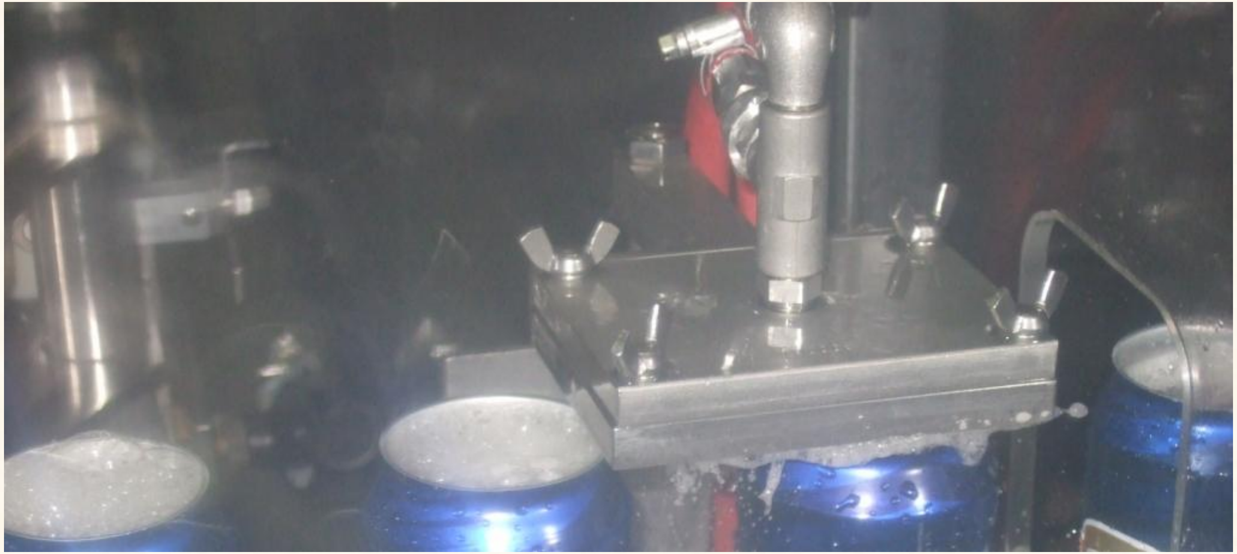
| Sample # | 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|---|
| TPO [ppb] | 255 | 140 | 128 | 95 | 106 |



# Oxygen in can filling

**Cans:**

- No vacuum, only $CO_2$ rinsing
- Bubble Breaker

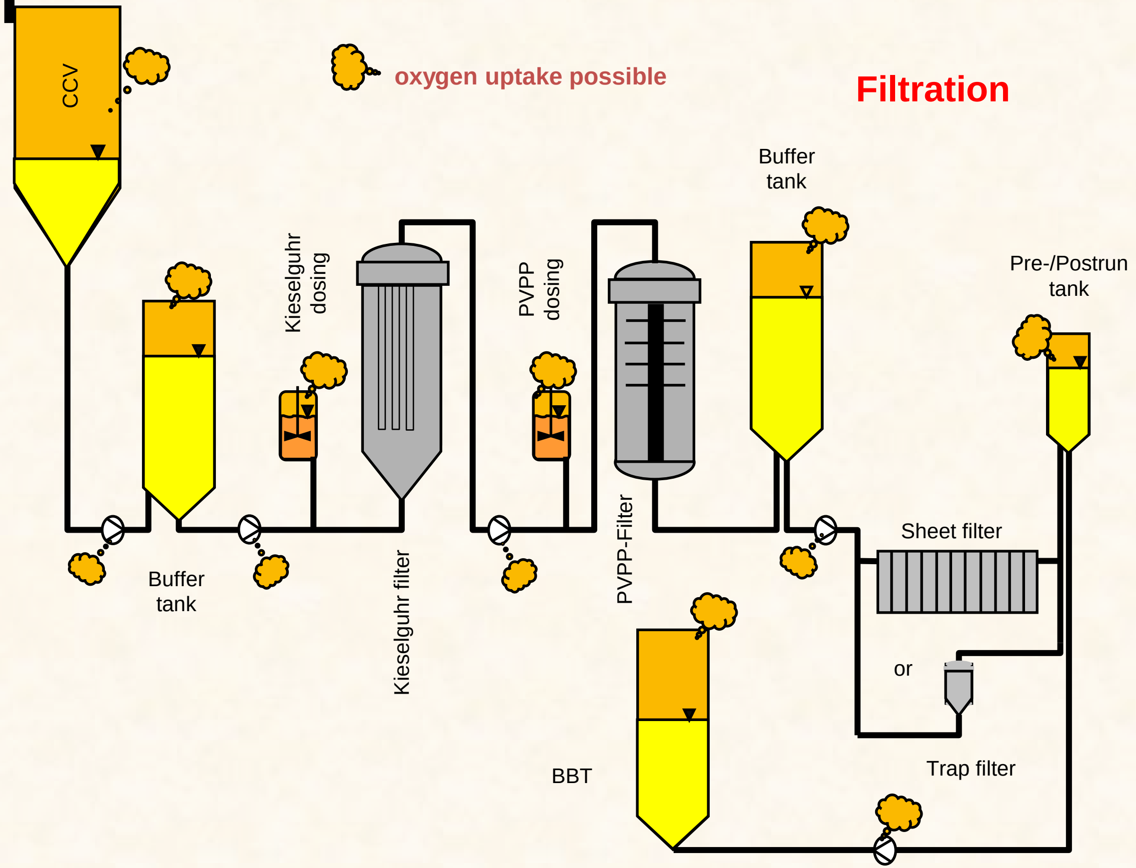


Source: VLB Berlin

# TPO influence temperature

| Sample # | Before Pasteurizer | | After Pasteurizer | |
|---|---|---|---|---|
| | 1 | 2 | 3 | 4 |
| TPO [ppb] | 281 | 323 | 87 | 72 |
| TPO Avg. [ppb] | 302 | | 80 | |

# Filtration



oxygen uptake possible
Filtration
CCV
Buffer tank
Kieselguhr dosing
Kieselguhr filter
PVPP dosing
PVPP-Filter
Buffer tank
Pre-/Postrun tank
Sheet filter
or
Trap filter
BBT

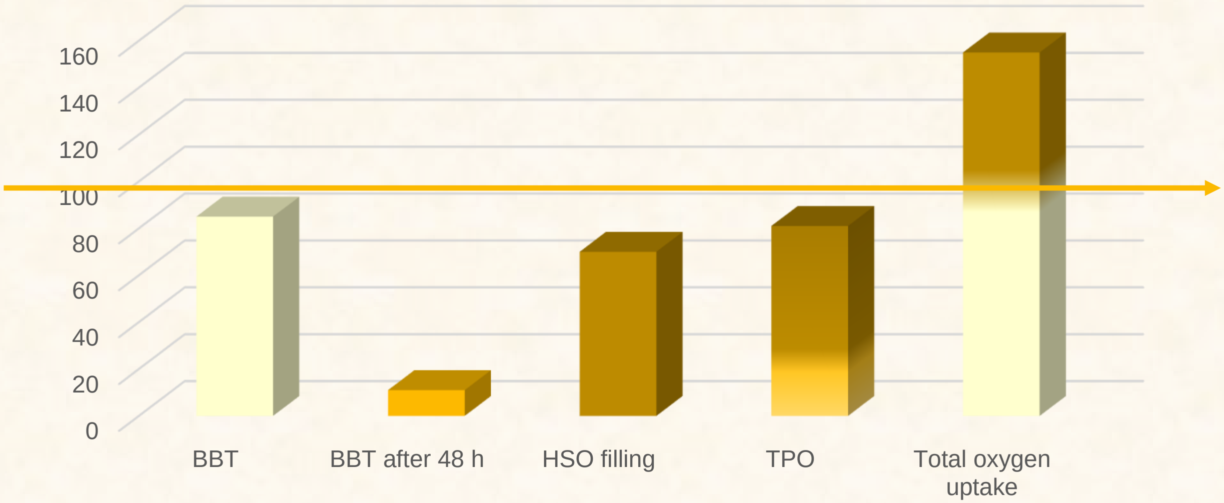
# Degradation of oxygen during storage time

Tab. 4: change in measured oxygen content during storage time in BBT

| Oxygen after | BBT 7 |
|---|---|
| Fresh filtered | 85 ppb |
| After 24 h | 27 ppb |
| After 48 h | 11 ppb |

# Oxygen –step control

+ Target < 100ppb in final product (total value)



# Anti- Oxidants

# Addition of anti-oxidants

+ Ascorbic acid
+ Sulfite products
+ Often in combination
+ Captures oxygen but…

# ANTIOXIDANTS

Standard dosages

| | | |
|---|---|---|
| Ascorbic acid | [ppm] | 20 - 80 |
| Isona D | [ppm] | 20 - 40 |
| Glucose-oxydase | [ppm] | 1 |
| Sulfites (e. g. potassium metabisulfite ($K_2S_2O_5$)) | | |
| P.M.S. | [ppm] | 10 - 30 |
| Sodium metabisulfite | [ppm] | 10 - 30 |

# Crown Corks - Permeation

INTERIOR PLASTIC LINER

## Oxygen Scavenger

A special liner that absorbs the oxygen remaining in the bottle neck finish, decreasing the beer or beverage oxidation. Oxygen scavenger liners provide extra freshness, better taste and extended shelf life. That's why they are strongly preferred by premium beer brands and craft breweries.

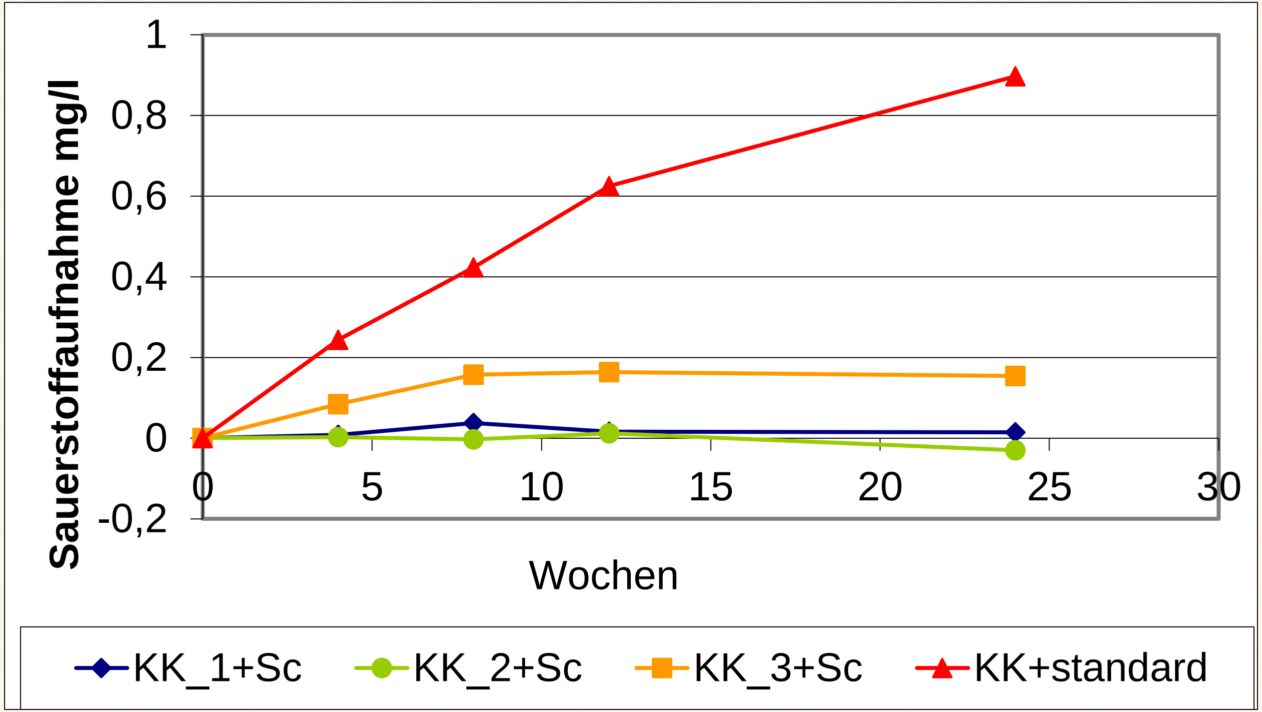


INTERIOR PLASTIC LINER

## Oxygen Barrier

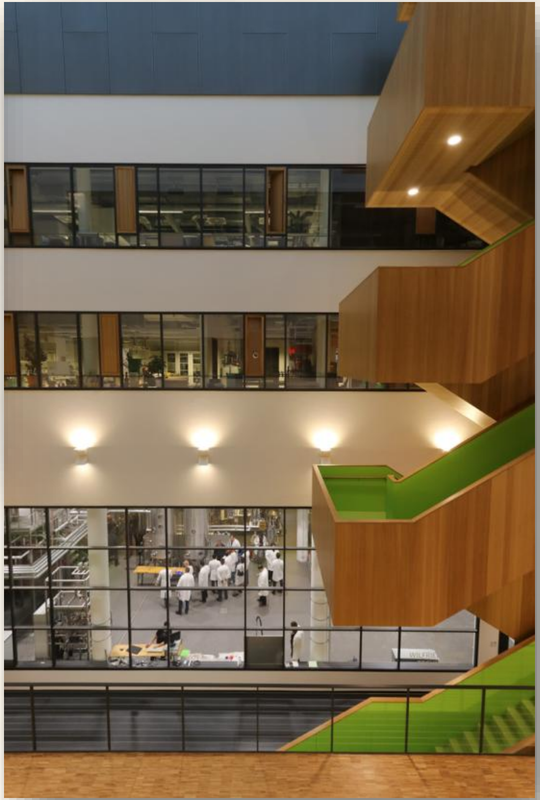
A liner profile that actually acts as a barrier to any external contamination such as odor and oxygen ingress into the glass bottle.

# Crown cork - permeation




CC (KK) 1 – 3 have Scavengers in Compound

# Thank you for your attention!



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