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The main weaknesses of NABLABs: a real challenge

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Journée d'étude de l'ARFB 13 October 2023

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NABLABs ⟶ What are they ?

NAB LAB

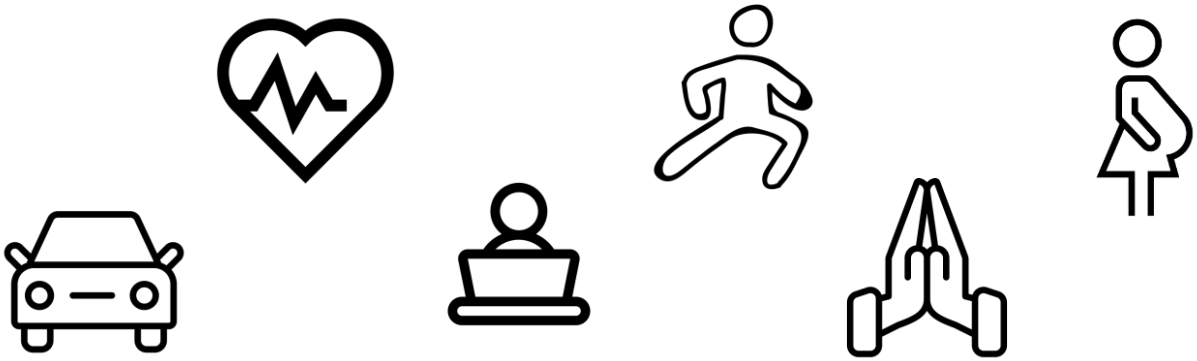
Non Alcoholic Beer Low Alcoholic Beer

≤ 0.5 % ABV 0.5 – 1.2 % ABV

NABLABs ⟶ Why ?

Substitute

- Healthier and more civic-minded lifestyles
- Restrictions



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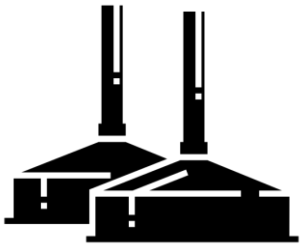
NABLABs → Production methods

- Restricting ethanol formation during fermentation
  - Biological process
    - Changed mashing process
    - Arrested/Limited fermentation – Cold Contact
    - Special yeasts or microorganisms



- Removal of alcohol = dealcoholization
  - Physical process
    - Thermal systems
      - Vacuum rectification
      - Thin film vacuum evaporation
    - Membrane systems
      - Dialysis
      - Reverse osmosis

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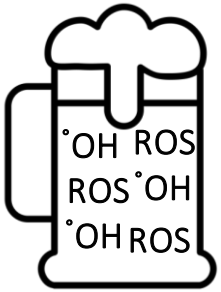
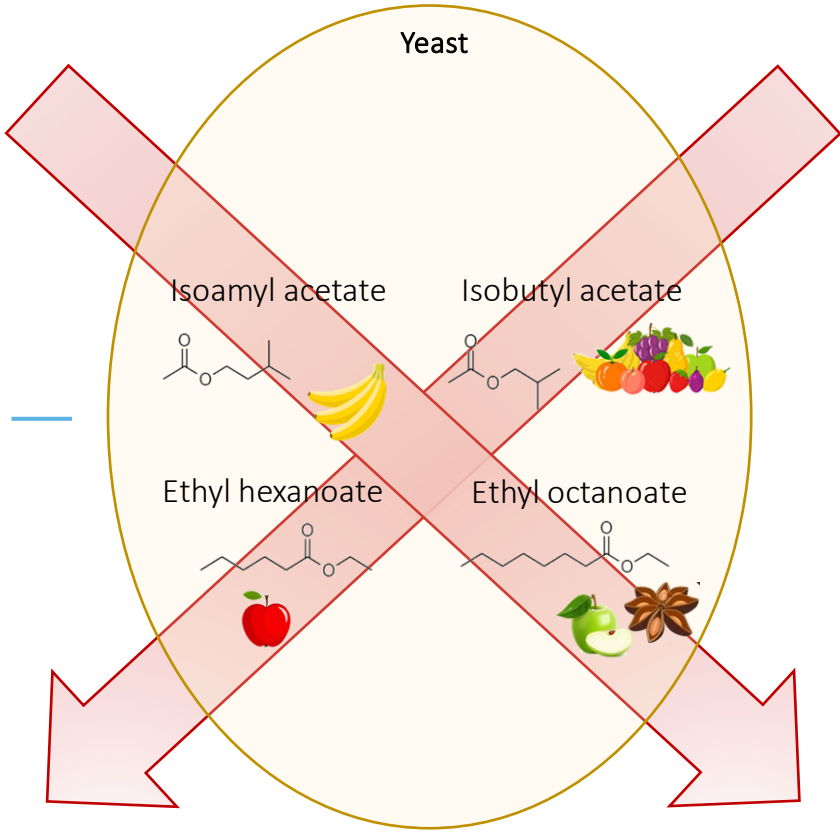
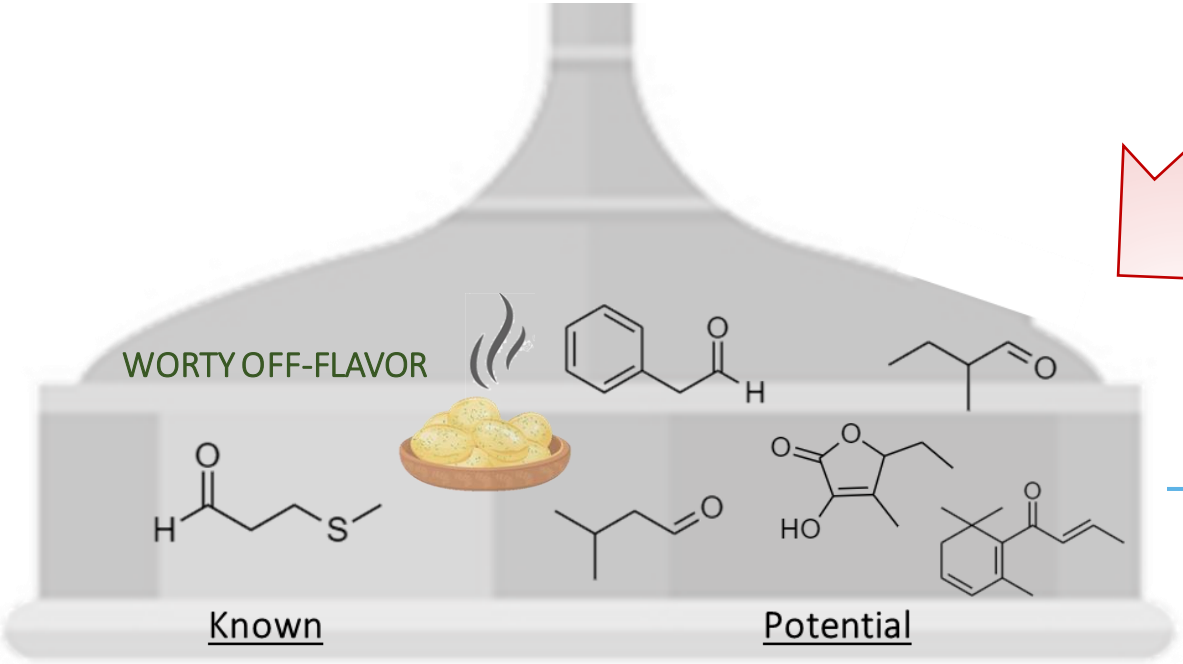
NABLABs → Major defects when fresh



— Absence of ethanol

Lack of fruity fermentation esters —





— Persistent stale-odorants

P. Perpète & S. Collin. Contribution of 3-methylthiopropionaldehyde to the worty flavor of alcohol-free beers. J. Agric. Food Chem. (1999), 47, 2374-2378.
J. A. Piornos, D. P. Balagiannis, L. Methven, E. Koussissi, E. Brouwer & J. K. Parker. Elucidating the odor-active aroma compounds in alcohol-free beer and their contribution to the worty flavor. J. Agric. Food Chem. (2020), 68(37), 10088-10096.

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Investigate the profile of 11 commercial NABLABs, derived from different technological processes **when fresh**…

► OXIDATION ISSUE

- Antioxidant power
- Bitter compounds
- Polyphenols
- Stale-odorants

► LACK OF FRUITY FLAVORS

- Fermentation esters
- Dimethylsulfide
- Polyfunctional thiols

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Selection of NABLABs available on the Belgian market

Star Light

A.

Energibajer

B.

Pico Bello

C.

Road Trip

D.

Palm 0.0

E.

Maes 0.0

F.

Hoegaarden rosée 0.0

G.

Carlsberg 0.0

H.

Jupiler 0.0

I.

Leffe Blonde 0.0

J.

Sport zot N.A.

K.

Biological process

Special yeasts

Limited fermentation (+LB) - Cold Contact

% ABV : 0.1 - 0.5

Ea (°P) : 3.6 – 6.9

Physical process

Thermal systems (Vacuum Dealcoholization)

Membrane systems (Filtration Dealcoholization)

% ABV : < 0.1

Ea (°P) : 3.8 – 9.1

PREMATURED OXIDATION

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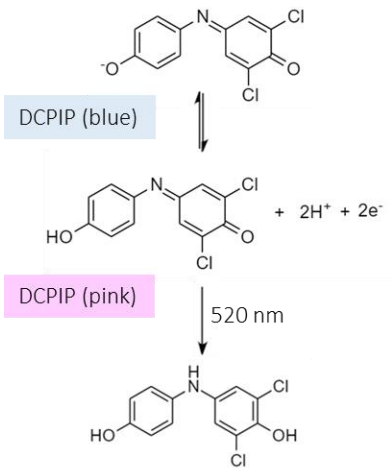
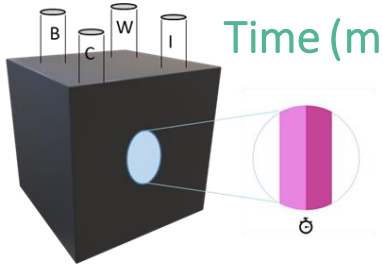
Premature oxidation

Antioxidant power in fresh NABLABs

ITT

Indicator Time Test





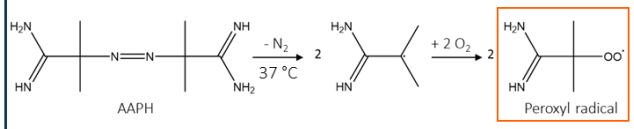
Time (min) ↘↘

B = Beer | W = Water | C = Comparator | I = Indicator in beer

AAPH

2,2′-azobis(2-amidinopropane) dihydrochloride

Initiation



$RO_2^\circ + LH \rightarrow ROOH + L^\circ$

Linoleic acid

Propagation

$L^\circ + O_2 \rightarrow LO_2^\circ$

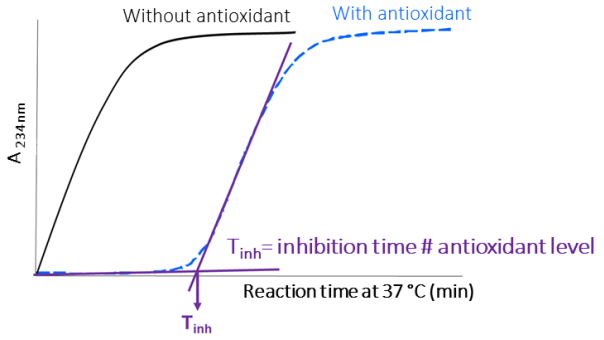
$LO_2^\circ + LH \rightarrow L^\circ + LOOH$

Termination

$2\ LO_2^\circ \rightarrow$ Non-radical products

Absorbance at 234 nm

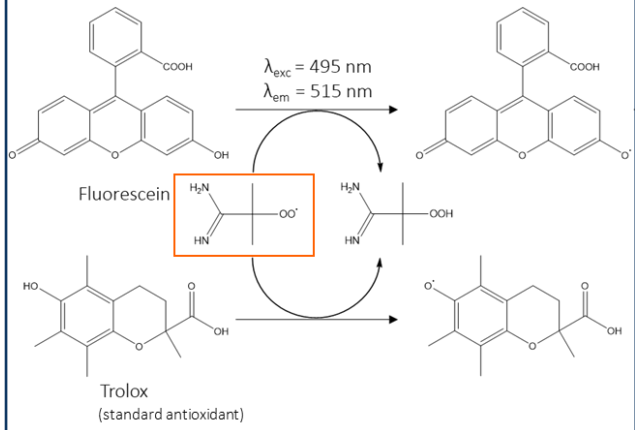
→ Conjugated diene hydroperoxide



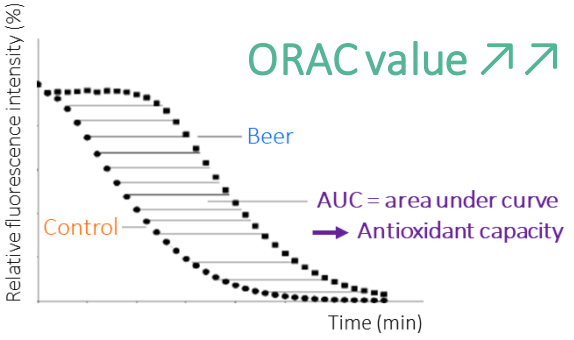
Time (min) ↗↗

ORAC

Oxygen Radical Absorbance Capacity



→ Fluorescence for 50 min



ORAC value ↗↗

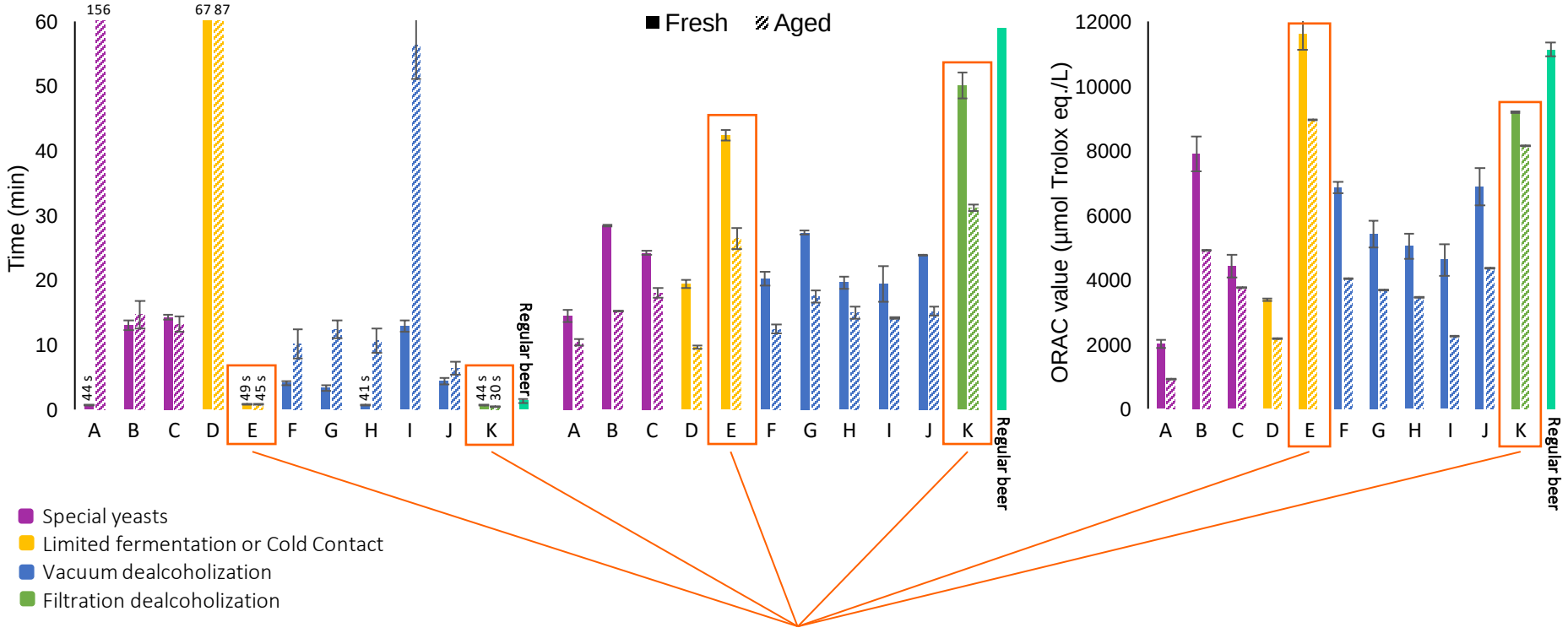
Premature oxidation

Antioxidant power in fresh NABLABs

ITT
Indicator Time Test

AAPH
2,2′-azobis(2-amidinopropane) dihydrochloride

ORAC
Oxygen Radical Absorbance Capacity

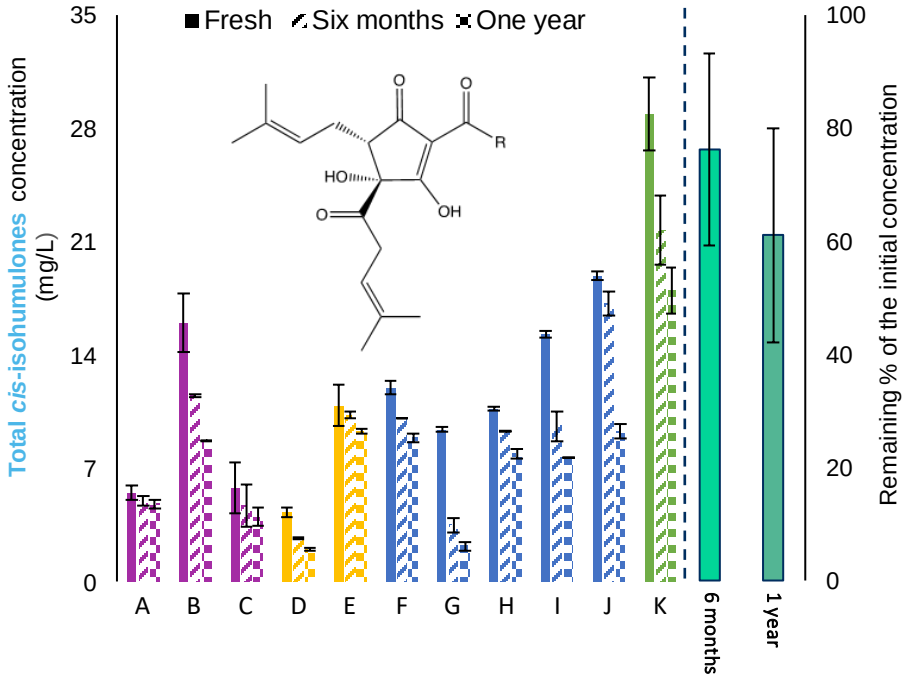


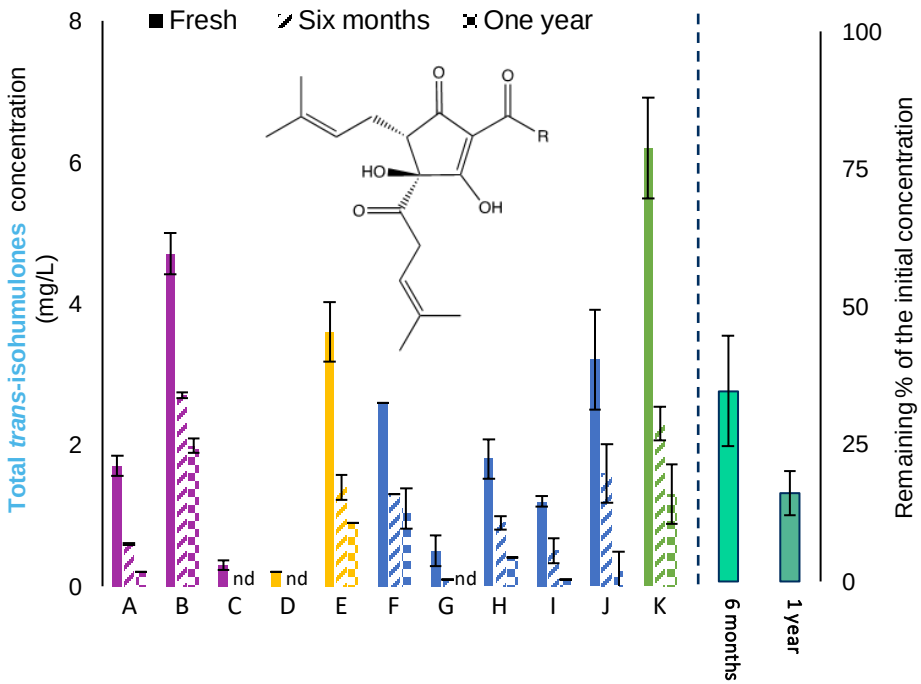
Production with special malts

Lower reduction power than regular beers

Prematured oxidation

Fate of bitter compounds





- Special yeasts
- Limited fermentation or Cold Contact
- Vacuum dealcoholization
- Filtration dealcoholization

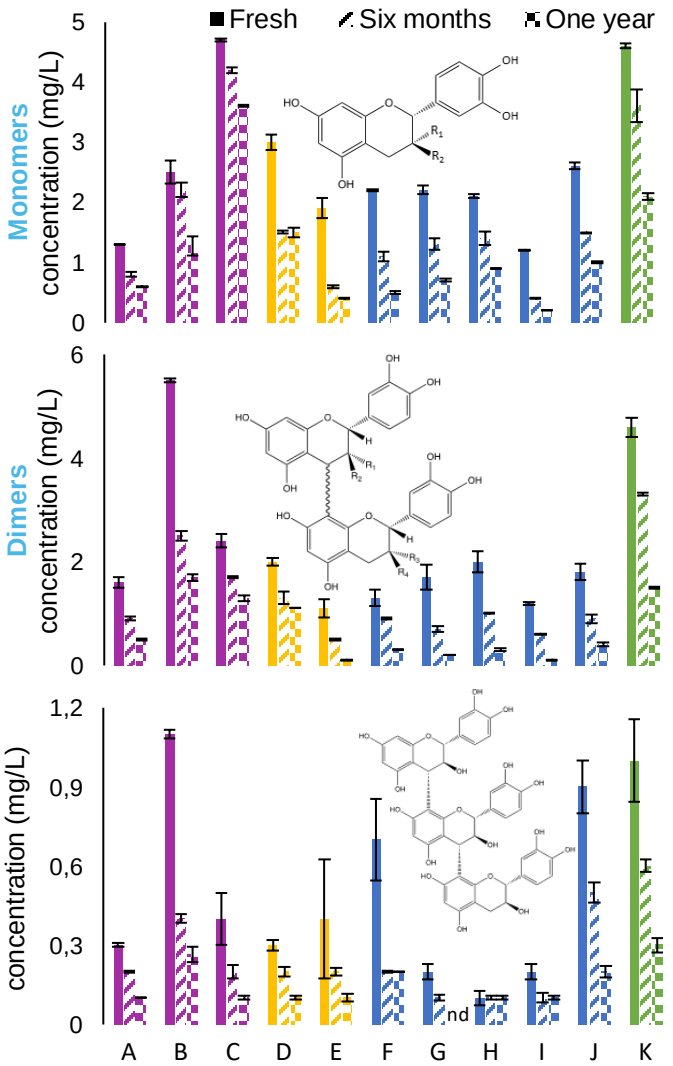
└ Susceptibility to **prematured aging**

└ Lead to **unpleasant bitterness**

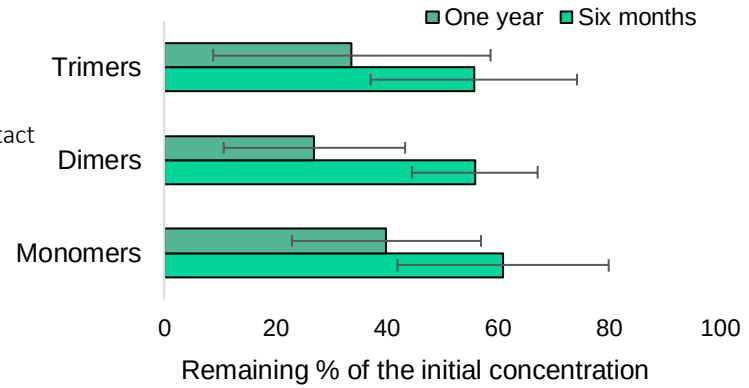
M. Simon & S. Collin. Why oxidation should be still more feared in NABLABs: Fate of polyphenols and bitter compounds. Beverages. (2022), 8(4), 61-74.

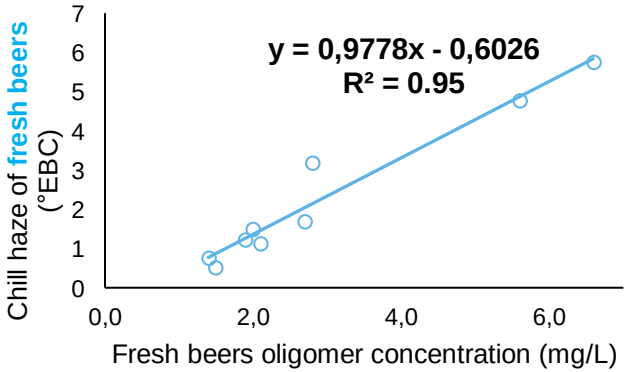
Prematured oxidation

Fate of flavan-3-ols and involvement in beer haze



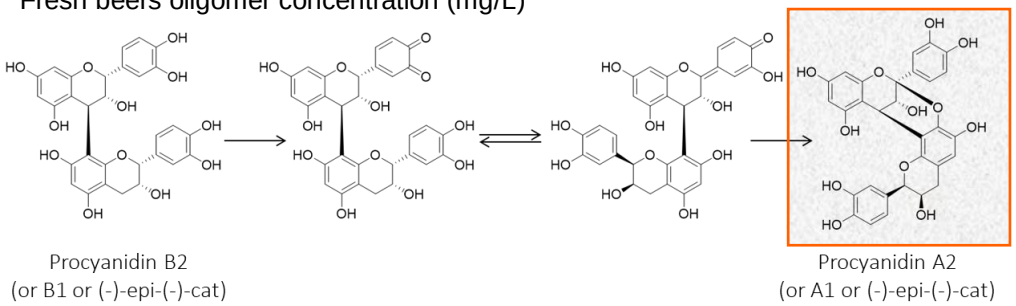
Special yeasts
Limited fermentation or Cold Contact
Vacuum dealcoholization
Filtration dealcoholization





L Significant **prematured oxidation**

++ colloidal instability



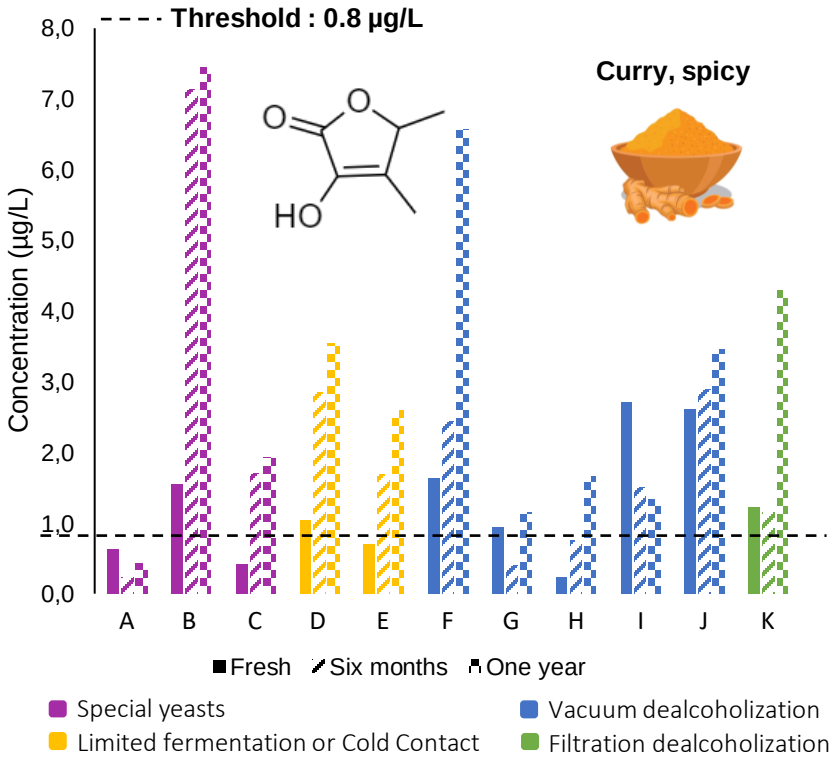
Procyanidin B2 (or B1 or (-)-epi-(-)-cat)

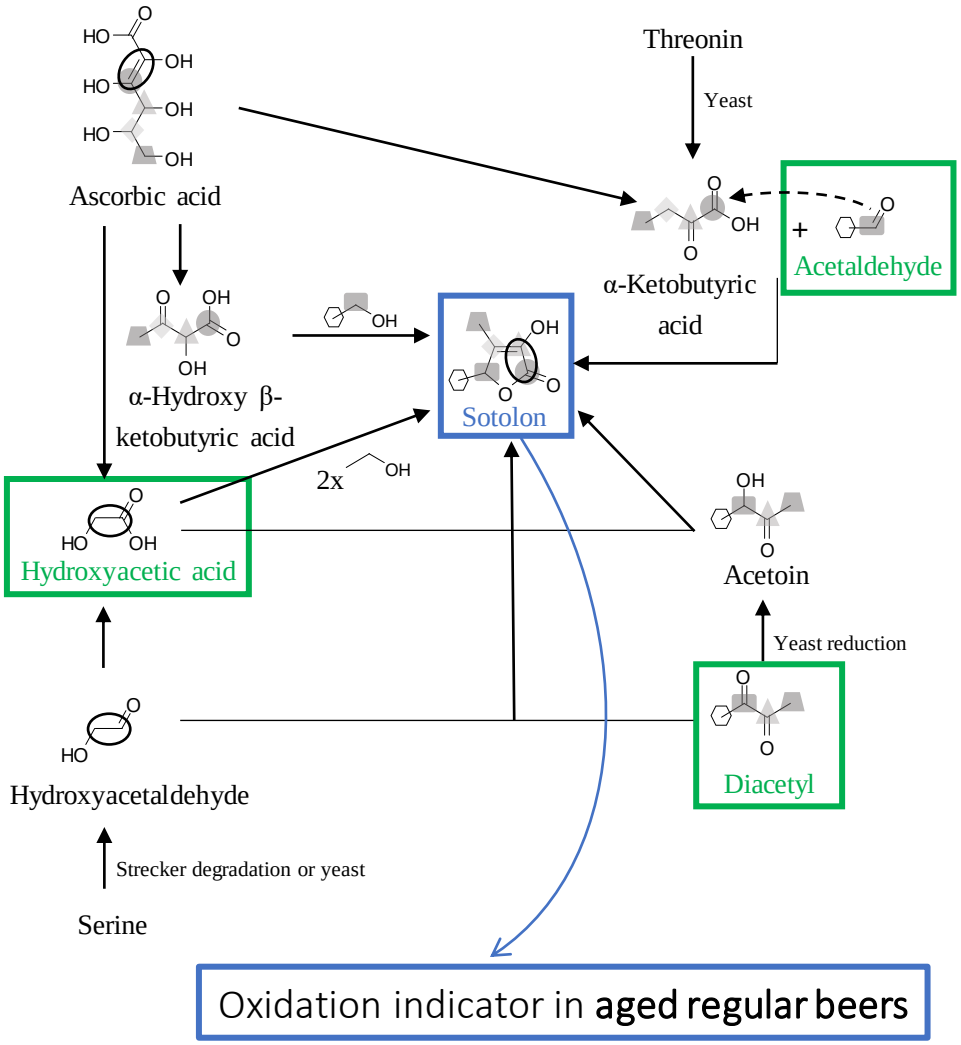
Procyanidin A2 (or A1 or (-)-epi-(-)-cat)

M. Simon & S. Collin. Why oxidation should be still more feared in NABLABs: Fate of polyphenols and bitter compounds. Beverages. (2022), 8(4), 61-74.

Prematured oxidation

Sotolon in fresh NABLABs





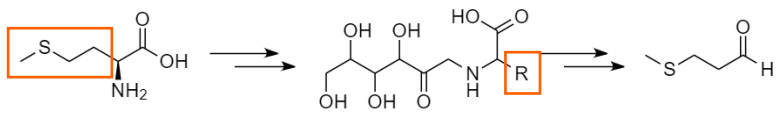
- > Perception threshold in most **fresh NABLABs**
- Higher occurrence of the following precursors :

Oxidation indicator in **aged regular beers**

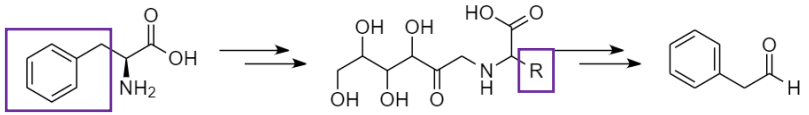
M. Simon, G. Vuylsteke & S. Collin. Flavor defects of fresh and aged NABLABs: New challenges against oxidation. J. Am. Soc. Brew. Chem. (2023), 81(4), 1-11.

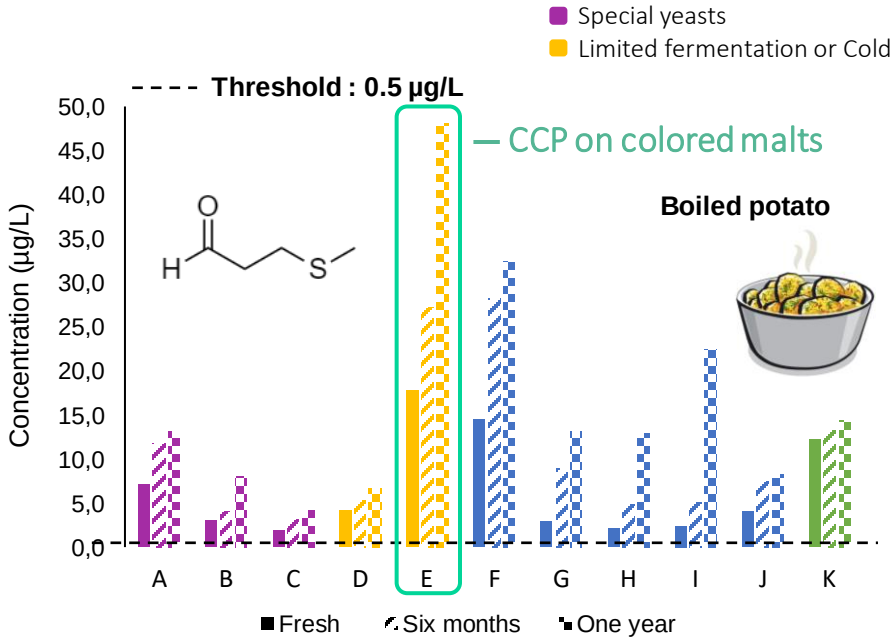
Premature oxidation

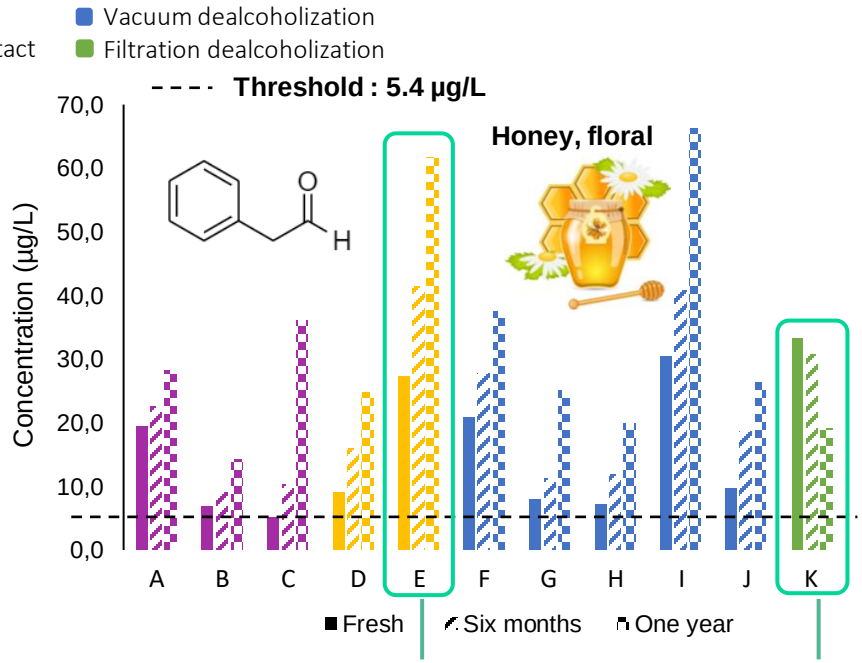
Methional in fresh NABLABs



Phenylacetaldehyde in fresh NABLABs







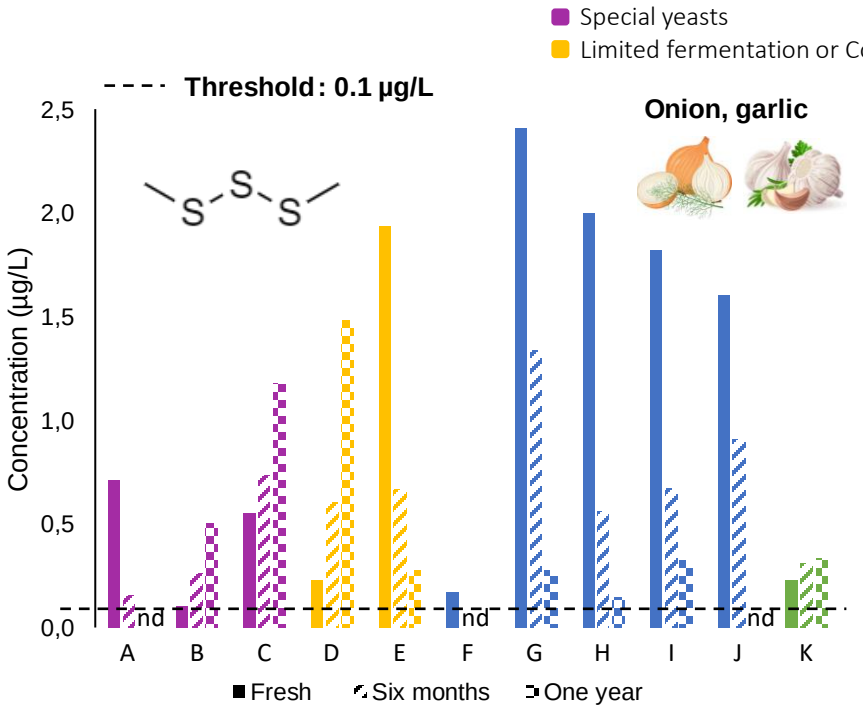
- **Insufficient reduction** to alcohol in biological process
- **Regeneration** in thermal dealcoholization
  - >> Perception threshold in **all fresh NABLABs**
  - Close to **aged regular beers**

Production with special malts

M. Simon, G. Vuylsteke & S. Collin. Flavor defects of fresh and aged NABLABs: New challenges against oxidation. J. Am. Soc. Brew. Chem. (2023), 81(4), 1-11.

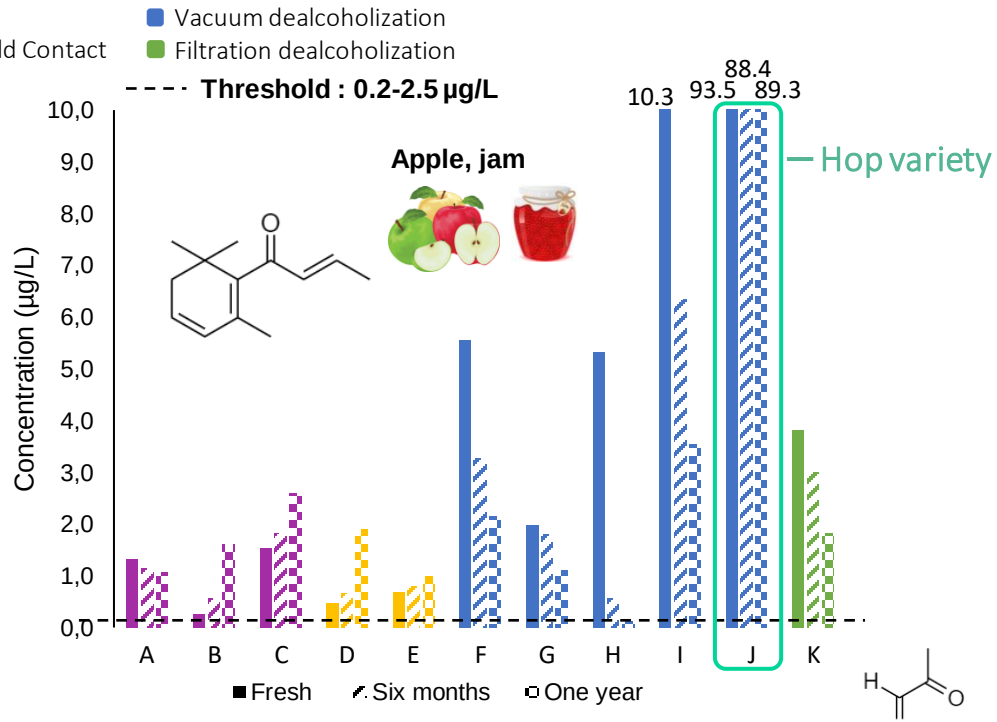
Prematured oxidation

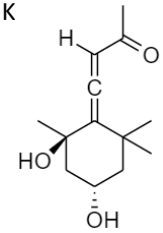
Dimethyltrisulfide in fresh NABLABs



- Close or higher than in **aged regular beers**
- Potential precursors : methional/methionol

β-damascenone in fresh NABLABs





- Close to **aged regular beers**, especially after **physical** process
- Release from **glycosides** (grasshopper ketone)

- > Perception threshold in **all fresh NABLABs**

M. Simon, G. Vuylsteke & S. Collin. Flavor defects of fresh and aged NABLABs: New challenges against oxidation. J. Am. Soc. Brew. Chem. (2023), 81(4), 1-11.

LACK OF FRUITY FLAVORS

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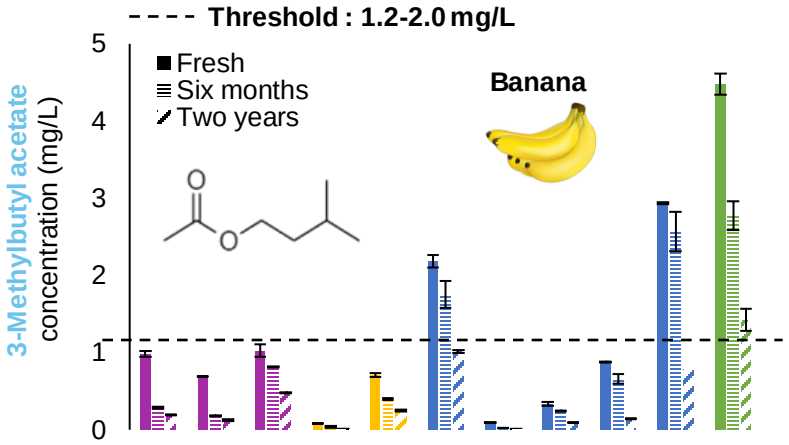
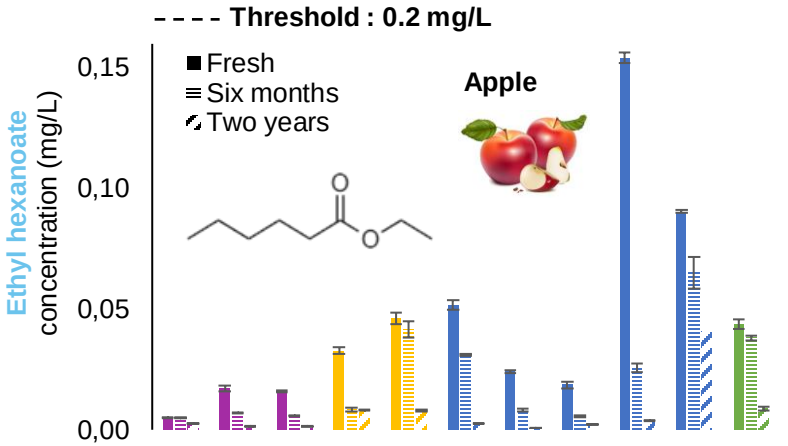
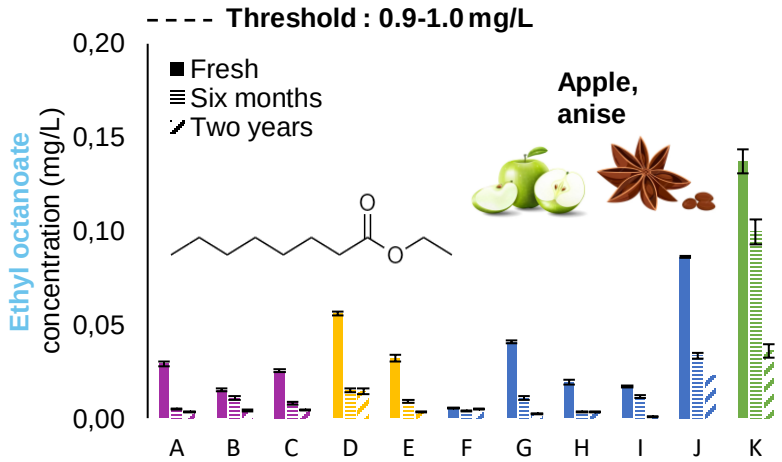
Lack of fruity flavors

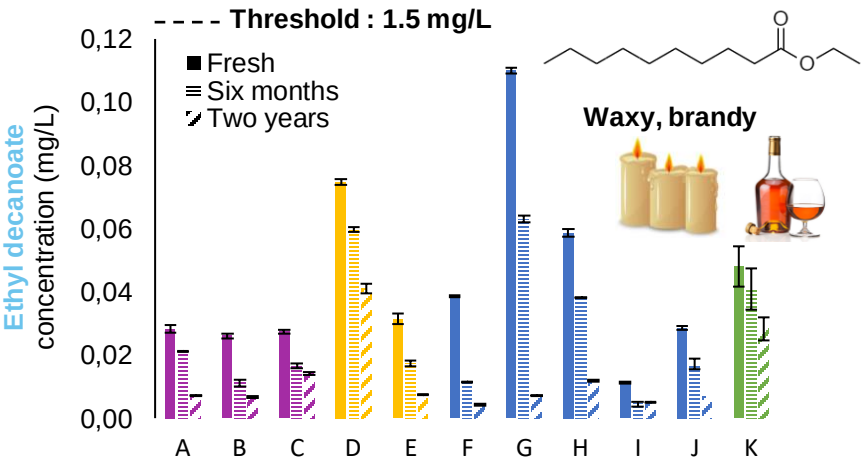
- Special yeasts
- Limited fermentation or Cold Contact
- Vacuum dealcoholization
- Filtration dealcoholization

Fruity fermentation esters in fresh NABLABs









- **Much lower** concentration than regular lagers
  - **Loss** in dealcoholization process
  - **Limitation** of biosynthesis in biological process

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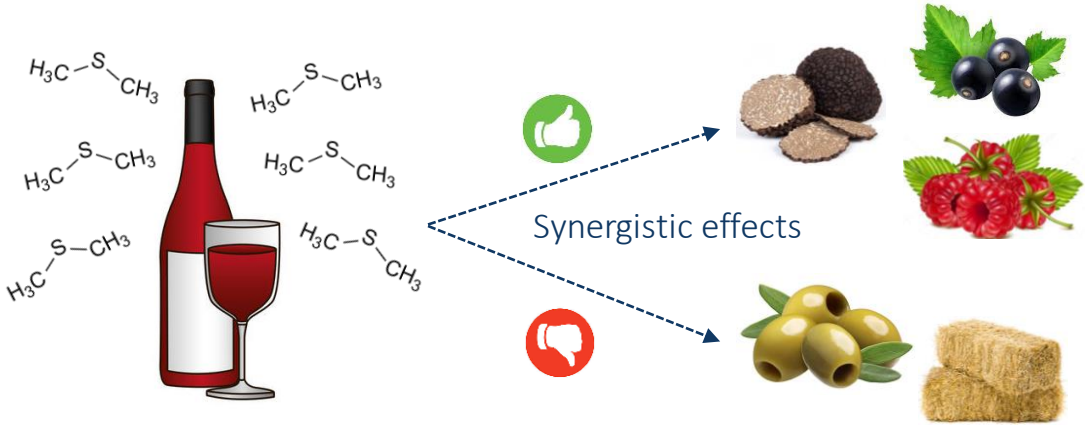
Lack of fruity flavors

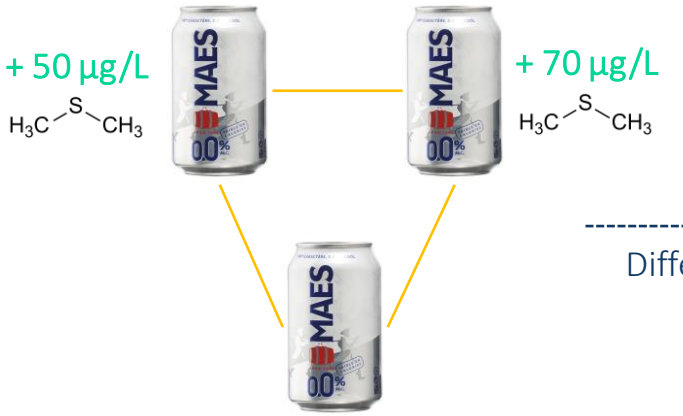
Dimethylsulfide in wine → Natural enhancer of fruity flavor perception



Depending on concentration and wine type

Triangular tests (15 trained assessors)

M. A. Segurel, A. J. Razungles, C. Riou, M. G. Trigueiro & R. L. Baumes. Ability of possible DMS precursors to release DMS during wine aging and in the conditions of heat-alkaline treatment. J. Agric. Food Chem. (2005), 53(7), 2637-2645.



Differentiation

Red fruits

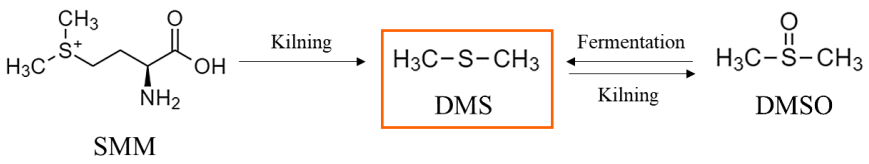
Banana **60 %** Citrus

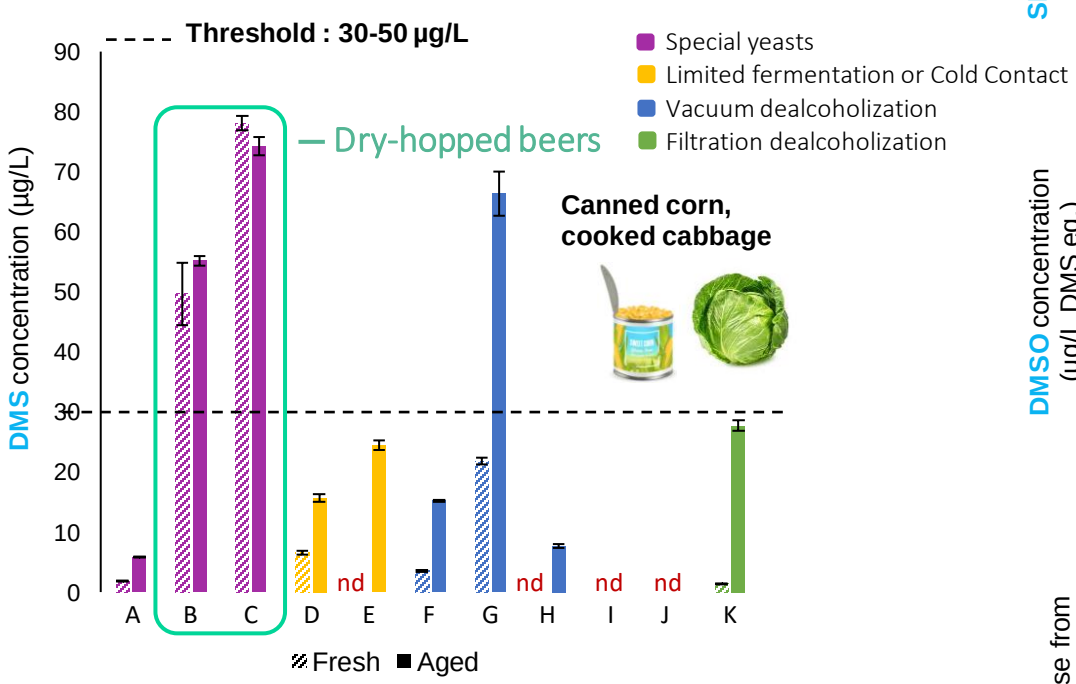
Floral

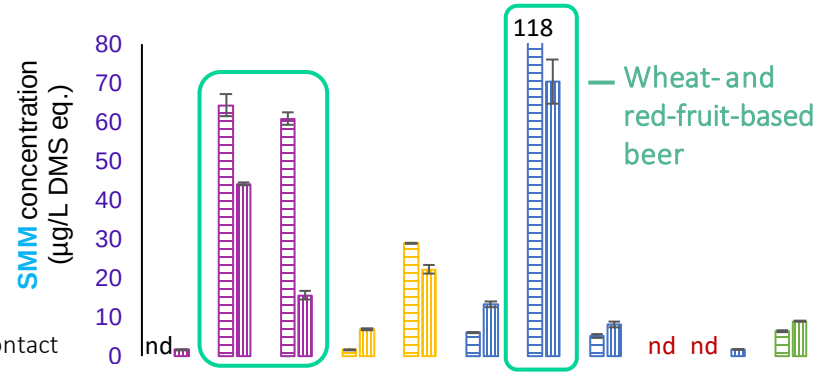
Synergy with fruity fermentation esters or polyfunctional thiols ???

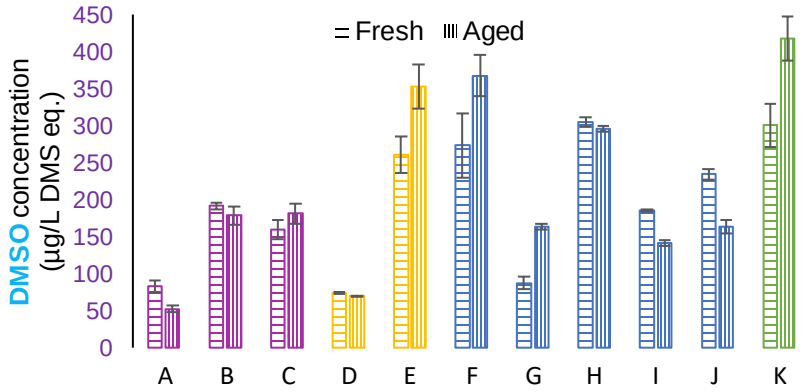
Lack of fruity flavors

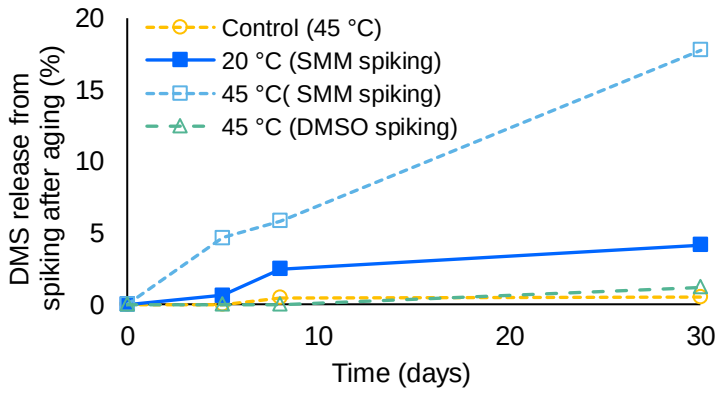
Dimethylsulfide in fresh NABLABs







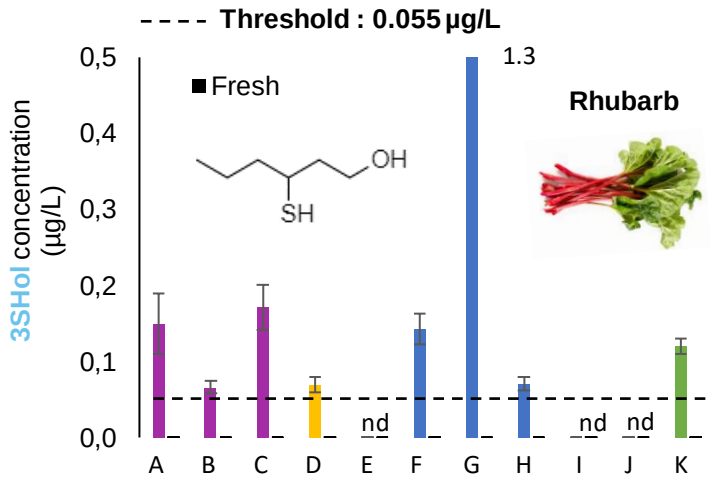


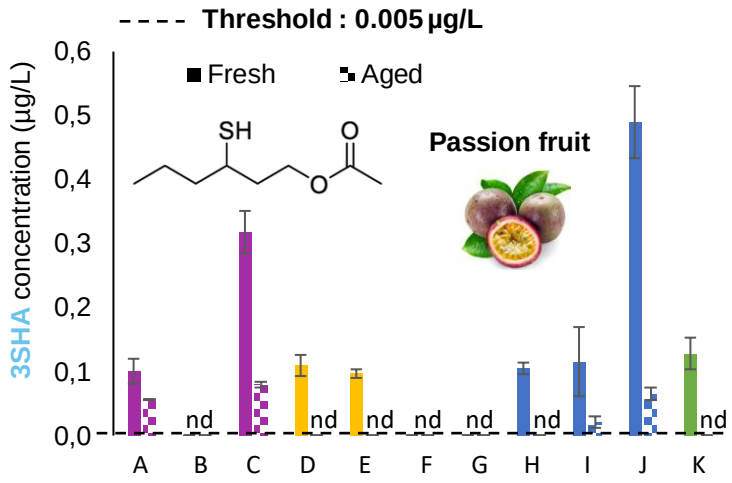


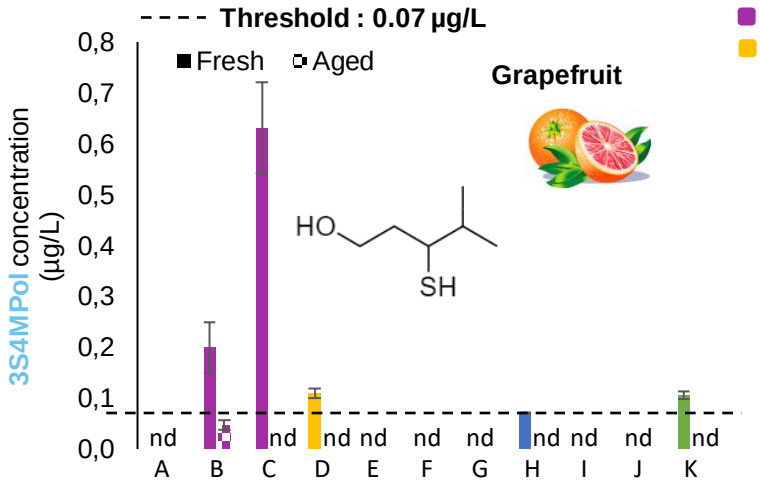
- Very low levels in most **fresh NABLABs**
- Production (**+63 %**) through aging in **almost all NABLABs**
  - **SMM** = main precursor

Lack of fruity flavors

Fruity hop-derived polyfunctional thiols in fresh NABLABs







Special yeasts
Limited fermentation or Cold Contact
Vacuum dealcoholization
Filtration dealcoholization

> Perception threshold in most **fresh NABLABs** (especially in **dry-hopped beers**)

Take home message in fresh NABLABs

OXIDATION ISSUE

- Weak antioxidant capacity
- More oxidation of *cis*- and *trans*-isohumulones
- Flavan-3-ols oligomers already oxidized into A2 dimers
  ➔ Source of CHILL HAZE
- Stale-odorants of six-months aged lagers :
  Sotolon, methional, phenylacetaldehyde, dimethyltrisulfide, β-damascenone
  OXIDATION

*Positive effect of **sulfites** or development of other efficient natural **antioxidants***

LACK OF FRUITY FLAVORS

- Low fermentation ester level
- Lack of dimethylsulfide

***Optimized dry hopping** : hop supplying both DMS (and its precursors) and fruity polyfunctional thiols*

Thank you for your attention !