IHPS

Inštitut za hmeljarstvo
in pivovarstvo
Slovenije

Hmelj i proizvodi od hmelja u suvremenoj proizvodnji piva

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OUTLINE

- Introduction
- Traditional use of hops
  - Processes during kettle hopping
  - Consequences of kettle hopping
- Alternative uses of hops
  - Late hopping
  - Dry hopping
  - Processes during late/dry hopping
  - Consequences of late/dry hopping vs. kettle hopping
- Negative consequences and disadvantages
- Improvements

Introduction – Beer aroma (taste and odour)

- Volatile and non volatile compounds originating from raw materails – hop, barley

- Also byproducts of fermentation – esters, higher alcohols - major part of beer aroma

- Hop – key role for beer aroma
  - alpha-acids – beer bitternes (taste)
  - polyphenols – taste, stability
  - composition of essential oils –
    - beer aroma (odour)

Introduction – chemical composition of hops

component	content (%)
alpha-acids	2 – 20
beta-acids	1 – 20
essential oil	0,5 – 4,0
polyphenols	2 – 5
fats and fatty acids	0 – 2,5
Proteins	15
cellulose	40 – 50
water	8 – 12
pectin	2
pepel	10

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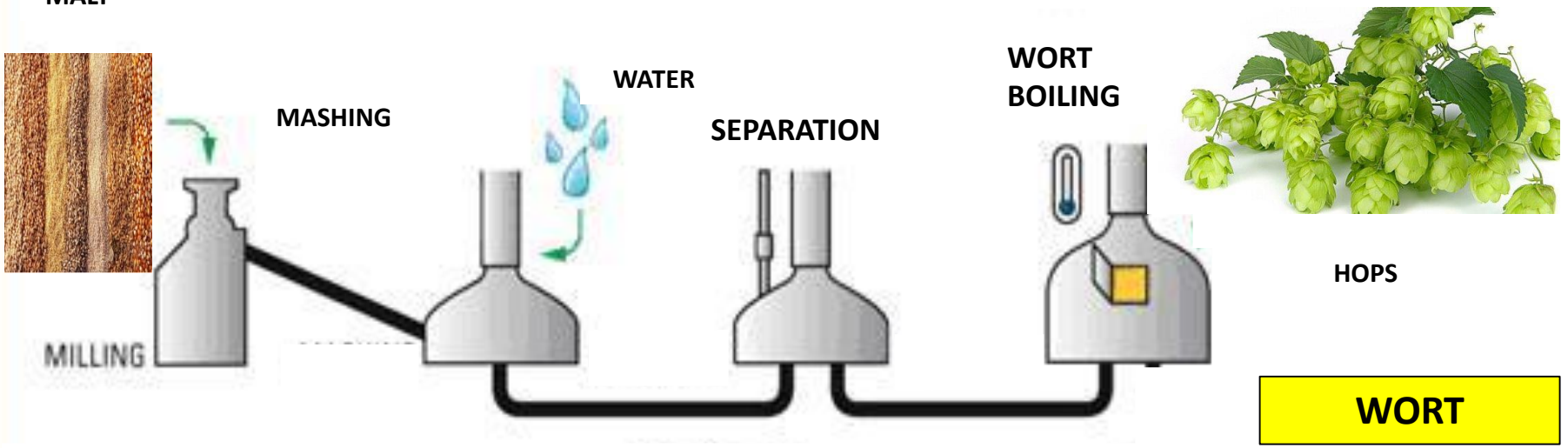
pectin	2
ash	10

TRADITIONAL USE OF HOPS

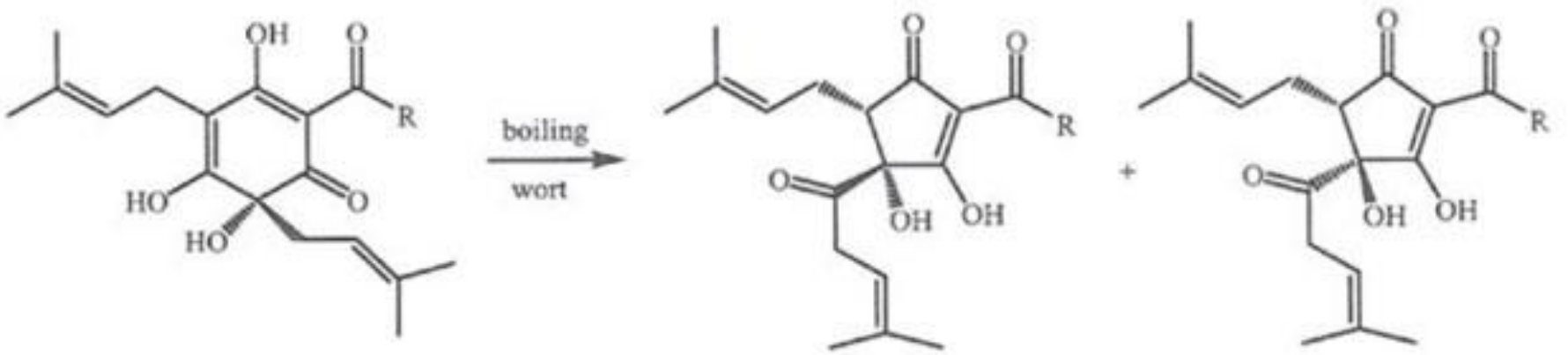
BREWING PROCESS – KETTLE HOPPING (HOT)



- Wort boiling/hopping takes place at T boiling point for about 90 min,
- Addition of hops in several portions (90, 45, 15-10 min),
- At the beginning bitter varieties, towards the end aromatic varieties,
- Bitter substances from hops are chemically modified and easily soluble in water ⟶ bitter taste of beer,
- Essential oils contribute to the hop aroma of beer.

PROCESSES DURING KETTLE HOPPING

- Isomerisation of alpha-acids

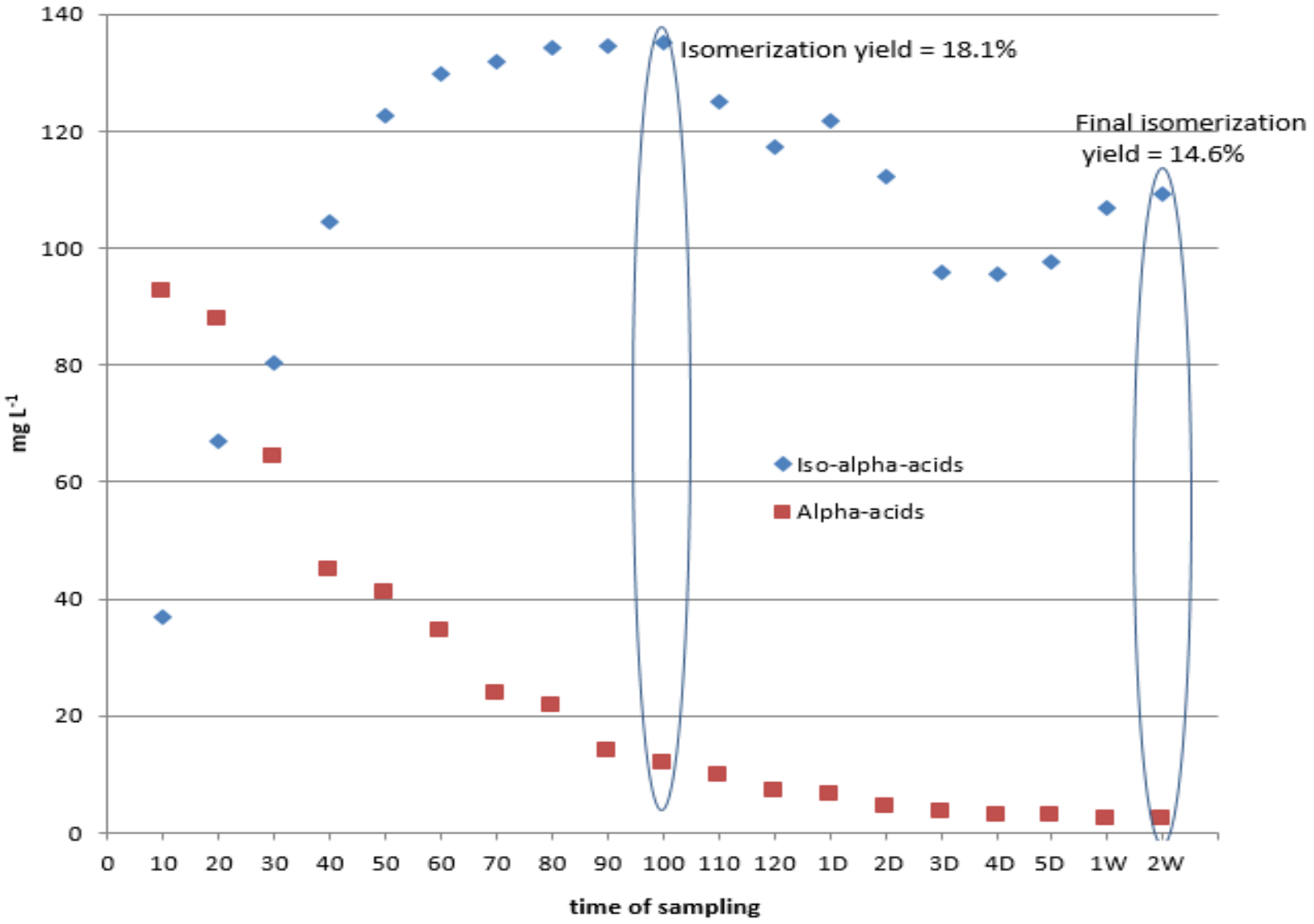


ICE 3 (α-acids)
CH(CH3)2 cohumulone
CH2CH(CH3)2 humulone
CH2 (CH3) C2H5 adhumulone

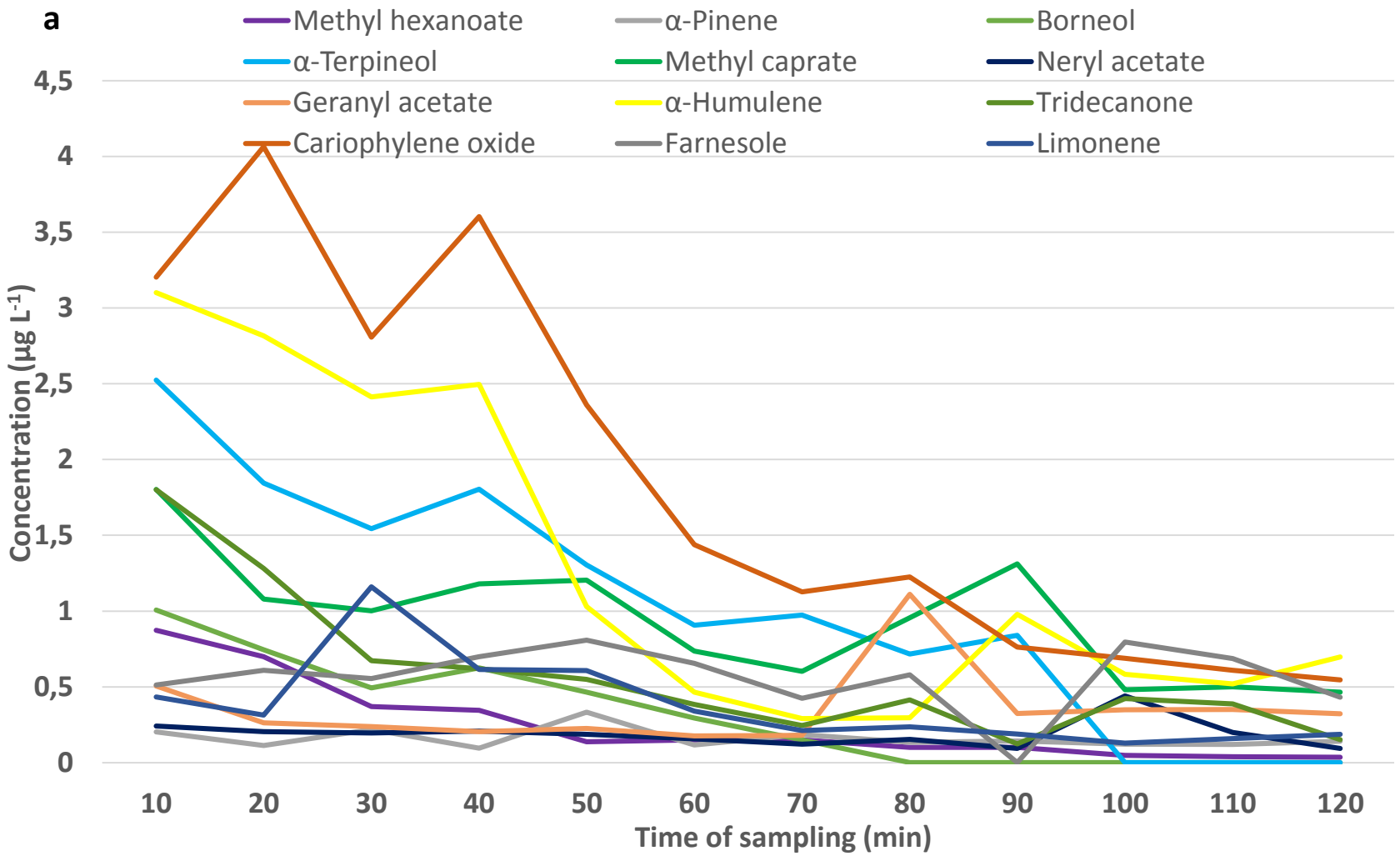
cis-iso-α-acids
cis-cohumulone
cis-humulone
cis-adhumulone

ICS- I3 (*trans*-iso-α-acids)
trans-cohumulone
trans-humulone
trans-adhumulone

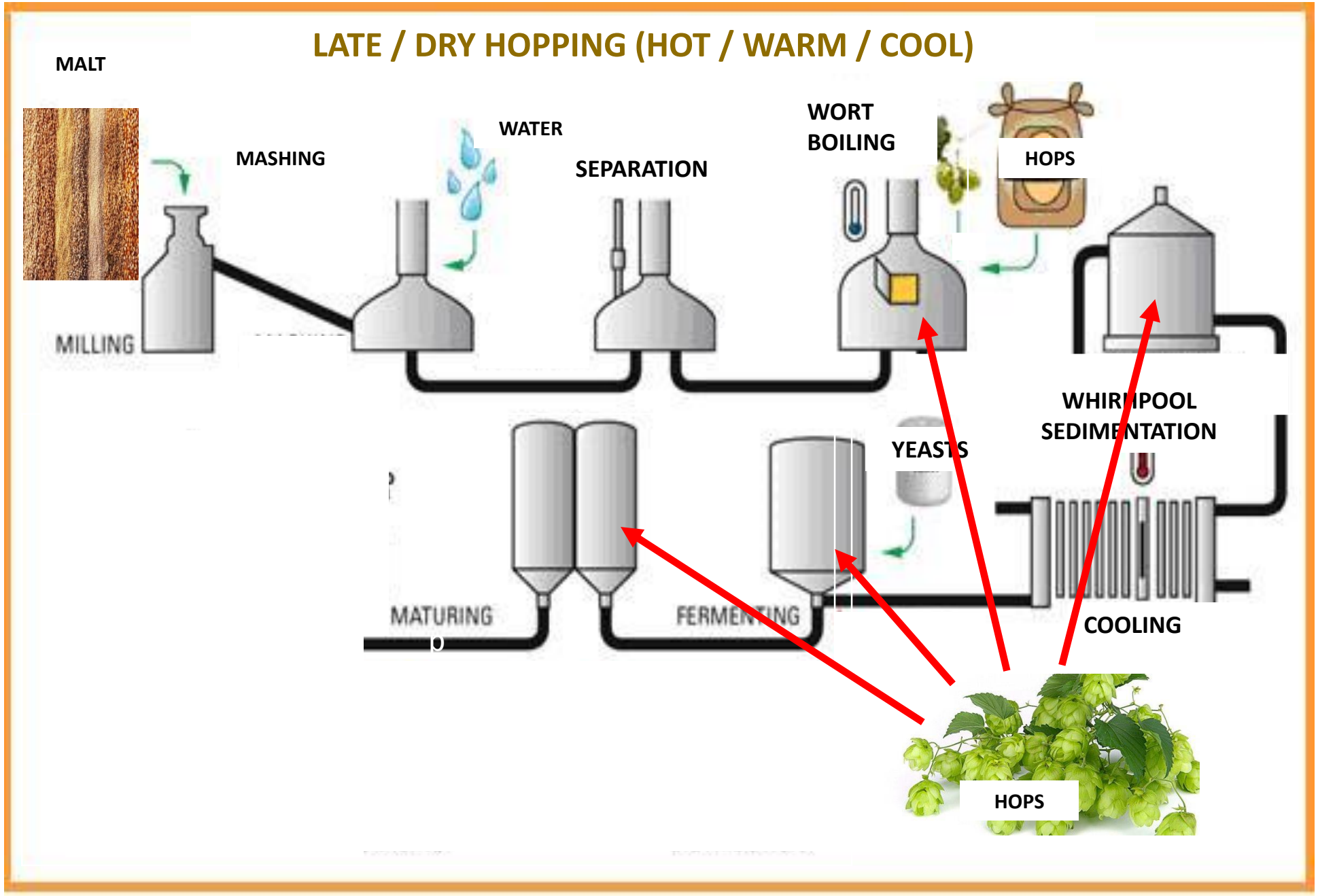
Isomerization of alpha-acids - dynamics



Essential oil components - dynamics



LATE/DRY HOPPING



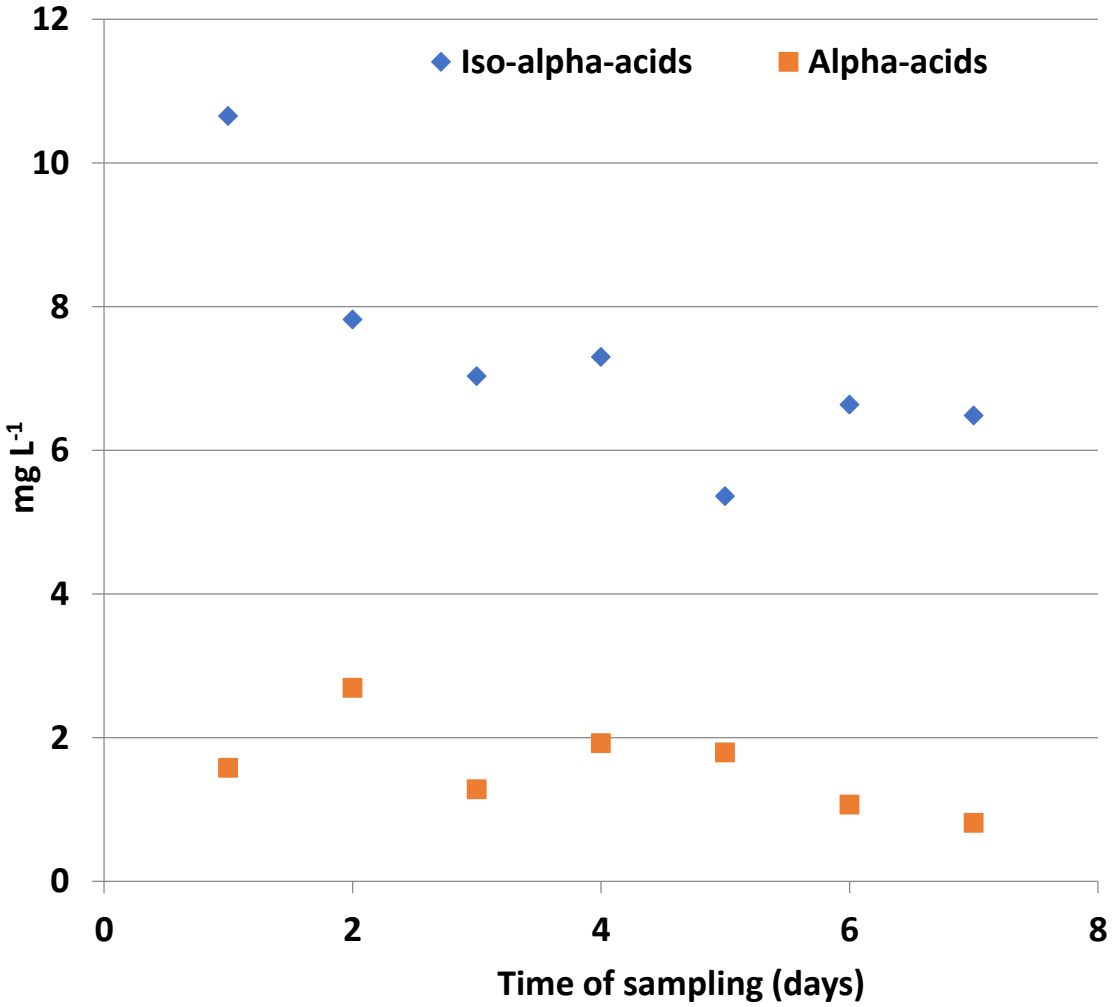
LATE / DRY hopping

- Late hopping:
  - in the kettle on the end of boiling, just prior transfer to the whirhpool,
  - in the whirhpool during cooling and sedimentation,
  - in both cases T is stil moderatly high ⟶ isomerisation, evaporation

- Dry hopping:
  - during the fermentation,
  - during maturation,
  - In both cases T is low ⟶ low yield of isomerisation, negligible evaporation,
  - 48-72 hours.

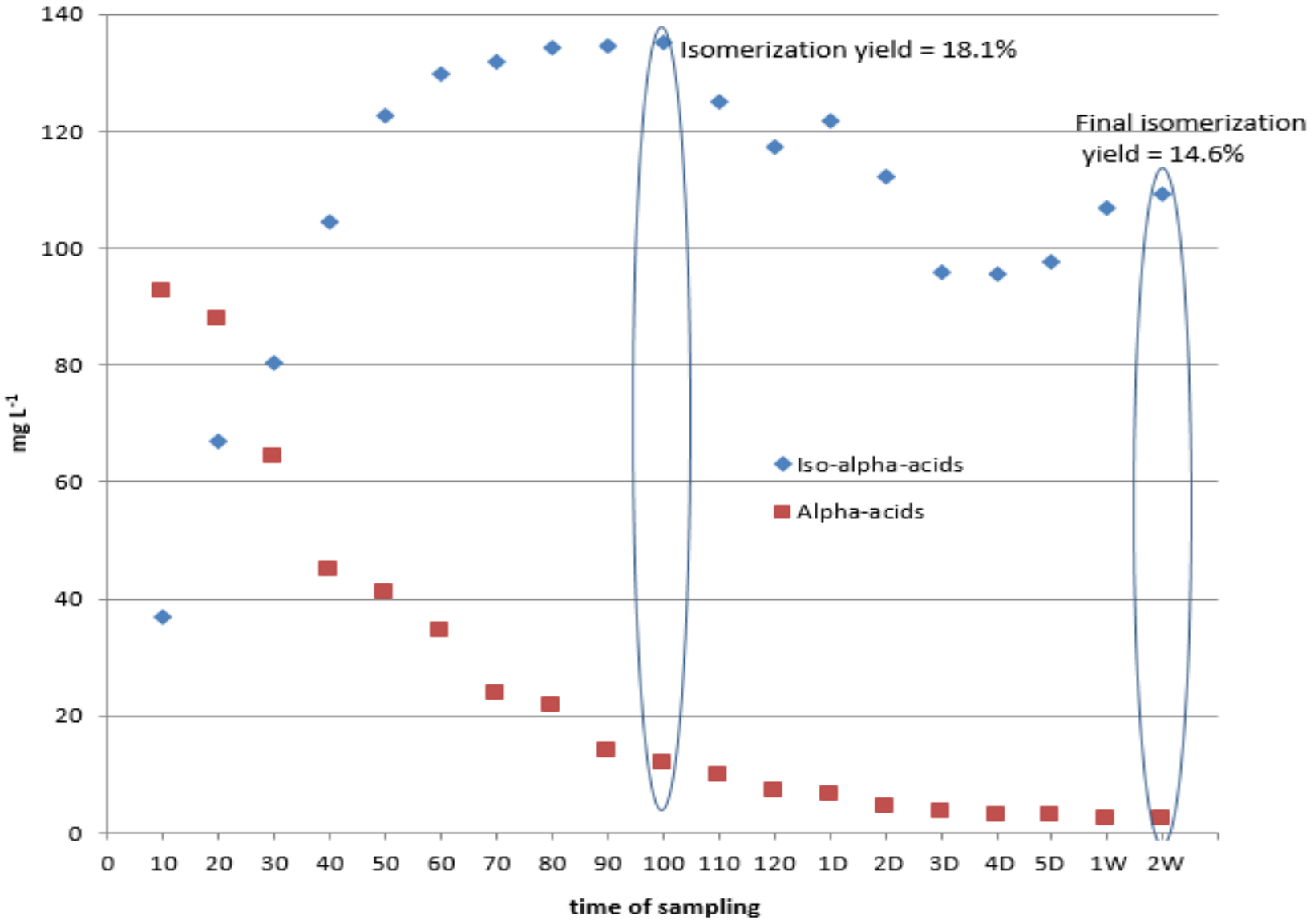
- Green hopping – a special case

Isomerization and transition of alpha-acids – dynamics during fermentation



Final isomerization yield < 1%

Isomerization of alpha-acids - hot



Isomerization and transition of alpha-acids – dynamics during maturation

Time of sampling	Alpha-acids (mg L^{-1})	Iso-alpha-acids (mg L^{-1})
After 1 week of maturation	7.2	5.8
After 2 weeks of maturation	8.6	6.0

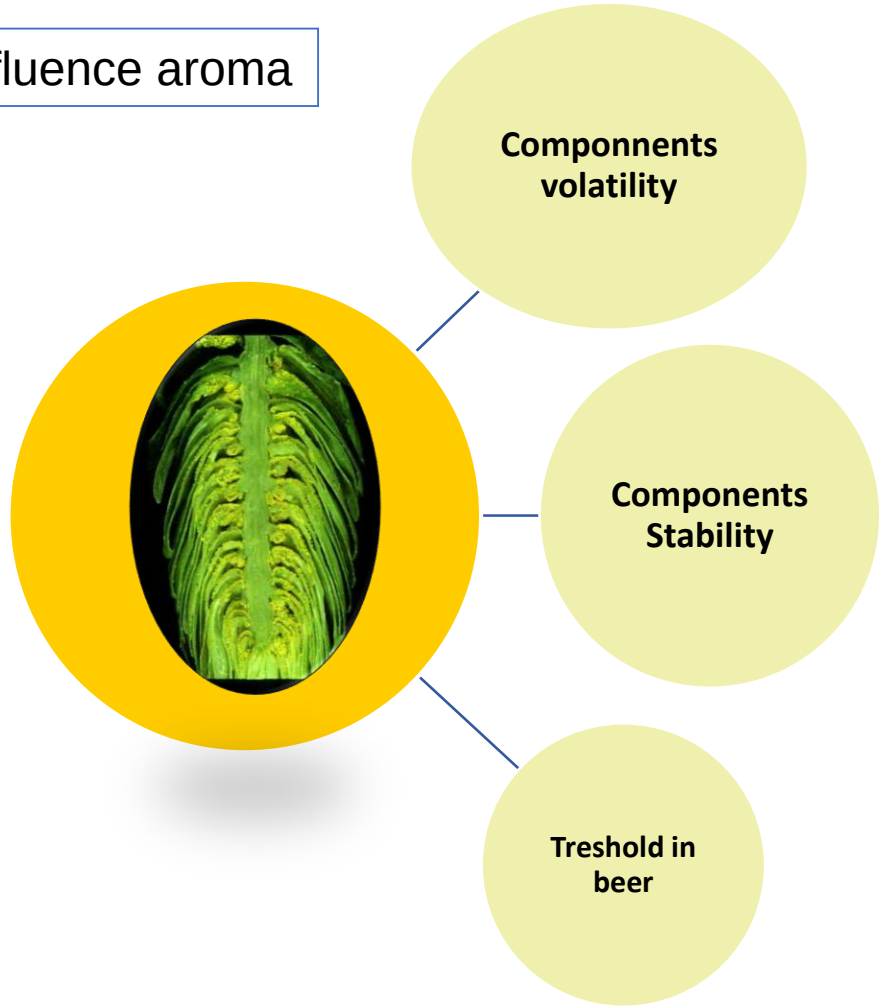
OCVIRK, M., KOŠIR, I.J.,*Acta Chimica Slovenica*, 2020

Hop essential oils

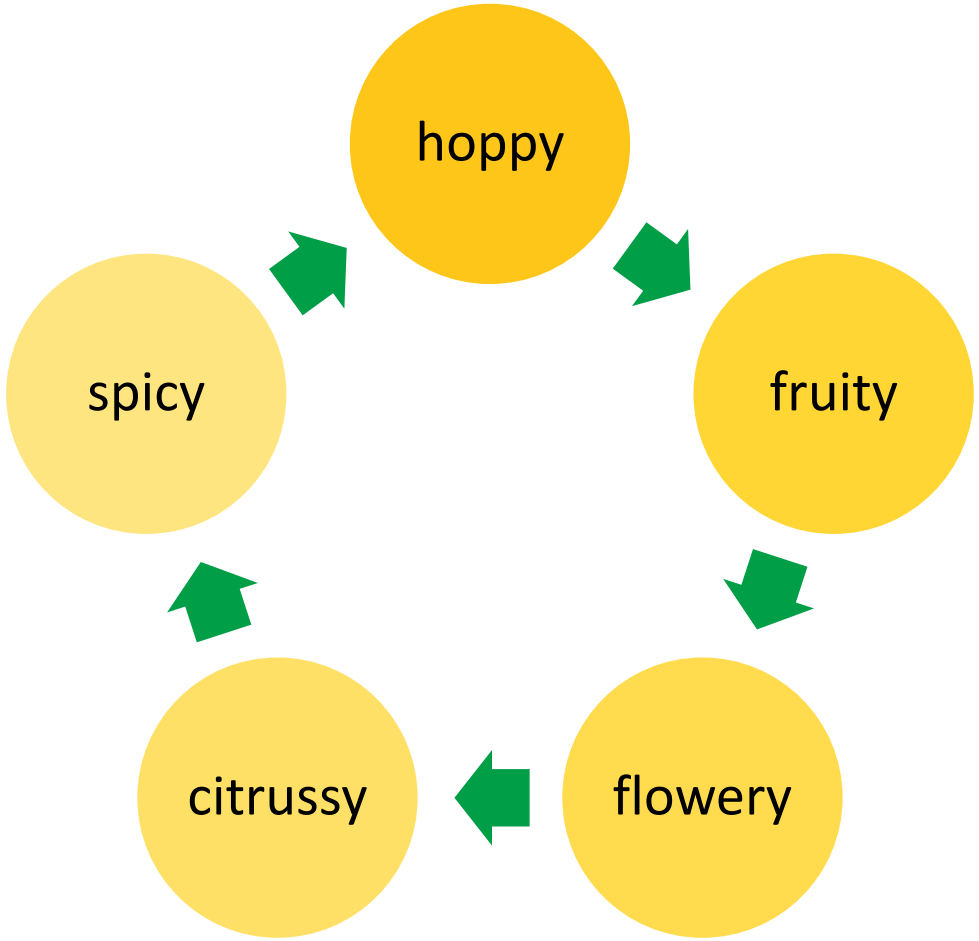
Contain about 1000 compounds

- Some compounds give
  - **Typical hoppy aroma** (humulene, cariofilene, farnesene, linalool,…)
  - **Atypical hoppy aroma** (citronelalol, limonene, geraniol…)

Factors that influence aroma



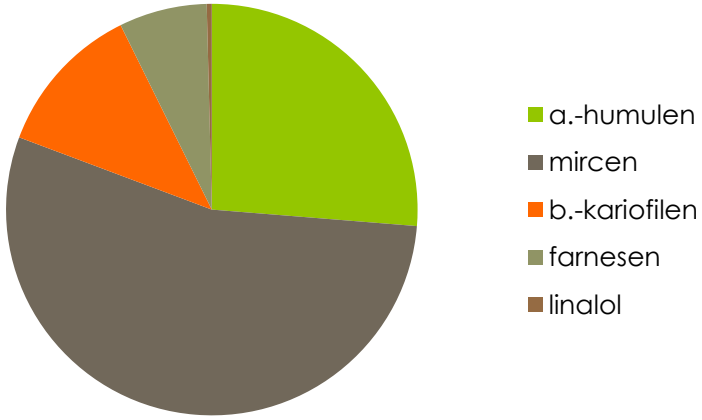
Classification of hop aromas



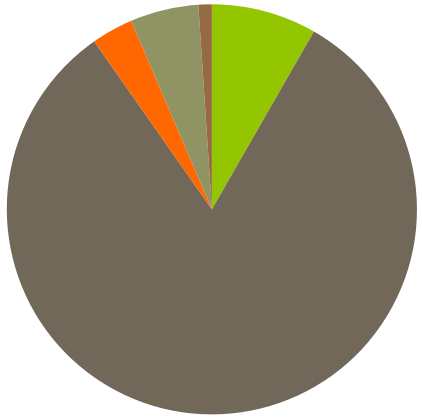
Components of essential oils

- In different varieties are present in different proportions

Styrian gold



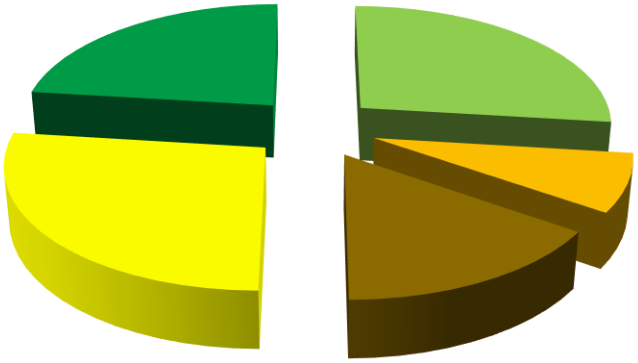
Styrian Wolf



Aroma expression upon different hopping used

+ dry hopping

Styrian Wolf



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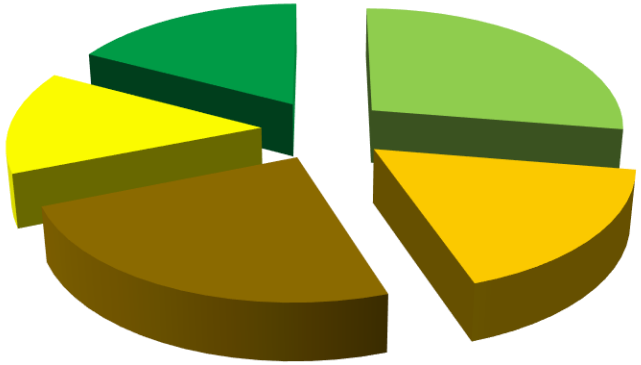
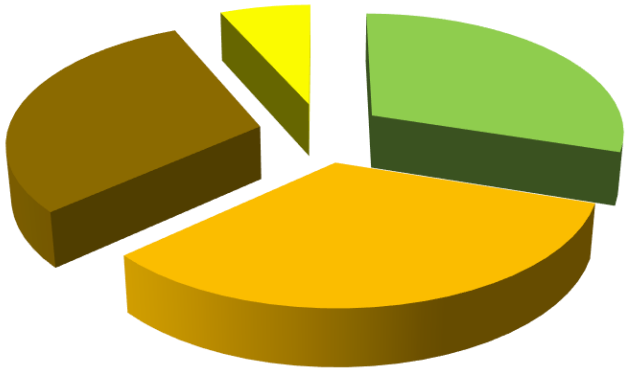


- fruity
- flowery
- spicy
- citrussy
- hoppy

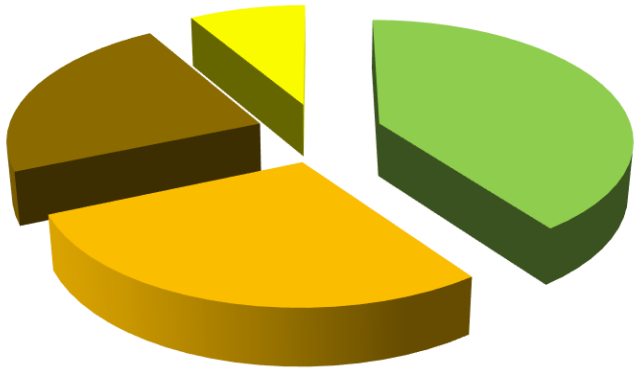
Aroma expression upon different hopping used

+ dry hopping

Styrian kolibri



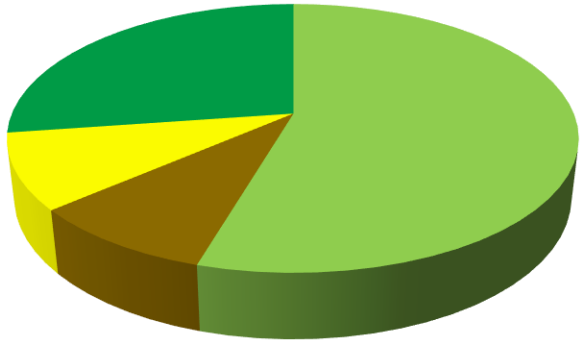
Styrian kolibri



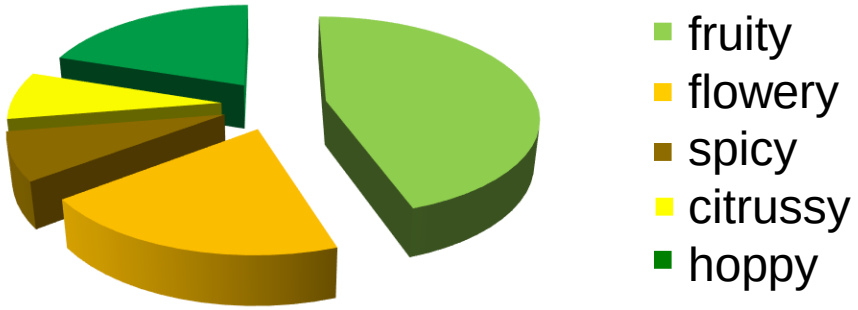
Aroma expression upon different hopping used

+ dry hopping

Styrian fox



Styrian fox

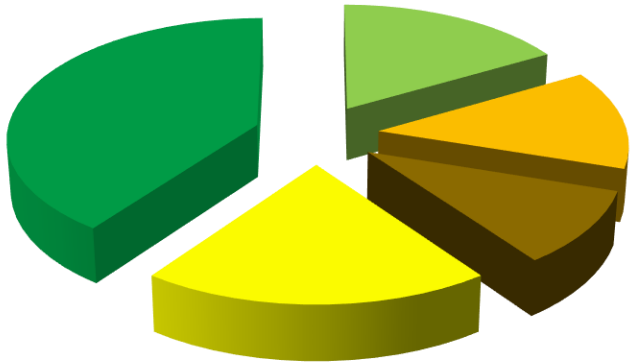


Aroma expression upon different hopping used

+ dry hopping

Styrian Dragon

Styrian Dragon



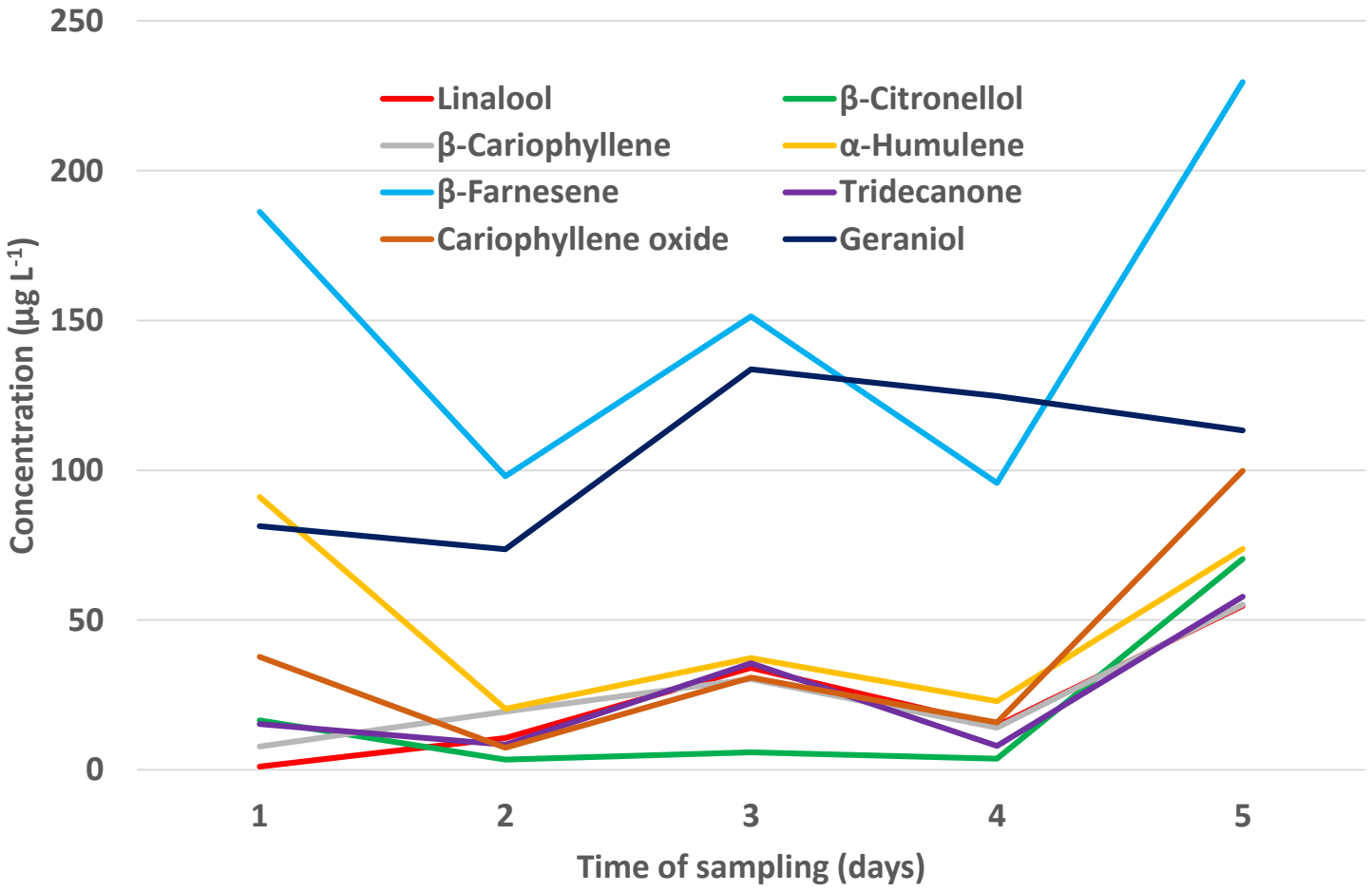
- fruity
- flowery
- spicy
- citrussy
- hoppy

DYNAMICS of hop essential oil

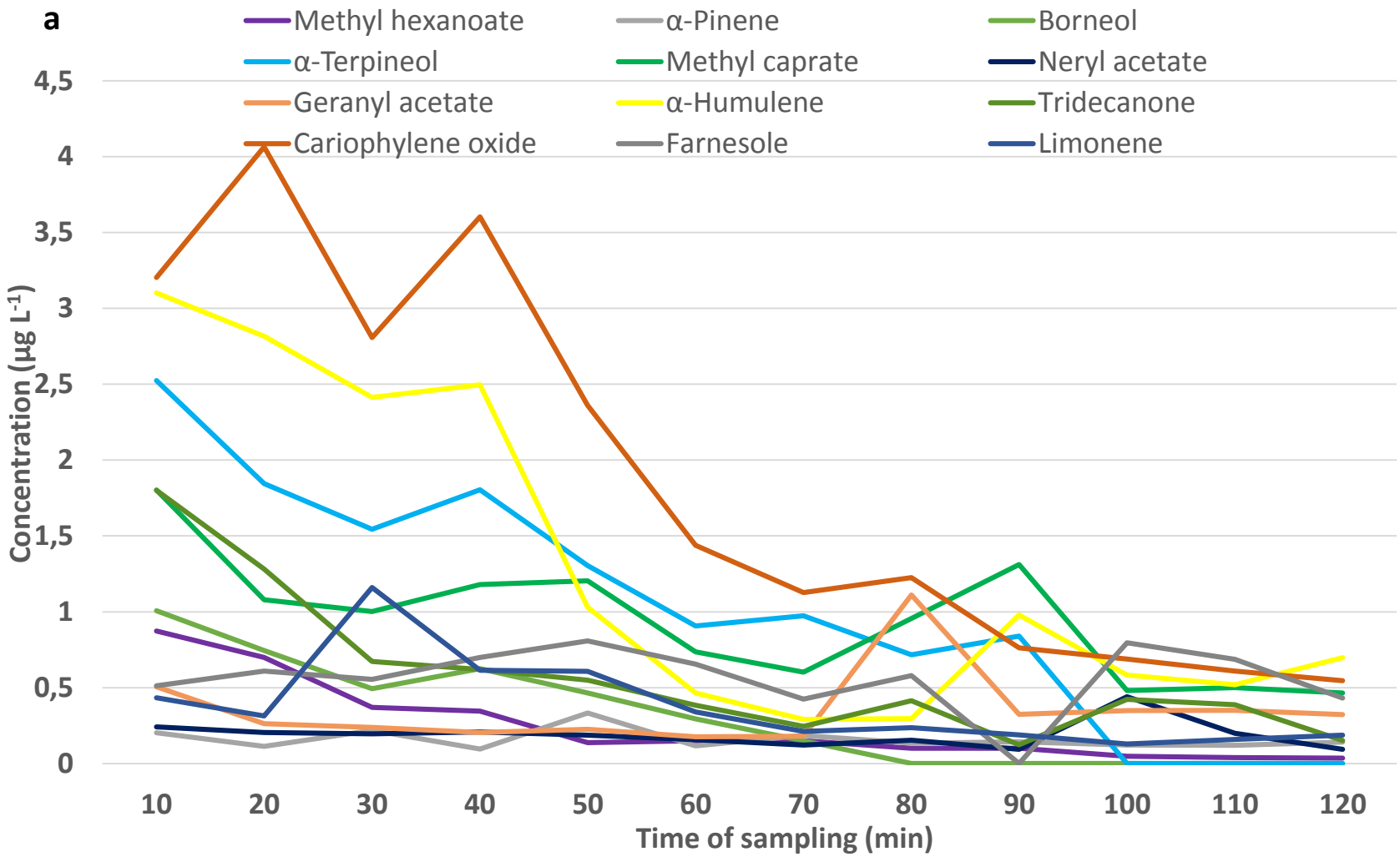
Depends on:

- solubility in water/alcohol medium, (more polar compounds like linalool, geraniol… easily pass, while nonpolar just in traces like farnesen…)
- temperature,
- chemical reactions during which synthesis or degradation is present (nerol, geraniol react in linalool, geraniol react in β-citronellol…),
- washing out because of CO_2,
- adsorption on the yeast cell walls.

Transition of hop essential oil components during fermentation



Essential oil components - kettle



Processes and consequences

- Alpha-acid / essential oil ratio
- Alpha-acid / polyphenols ratio
- Polyphenols / essential oil ratio
    - Too much hops or too lon contact time can cause unwanted astringency
- Addition during fermentation or maturation does not produce the same result

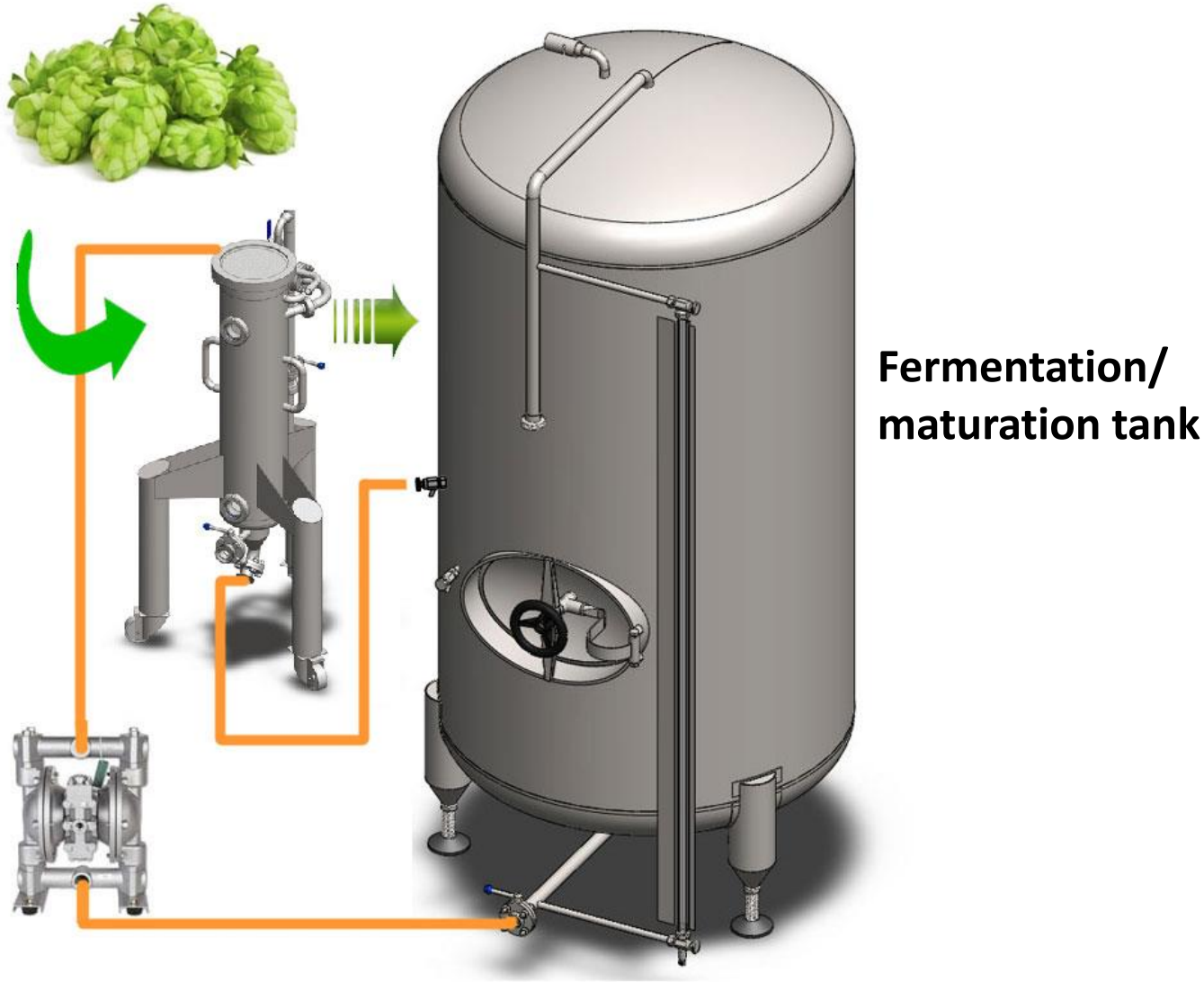
Negative consequences and disadvantages of dry hopping

- transition of polyphenols that reflect into the change of taste and colloidal haze (NEIPA), however influence long term storage stability
- solubilisation of alpha-acids that reflect in „harsch“ bitterness and aftertaste, however contribute to compact foam,
- oxygen intake and oxidation,
- microbiological contamination,
- loss of beer (250g hops/hl app.2%, 2kg hops/hl app.14%,
- rise of costs
- HOP CREEP.

Improvements

- not in a static form (reducing time),
- using equipment that allows evacuation of oxygen,
- intensive shaking/mixing outside of the fermentation/maturation tank that shorten the contact time and increase the dynamics of the transition of bioactive compounds.

Improvements



Hops extractor
- **cooled,**
- **evacuated of oxygen**

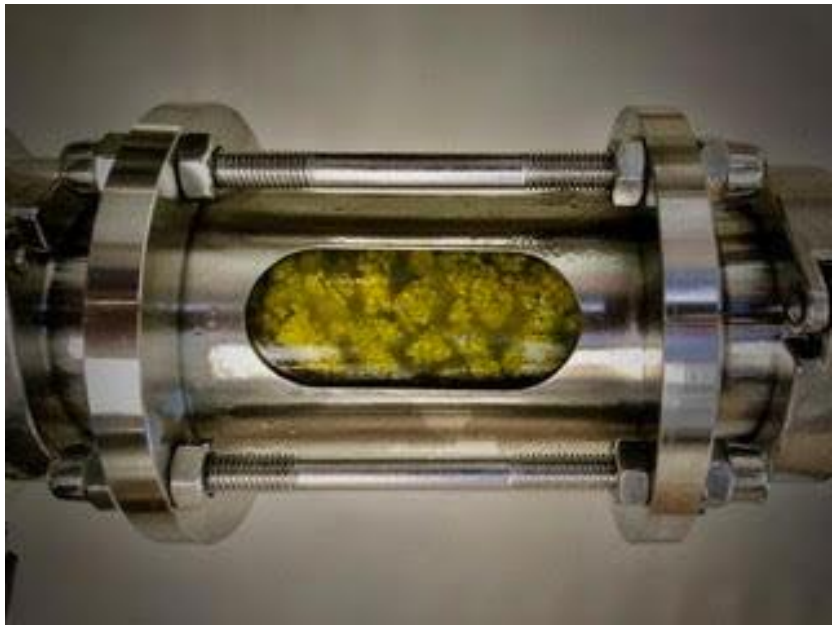
pump

Fermentation/ maturation tank

Improvements

Hop gun, hop cannon, hop rocket…

Improvements



Possible application when streaming the wort from boiling to whirhpool

Improvements

Appliation of bags to reduce „hop waste“ in the beer.

Improvements

Centrifuge after dry hopping to reduce beer lost.

Use of novel hop products

Izomerized hop products (pellets of extracts)	• better efficiency
Pellets type 45	• better ratio (alpha/oils/green matter)
Crio hops pellets	• better ratio and pronounced aroma
Extracts enriched with hop essential oils	• enriched aroma
Hop oils with a particular aroma pronounced	• pronounced aroma
Pure alpha-acids	• foam stability

CONCLUSIONS

- Late or dry hopping is a great challenge to improve beer aroma in both taste and odour part.
- Attention need to be paid on possible negative consequences.
- Careefull choice of appropriate hop varieties is required.
- In late hopping, hop products like pellets type 45 (crio hops) is possible to intensify aroma and reduce alpha-acids and polyphenols.
- Relatively simple to conduct.

Thank you for your attention