



Thoughts on hop aroma in beer

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Bangkok Brewing Conference 2019

Objectives of the talk

*“....Brewing Conference 2019 will focus on **trends, new products** and the **challenges for production, filling and packaging....**”* (conference theme)

My talk will focus on...

- breeding of **aroma influencing hop varieties**
- **application** of different **products** or relevant hop components
- **sensory impact** and additional **benefits** in hop aromatic beers

The hop aroma story begins here



Glandular trichomes
„Lupulin glands“
production and storage of
secondary metabolites



Hopsteiner FlavorWheel



Protected Design

Hop varieties

Classifications (acc. to IHGC Variety List 2018)

- Official classifications
 - Aroma / Bitter
 - Defined by the **breeder**
- In addition (but not official)...
 - „Noble Aroma Hops“
 - „(Very) Fine Aroma Variety“
 - “Flavor Hops” or “Special Hops” “Dual”



<http://www.herbaversum.de/images/hopfen1.jpg>

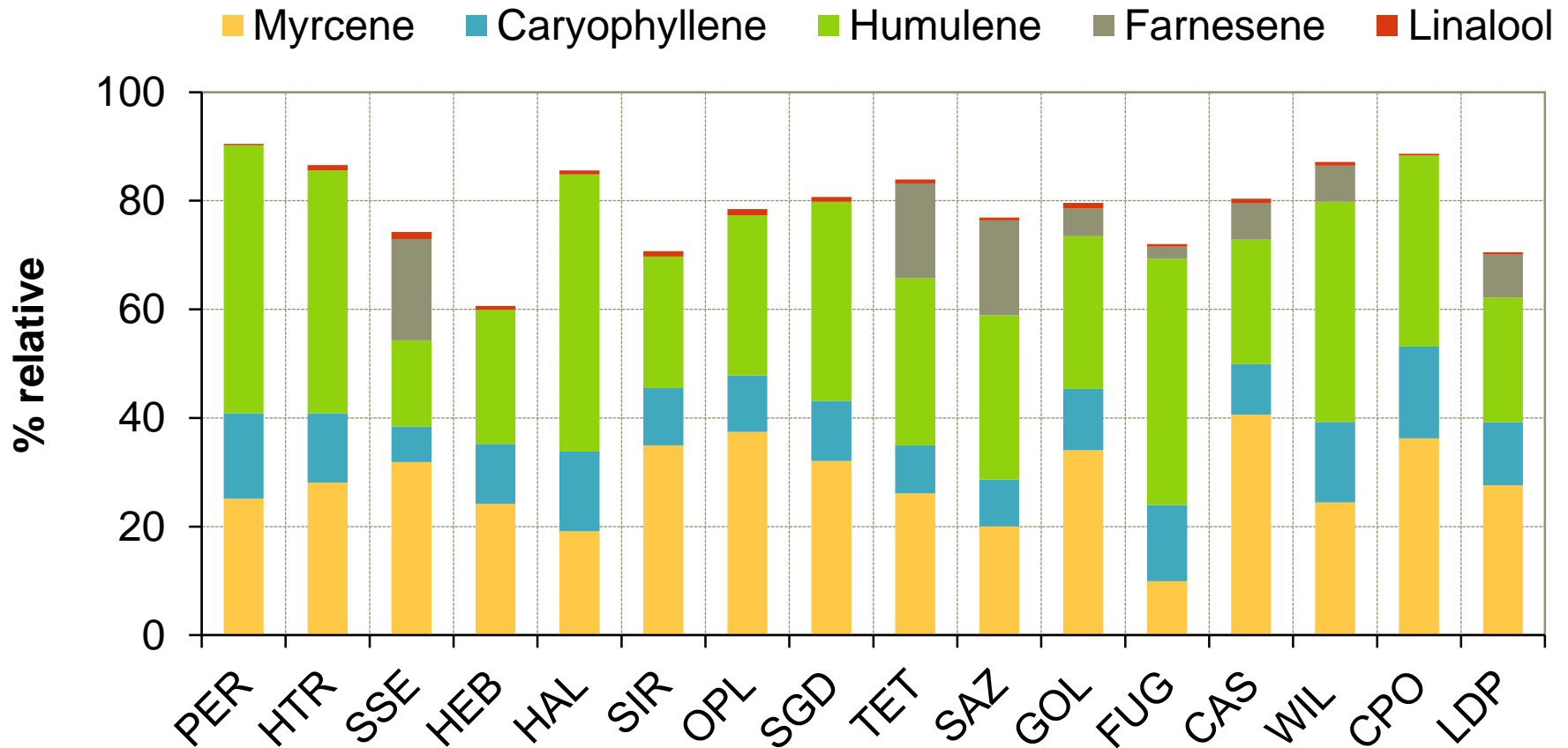
Groups of aroma compounds	Compounds in hops (examples)
Monoterpenes	Myrcene, Limonene, α/β - Pinene
Sesquiterpenes	β -Caryophyllene, Humulene, Farnesene
Monoterpenoxides	Linalool, Geraniol, β -Citronellol, α -Terpineol
Odour active thioles (mercaptanes)	3M4MP (Nelson Sauvign) – white wine like 4MMP (Cascade) – black currant
Aliphatic aldehydes and ketones	Hexenal, Epoxydecenal, Octadienone
Carboxylic acid esters	Methyl-, Propyl- or (Iso-) Butyl esters, e.g. 2-Methylbutyl-isobutyrate
Sesquiterpenoxides	Humulenol, Humulol, Eudesmol
Free carboxylic acids	Butanoic acids, Pentanoic acids, e.g. Isovalerian acid

Odor thresholds of selected compounds

Compound	Odor threshold in ppb
linalool	2-80
α -terpineol	330
β -citronellol	9-40
geraniol	4-300
myrcene	9-1000
limonene	1.500
farnesene	550
β -caryophyllene	160-420
humulene	750
2-methylbutyl isobutanoate	80
3-methylbutyl isobutanoate	100
ethyl isobutyrate (ethyl-2-methylpropanoate)	6-160
4-MMP	0.0005-0.0015
Isobutyl isobutyrate	35

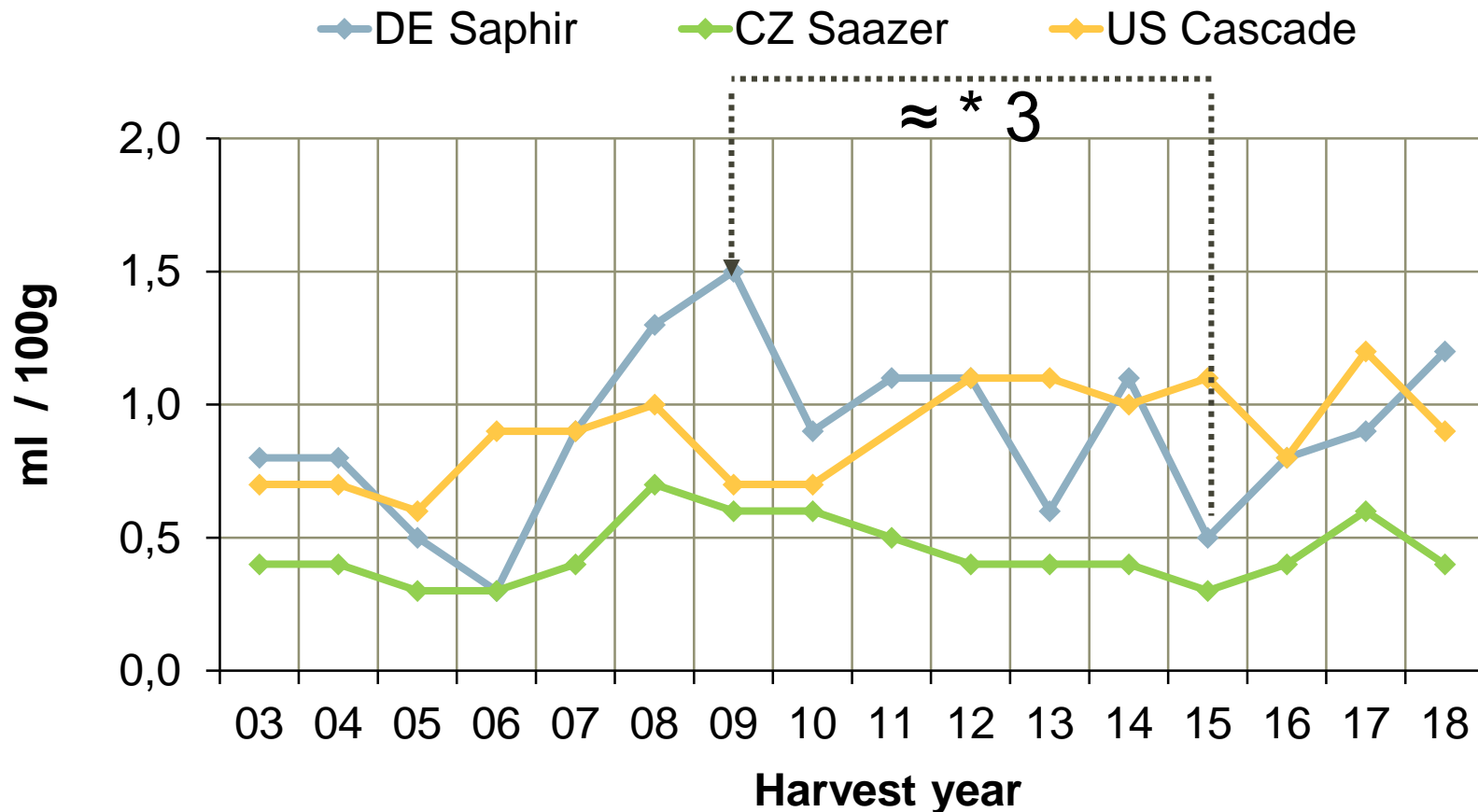
Hop oil – components EBC 7.12

Mean value of selected aroma varieties



Hop oil content in hops (Analytica-EBC 7.10)

Yearly fluctuation



Hopsteiner breeding locations



USA
-
Greenhouses, Nursery,
Labs, Growing



Germany
-
Greenhouse, Nursery,
Lab



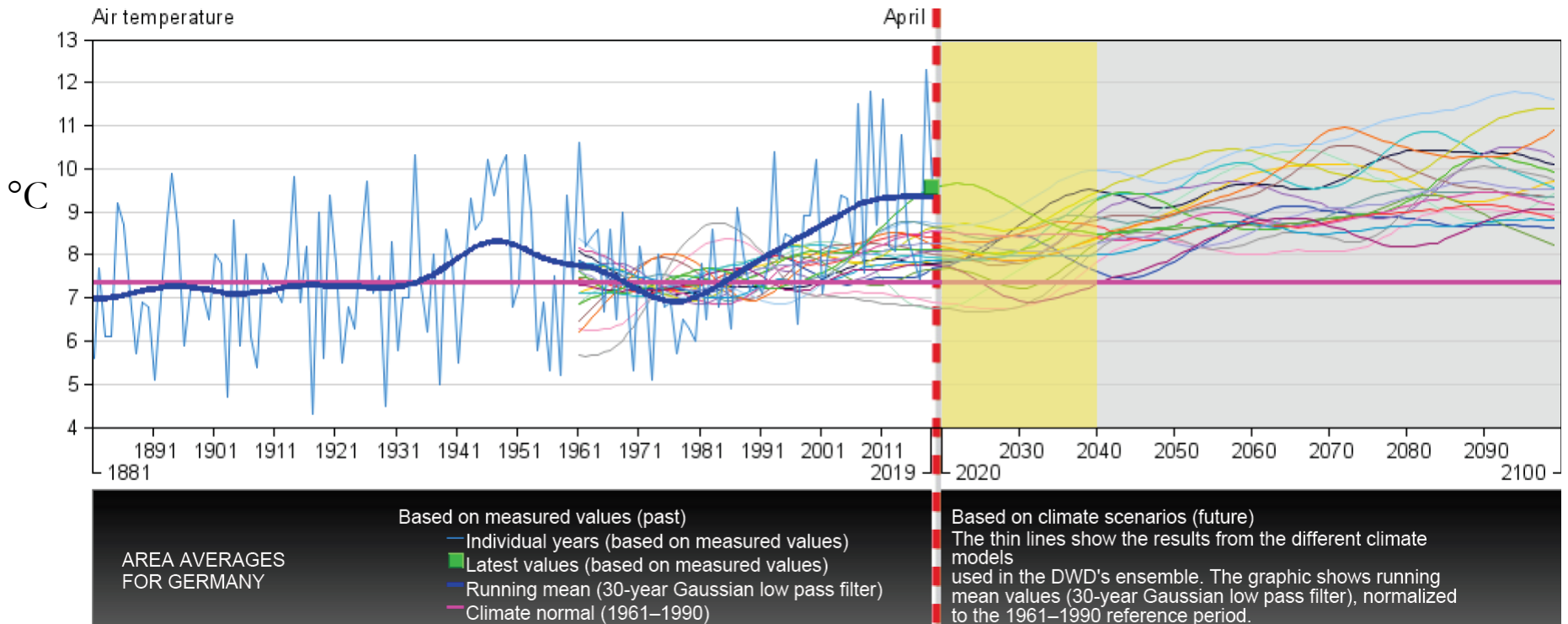
Goals of the Breeding Program



Average temperature Germany

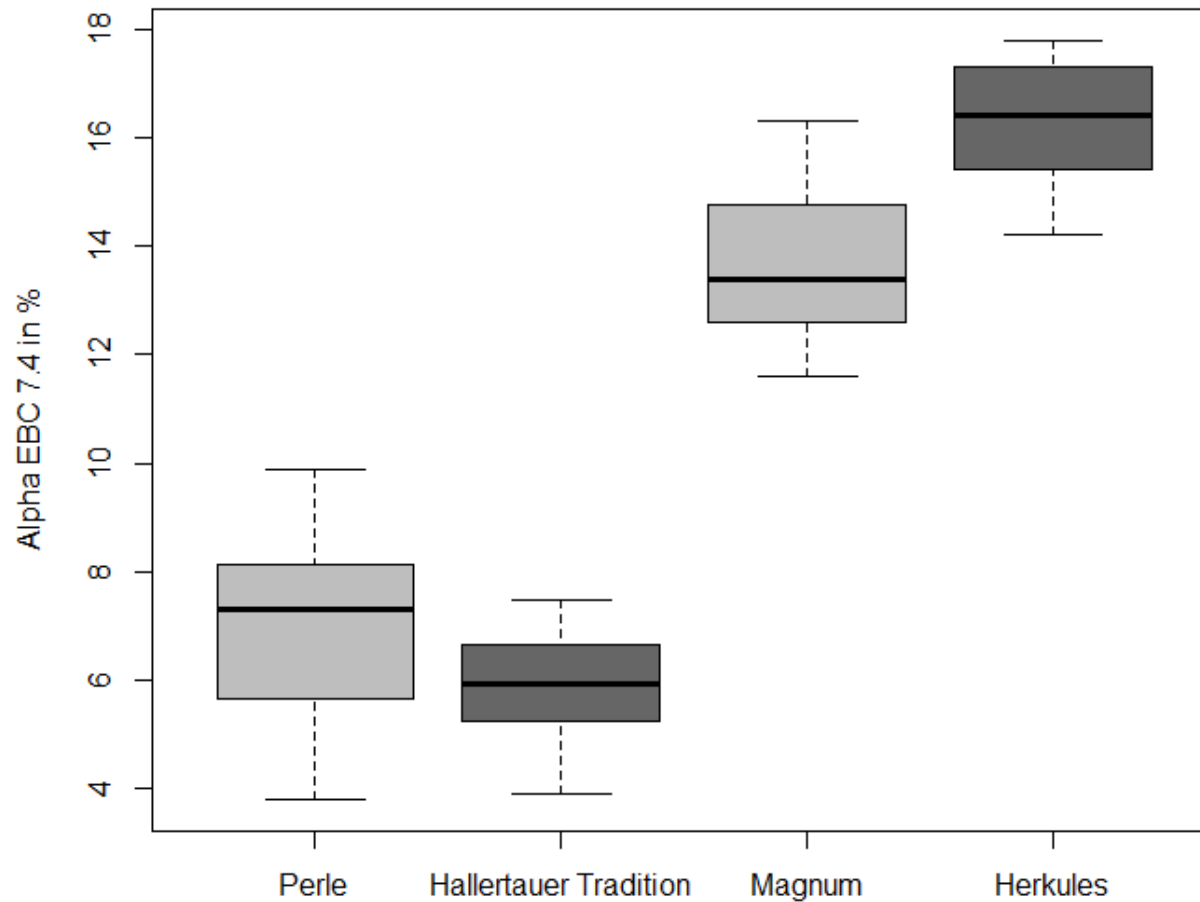
1881-2019

2020-2100



Reference: Deutscher Klimaatlas, DWD, 2019

Fluctuating alpha contents in key varieties



Reference: Hopsteiner analysis

Requirements for new varieties

	Replacements		Unique Flavor	
	Aroma	High Alpha	"Citrusy"	"Fruity"
Yield	> 2,500 kg/ha	> 500 kg alpha/ha	> 2,500 kg/ha	
Resistance/Tolerance	resistance to abiotic and biotic stress			
Bitterness	pleasant bitterness quality			
Aroma	traditional and comparable	-	unique	

Semi commercial experimental

ALPHA ACID
9.0 - 10.0 %
TOTAL OILS
1.5 - 2.0 ml/100 g
AROMA
tea, hoppy, green fruits, pepper
GENETIC ORIGIN
Zenith x Hopsteiner Experimental (crossed 2012)
CATEGORY
Aroma

Experimental #99/268



99/268 – harvest 2018

	Location 1	Location 2	Location 3
Alpha 99/268	10,8%	9,0%	7,0%
Alpha Perle (at the location)	5,9%	6,9%	3,3%
Irrigation	No	Yes	No

„mild aroma...“

„close to Perle“

„..., but more intensive than existing aroma varieties“

„close to Hallertauer Tradition“

- comments during hop selection 2018 -

Tasting at BrauBeviale 2018

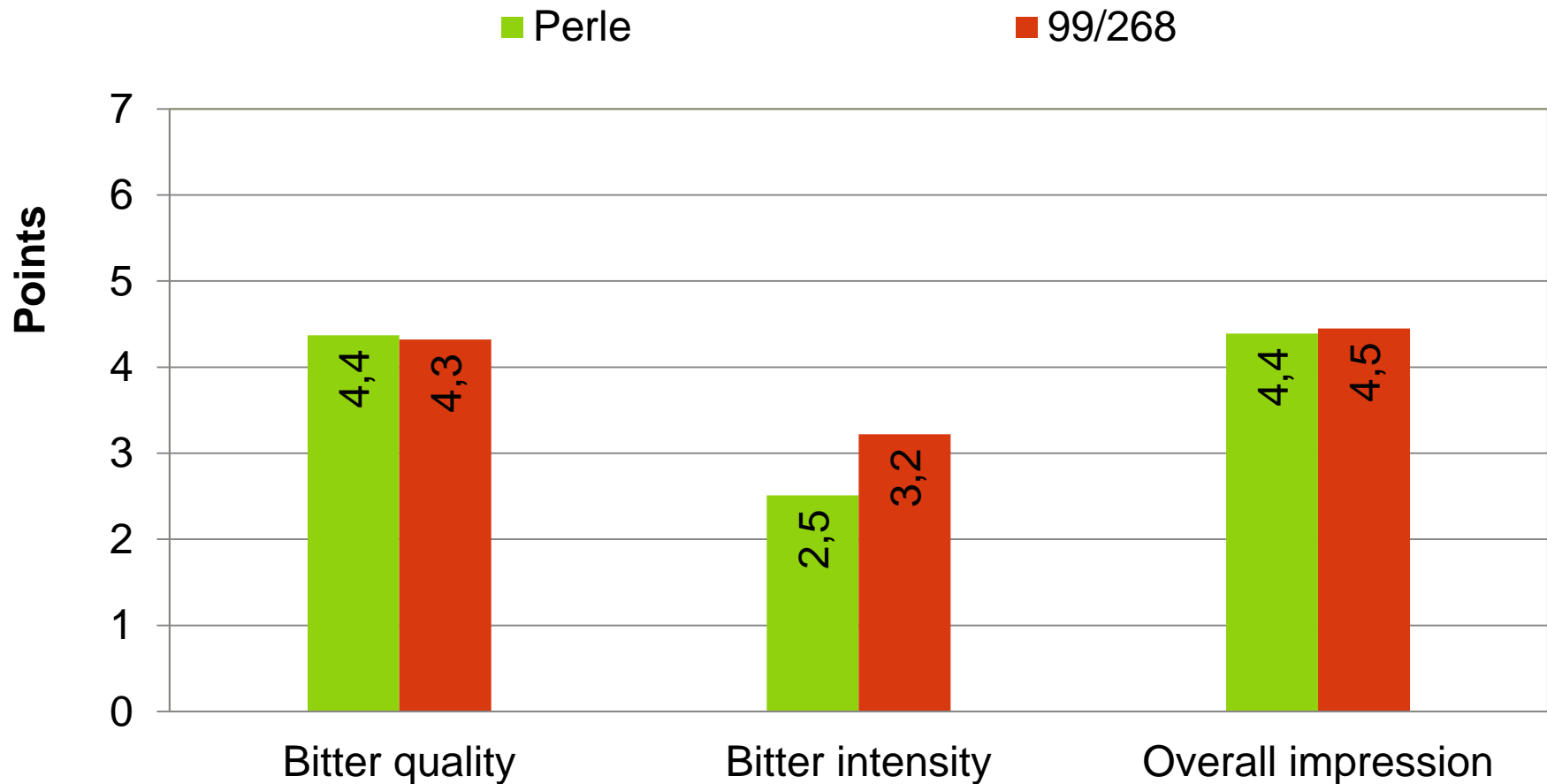


Comparison

- Beer type: Bavarian lager
- Single hopping with either
 - Perle or
 - 99/268

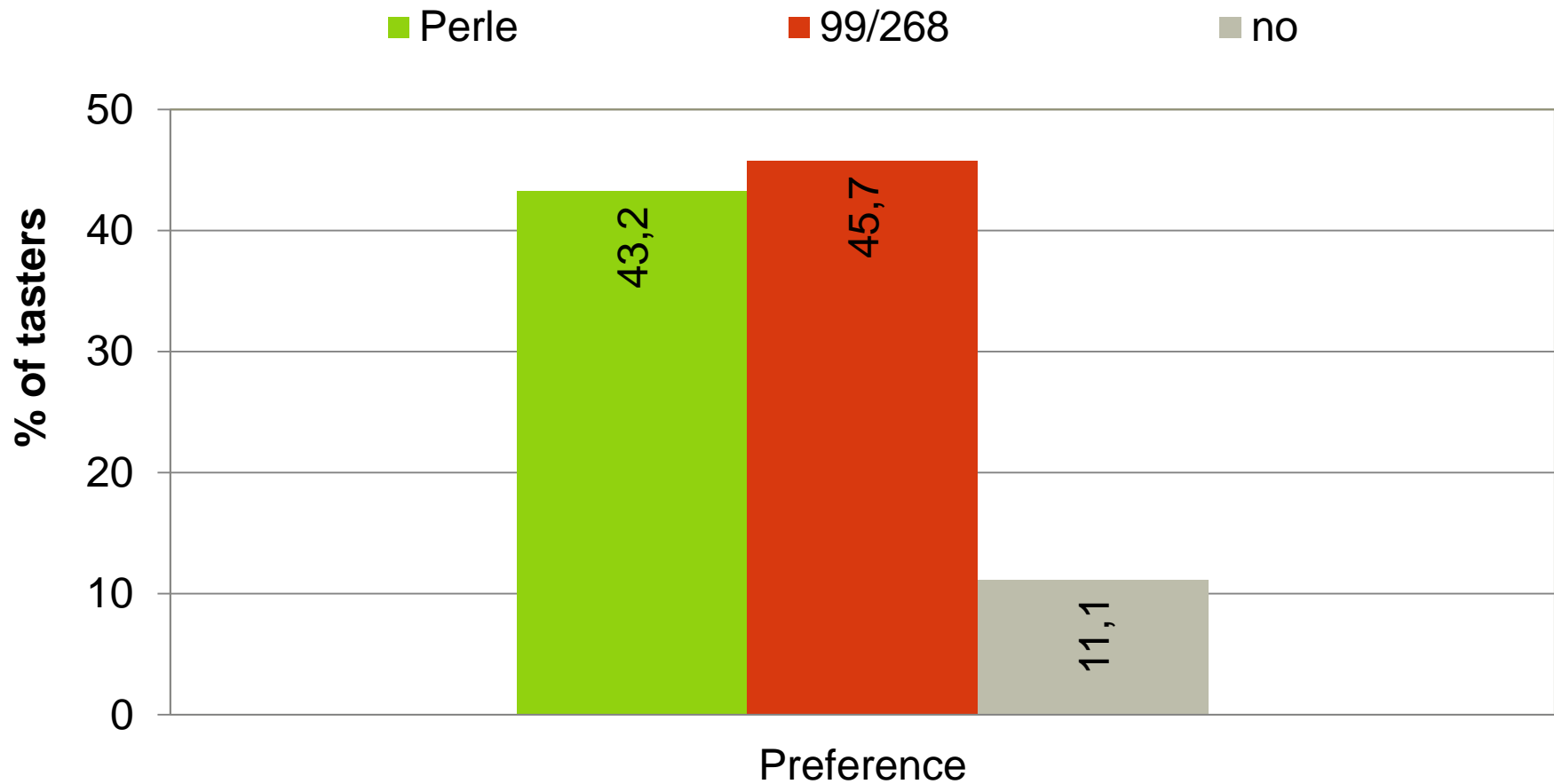
Bitterness and overall impression

Mean values (max. 7), n=315



Preference

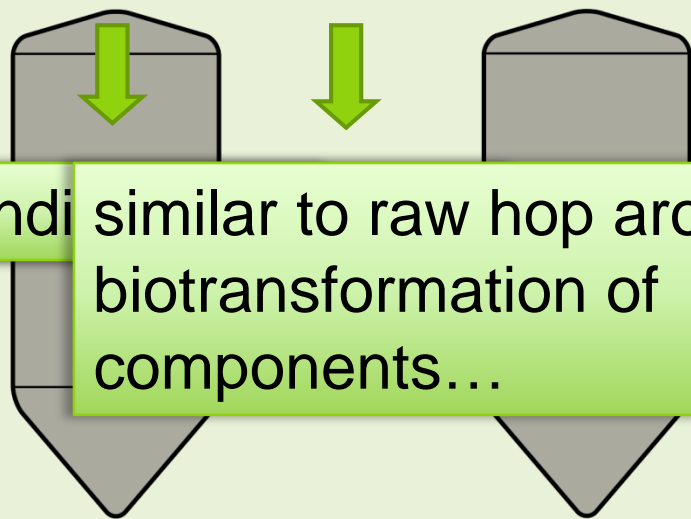
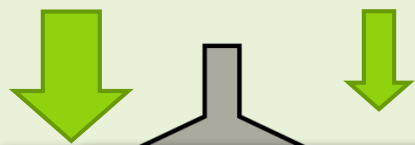
% of tasters, n=315



Kettle Hopping

Late Hopping

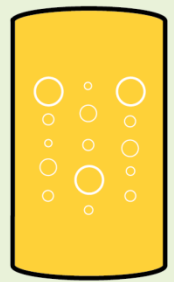
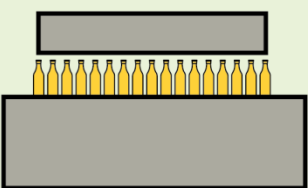
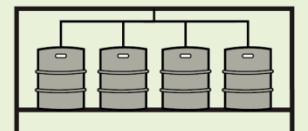
Dry Hopping



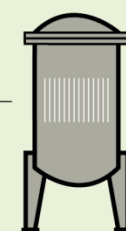
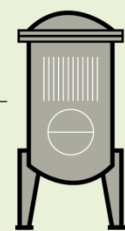
ooler

be Linalool as key indi similar to raw hop aroma, biotransformation of components...

-  BREWHOUSE
-  FERMENTATION TANK
-  MATURATION TANK
-  FILTRATION
-  STABILIZATION + FILTER
-  BRIGHT BEER TANK
-  BOTTLING LINE
-  KEG LINE

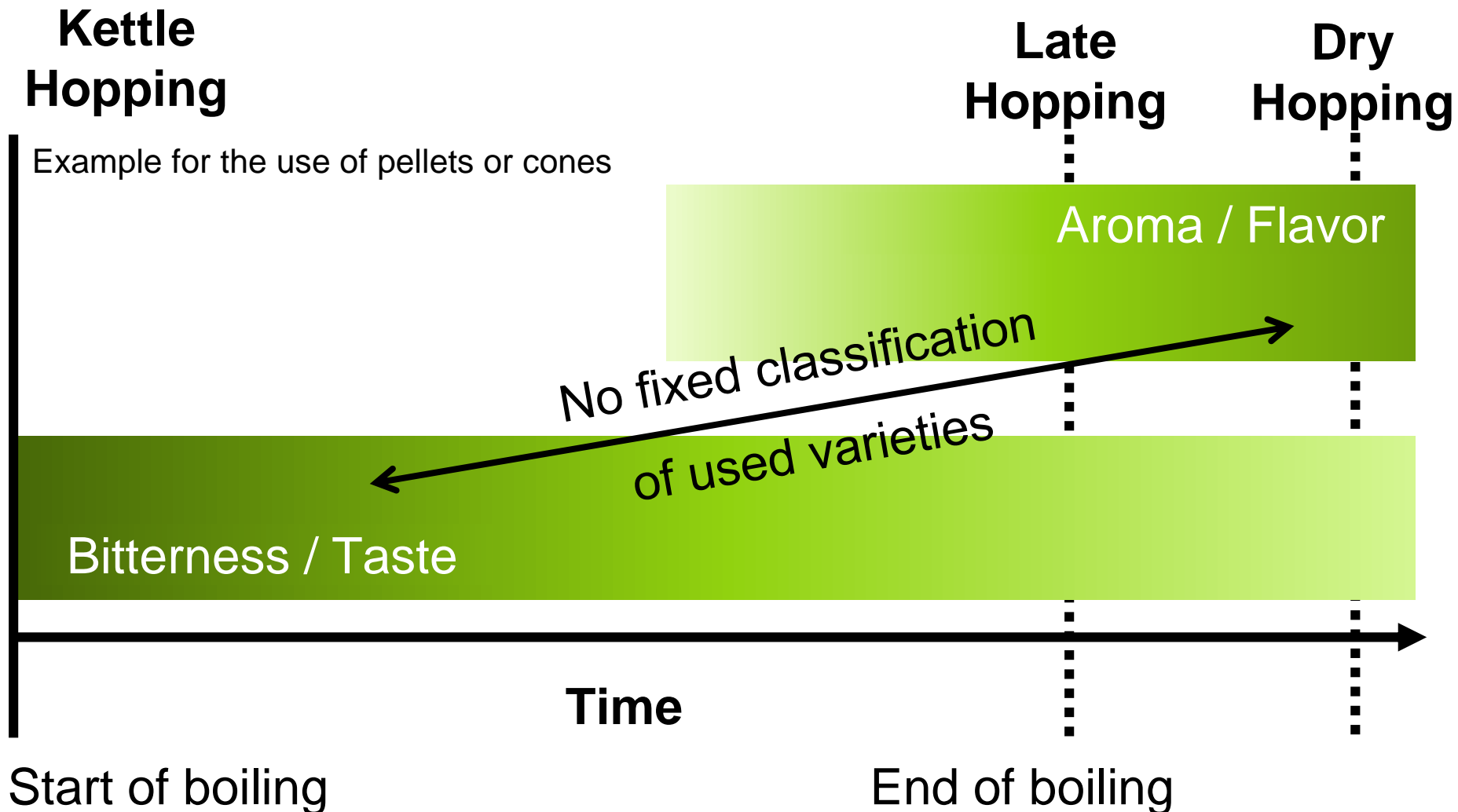


CO₂



CO₂

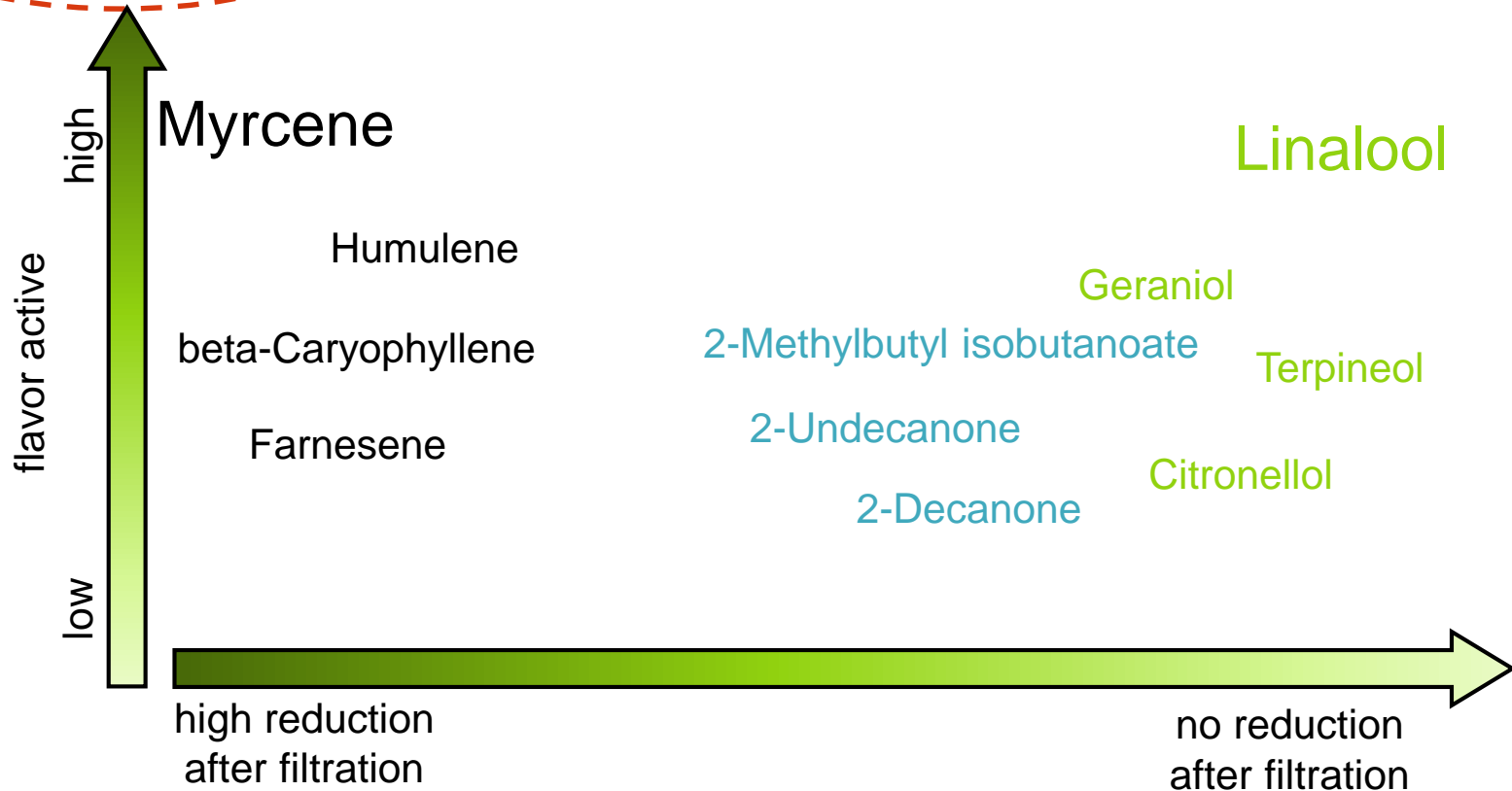
Main impact on flavor: time of dosage






























Hop aroma components & filtration

70 - 80% less
compared to non-
filtered!

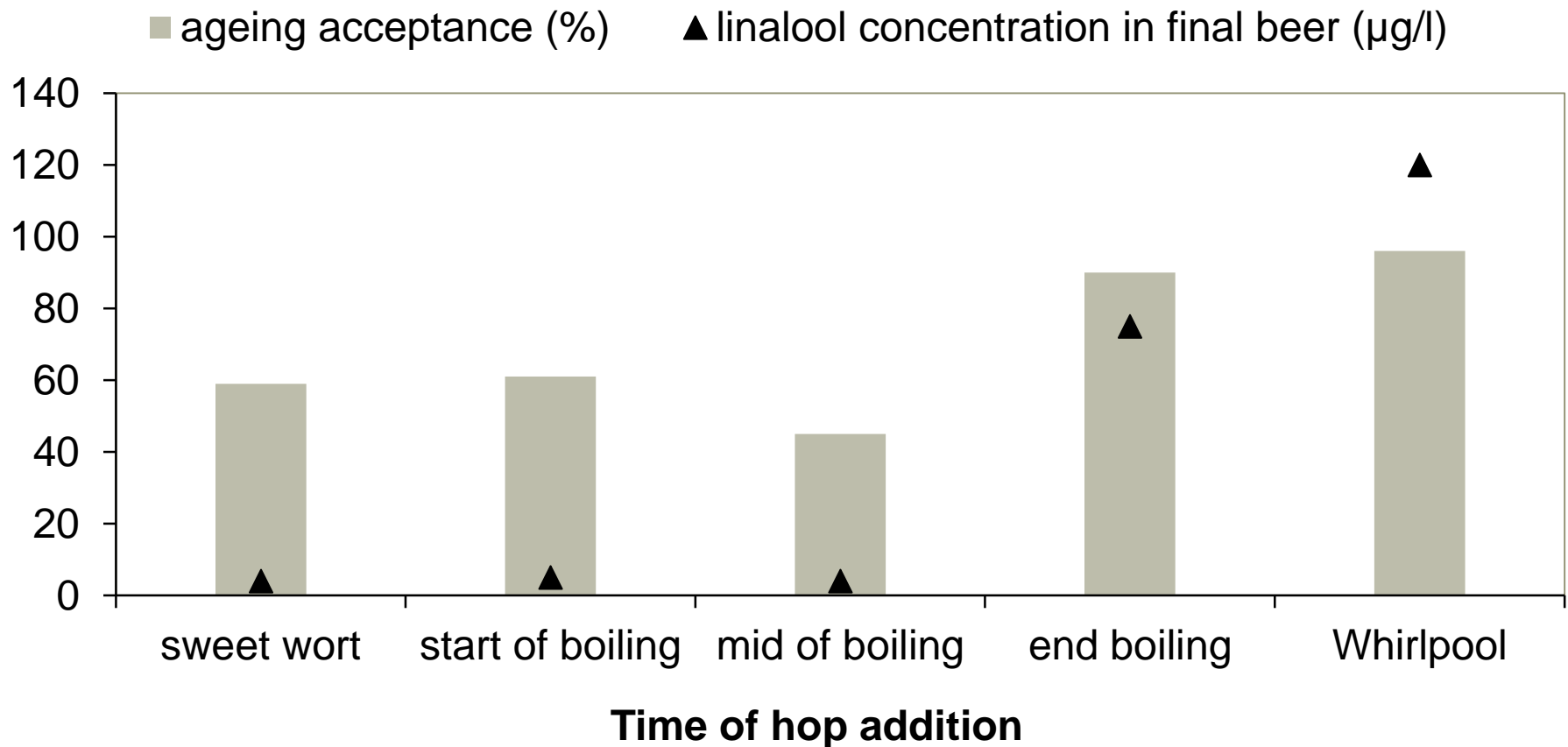
3 - 5 % less compared to
non-filtered!



Aroma relevant hop products

	Functionality			Addition	
	Bitterness	Aroma	Anti-microbial	Kettle/Late	Dry
Leaf hops					
Pellets					
Iso-Pellets					
Isomerized Kettle Extract (IKE / PIKE)					
AromaExtract					
Light Stable Kettle Extract					
Hop oils					

Linalool – a key contributor to hop aroma



Reference: Stefan Hanke, MBAA, 2009

Usage of hop oils – an alternative!?

- Addition of hop oils at any point after wort cooling
- Dry Hopping or Late Hopping flavor
- Our products
Type “Dry”, “Noble” and “Noble Plus”

- 👍 100% from hops
- 👍 Consistency, no annual variations
- 👍 No plant or foreign materials
- 👍 High flexibility in brewing



Hop oil dosage to heavily aged beer

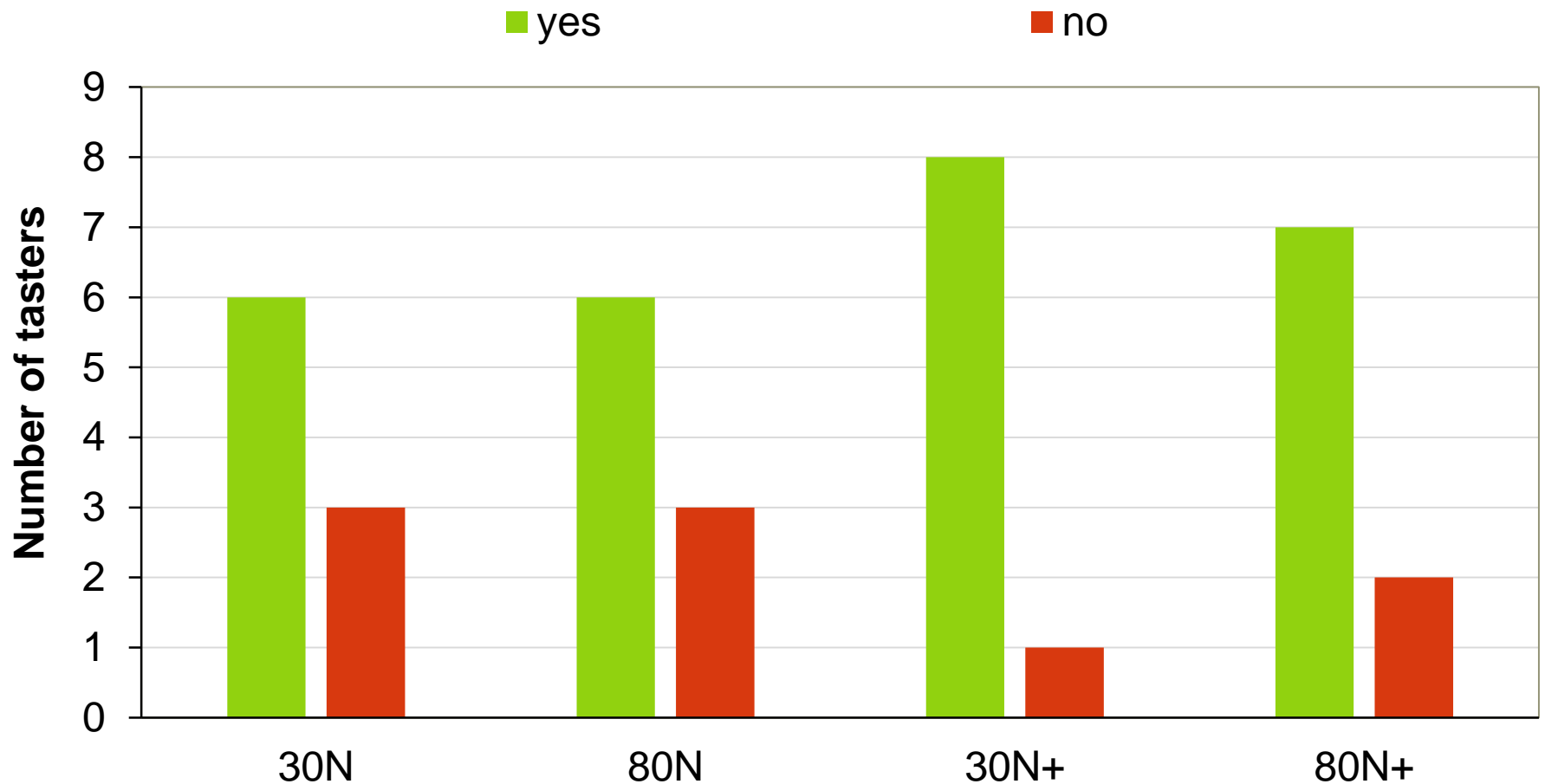
- Oxidized beer
- Addition of Type Noble (N) or Type Noble plus (N+)
 - 30 $\mu\text{g/l}$ Linalool
 - 80 $\mu\text{g/l}$ Linalool
- Tasting in comparison to a reference
(without hop oil addition)

Samples

- Reference
- 30N -> 30 $\mu\text{g/l}$ Linalool (from Noble)
- 80N -> 80 $\mu\text{g/l}$ Linalool (from Noble)
- 30N+ -> 30 $\mu\text{g/l}$ Linalool (from Noble plus)
- 80N+ -> 80 $\mu\text{g/l}$ Linalool (from Noble plus)

Improvement compared to reference sample

n=9 tasters



Summary

- Hops contain a heterogeneous and complex mix of aroma relevant components
- Breeding is an important tool for consistent and new aromas
- Various options of different products and techniques to influence the aroma in beer
- Benefits of hop aroma to improve beer quality



Thank you very much for your attention.