EVALUATION OF TERROIR EFFECTS ON THE BREWING VALUE OF HOPS

ANN VAN HOLLE, DE PROEFBROUWERIJ

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Introduction

Preliminary study of terroir significance

Hop terroir study

Genetic fingerprinting

Biochemical fingerprinting

Case studies

cv. Amarillo
cv. Cascade

Conclusions

PRELIMINARY STUDY OF TERROIR SIGNIFICANCE

HOP
BREWING VALUE

BIOCHEMICAL PROPERTIES

BEER
QUALITY

TASTE / AROMA

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PRELIMINARY STUDY OF TERROIR SIGNIFICANCE

Specific case: Amarillo single-hop beer

Amarillo hops cultivated in
Idaho ↔ Washington State

HOP
BREWING VALUE

divergent hop aroma profile

BEER
QUALITY

less citrussy aroma, more piney and grassy flavours

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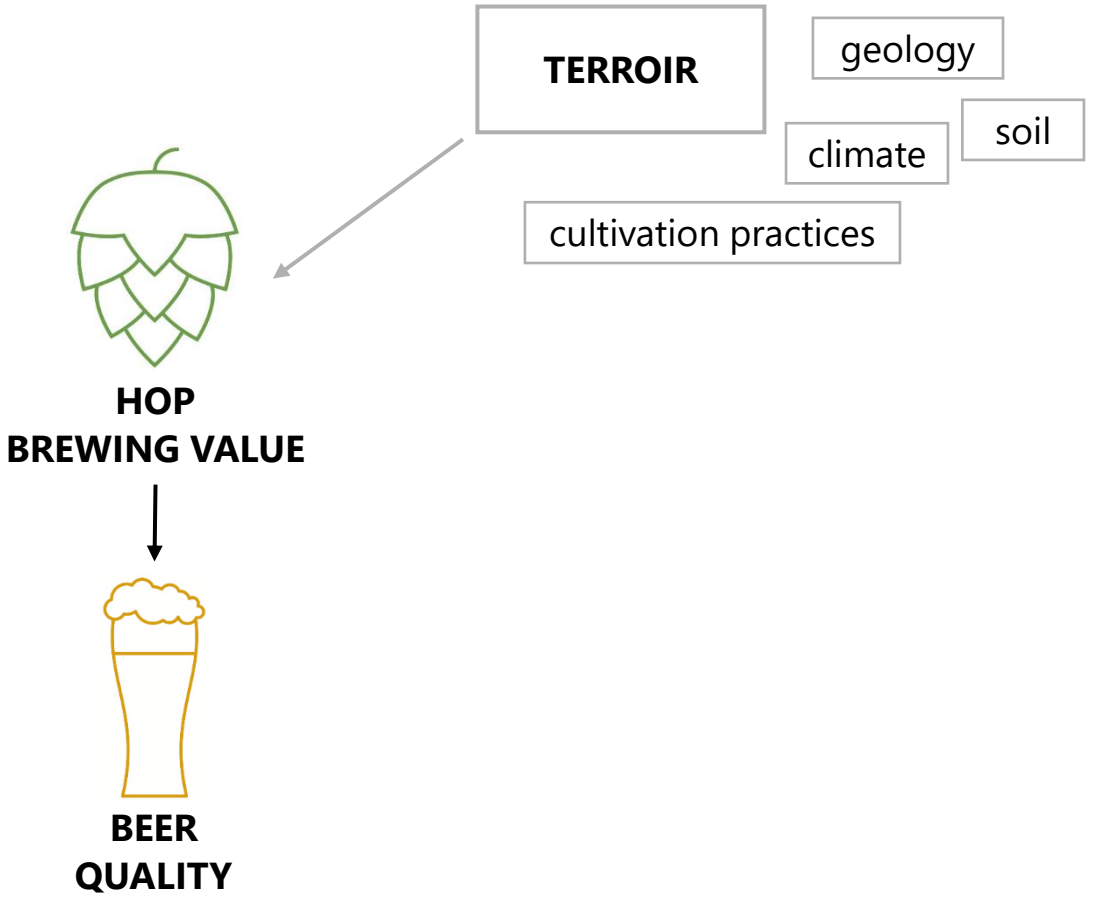
Van Holle A., Van Landschoot A., Roldán-Ruiz I., Naudts D., and De Keukeleire D.
The brewing value of Amarillo hops (*Humulus lupulus L.*) grown in northwestern USA: A preliminary study of terroir significance.
J. Inst. Brew., 2017, 123(3): 312-318.

PRELIMINARY STUDY OF TERROIR SIGNIFICANCE



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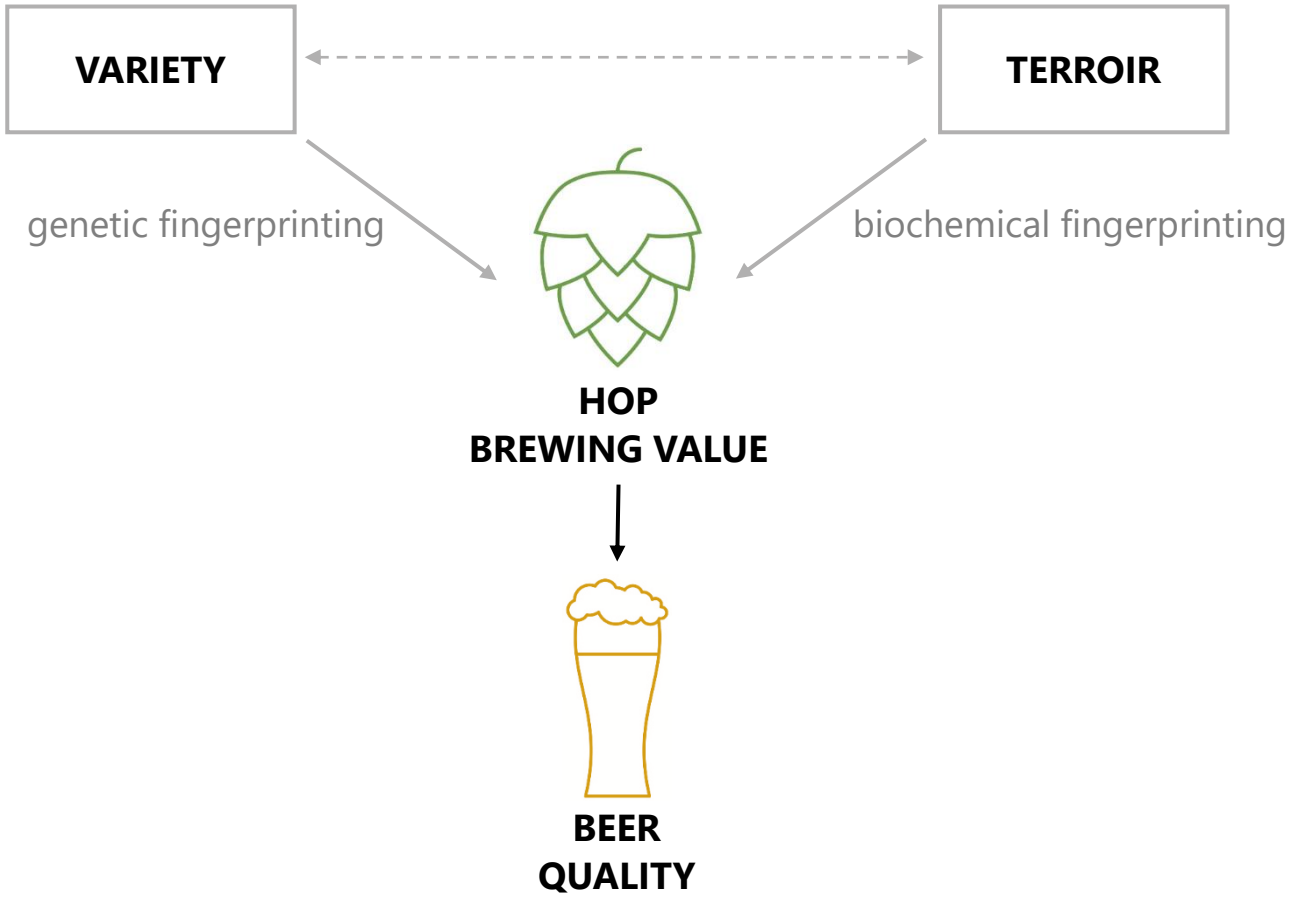

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cv. Amarillo
cv. Centennial

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HOP TERROIR STUDY | APPROACH

SAMPLING hop cones
20 varieties; crop 2015 – 2016 – 2017
Amarillo – Cascade – Centennial – Chinook – Citra – Fuggle – Golding – Hallertau Mittelfrüh – Magnum – Mosaic – Mt. Hood – Northern Brewer – Perle – Saaz – Simcoe – Sorachi Ace – Tettnanger – Tradition – Willamette – Zeus

Genetic and biochemical fingerprinting HOPS

Biochemical and sensory profiling single hop BEERS

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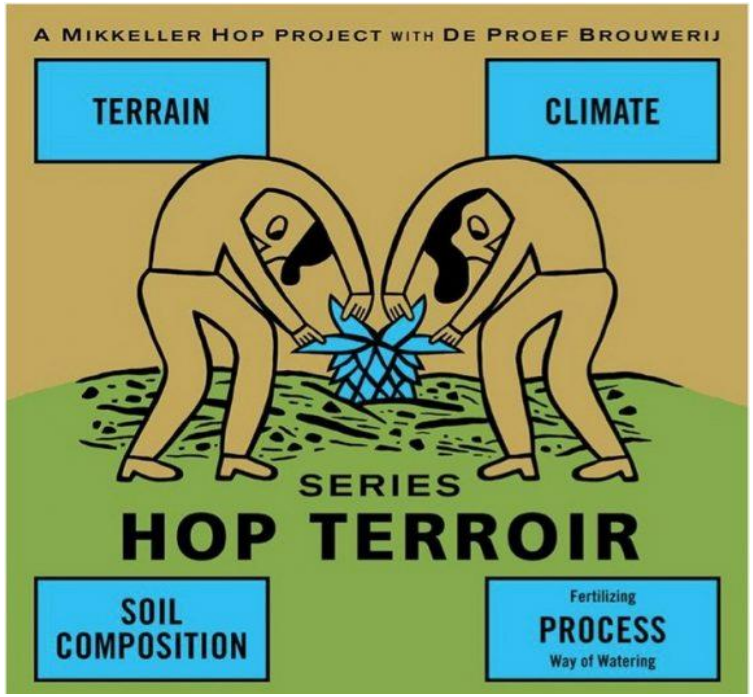
HOP TERROIR STUDY | APPROACH



http://blog.mikkeller.dk/mikkeller-launches-terroir-series

RECIPE

NEIPA style

Original gravity 16°P
Alcohol 7% ABV

Hop dosage (pellets T90)
- Late hopping: 250 g/hL
- Dry hopping: 1000 g/hL

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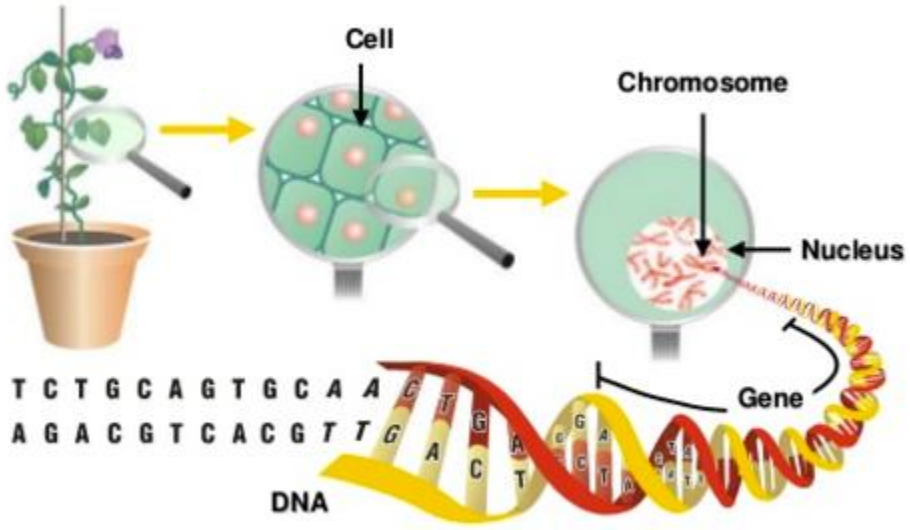
HOP TERROIR STUDY | METHODOLOGY

Genetic and biochemical fingerprinting HOPS

- Genetic fingerprinting

	HOP (*Humulus lupulus* L.)	HUMAN
Chromosomes	2n=20	2n=46
Genome size	2,57 Gb	3,23 Mb
Genes	± 50,000	± 23,000



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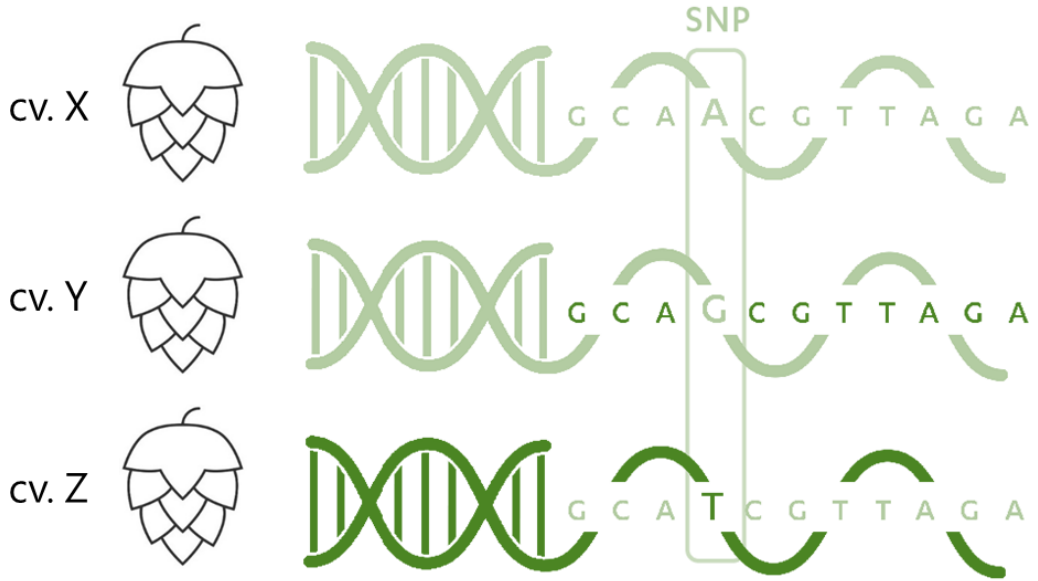
HOP TERROIR STUDY | METHODOLOGY

Genetic and biochemical fingerprinting HOPS

- Genetic fingerprinting
  - SNP markers
    (GBS genotyping-by-sequencing)
    → Authenticity control of hop batches toward varietal origin



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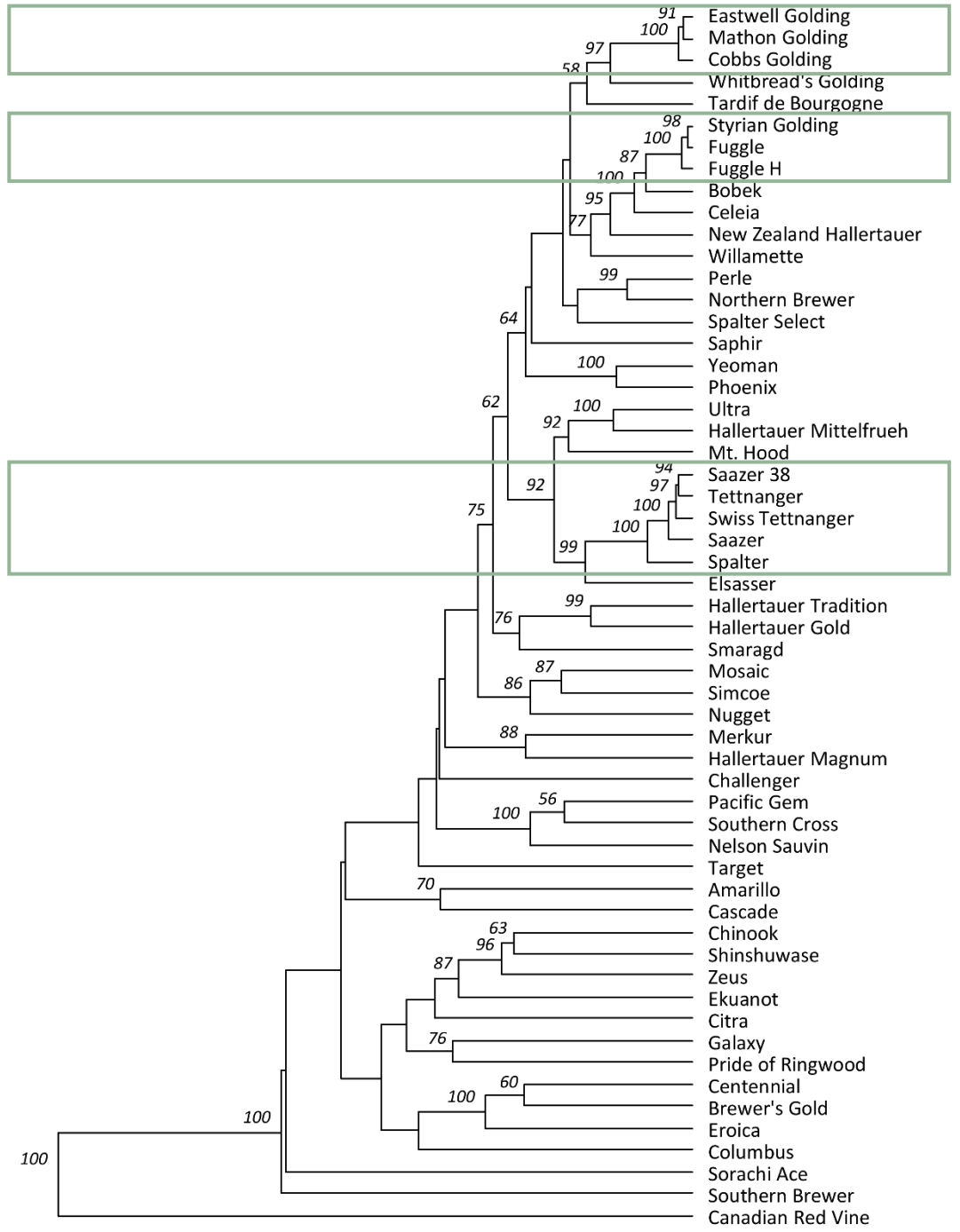
Van Holle A., Muylle H., Ruttink T., Van Landschoot A., Haesaert G., Naudts D., De Keukeleire D., and Roldán-Ruiz I.
Single Nucleotide Polymorphisms and biochemical markers as complementary tools to characterize hops (Humulus lupulus L.) in brewing practice.
J. Agric. Food Chem., 2019, 67: 3761-3771.

Genetic fingerprinting of hops

Phylogenetic relationships among 56 varieties

Cluster analysis (Nei, UPGMA)
based on 1,830 polymorphic SNP markers

- 48 unique genetic fingerprints
- 3 groups of somaclonal variants (identical genetic fingerprints)



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HOP TERROIR STUDY | METHODOLOGY

Genetic and biochemical fingerprinting HOPS

- Genetic fingerprinting
- Biochemical fingerprinting
  - Hop acids (ASBC Hops-6A) and HSI 'Hop Storage Index' (ASBC Hops-12)
  - Hop oil content (EBC 7.10)
  - Hop aroma profiling (in-house HS-SPME-GC-MS method)

  → Classification of hops according to growth location

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HOP TERROIR STUDY | METHODOLOGY

Biochemical and sensory profiling single hop BEERS

- Aroma profiling (HS-SPME-GC-MS)
- Sensory evaluation
  - Triangle tests
  - Descriptive analysis

ODOUR main / side impression(s)

AROMA main / side impression(s)

TASTE

- Bitter intensity
- Bitterness quality
- After-bitterness quality
- Astringency

GLOBAL APPRECIATION

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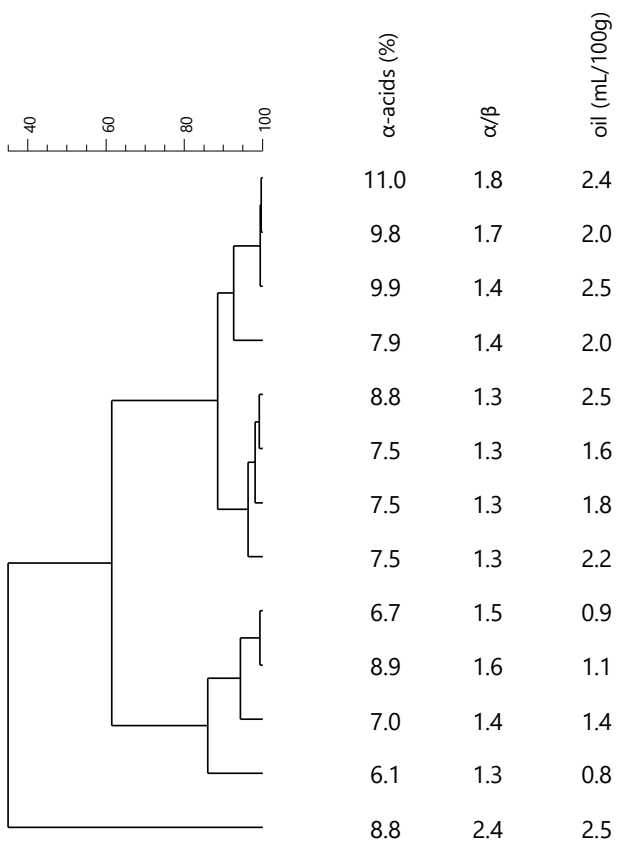
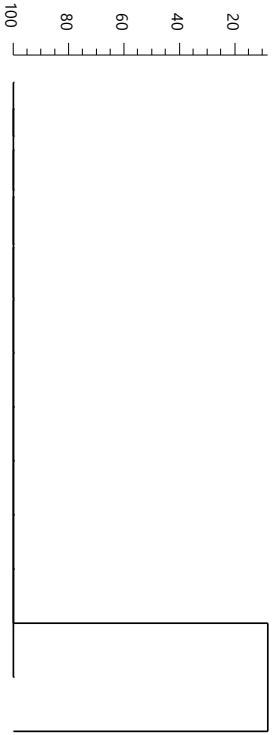
CASE STUDY – AMARILLO



Cluster analysis (Pearson, UPGMA) based on hop aroma profile

	AMA_WA(1)_2017	Washington, USA
	AMA_WA(2)_2017	Washington, USA
	AMA_WA(1)_2015	Washington, USA
	AMA_WA(2)_2015	Washington, USA
	AMA_WA(1)_2016	Washington, USA
	AMA_WA(2)_2016	Washington, USA
	AMA_WA(3)_2016	Washington, USA
	AMA_WA(3)_2015	Washington, USA
	AMA_ID(1)_2015	Idaho, USA
	AMA_ID(1)_2016	Idaho, USA
	AMA_ID(1)_2017	Idaho, USA
	AMA_DE(1)_2017	Germany
	CEN_WA(1)_2016	Washington, USA



Cluster analysis (Pearson, UPGMA) based on SNP genotyping data

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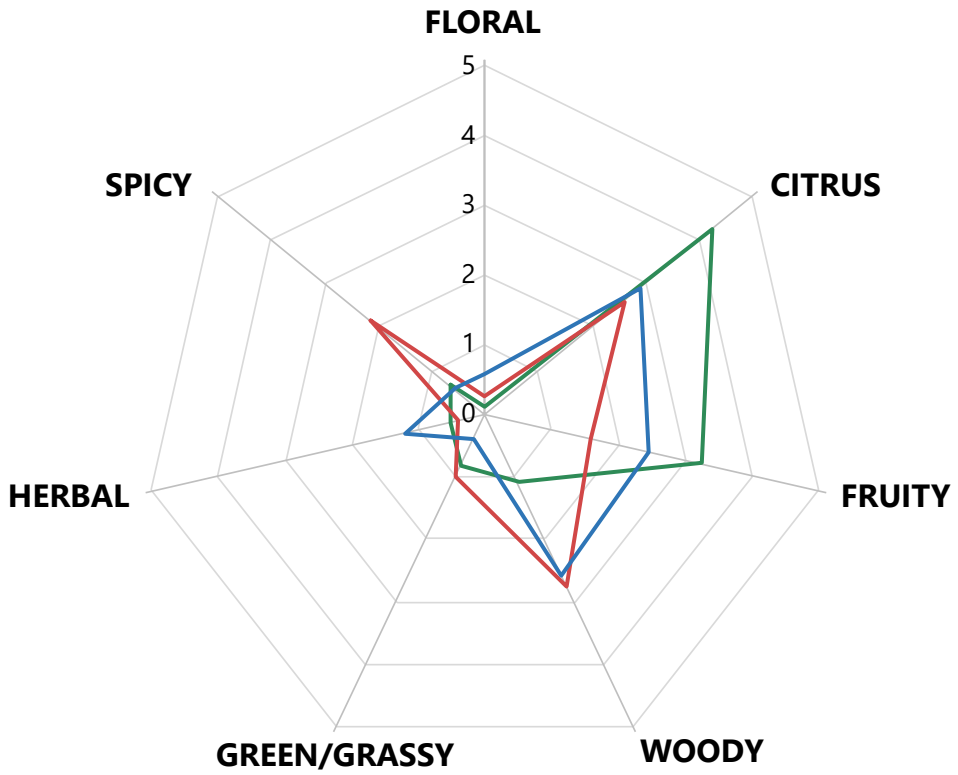
CASE STUDY – AMARILLO



	WA, USA	ID, USA	Germany
CITRUS	grapefruit, orange, lemon	grapefruit	orange, tangerine
FRUITY	tropical fruits, lychee, apricot		green apple, tropical fruits
WOODY		resin	resin
SPICY		pepper	

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CASE STUDY – AMARILLO

	WA, USA	ID, USA	Germany
Bitter intensity			
(score 0-8)	5	4	4
Bitterness quality			
pleasant	18	11	14
neutral	1	5	5
unpleasant	1	5	0
After-bitterness			
pleasant	14	10	11
neutral	5	6	7
unpleasant	1	5	1
not perceivable	0	0	0
Astringency			
(score 0-8)	3	4	4
Global appreciation			
(score 0-10)	6.4	5.3	5.7
	3.67	3.51	3.47

RateBeer

TRIANGLE TESTS

Significant difference between the 3 Amarillo beers

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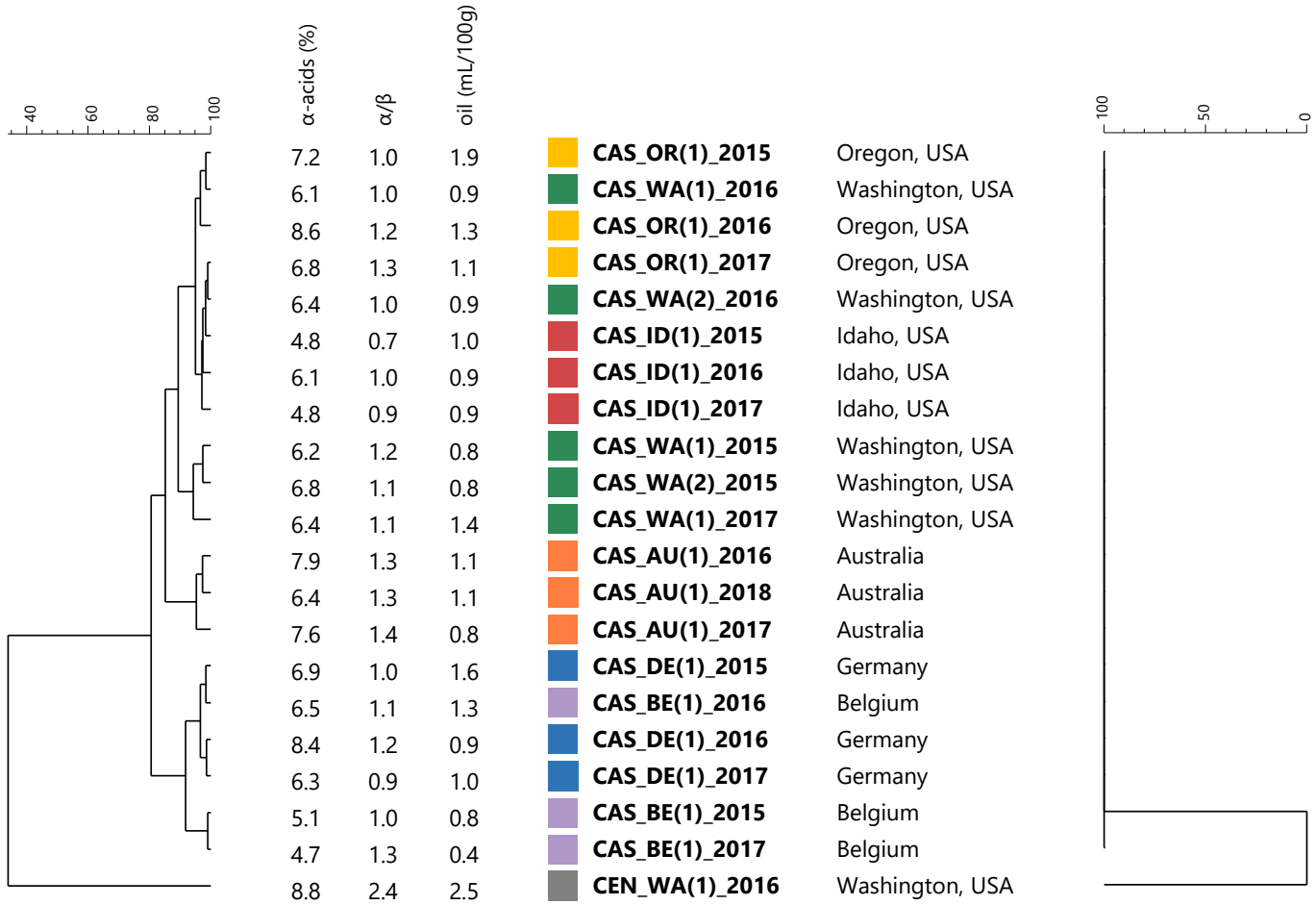
CASE STUDY – CASCADE



Cluster analysis (Pearson, UPGMA)
based on hop aroma profile

Cluster analysis (Pearson, UPGMA)
based on SNP genotyping data

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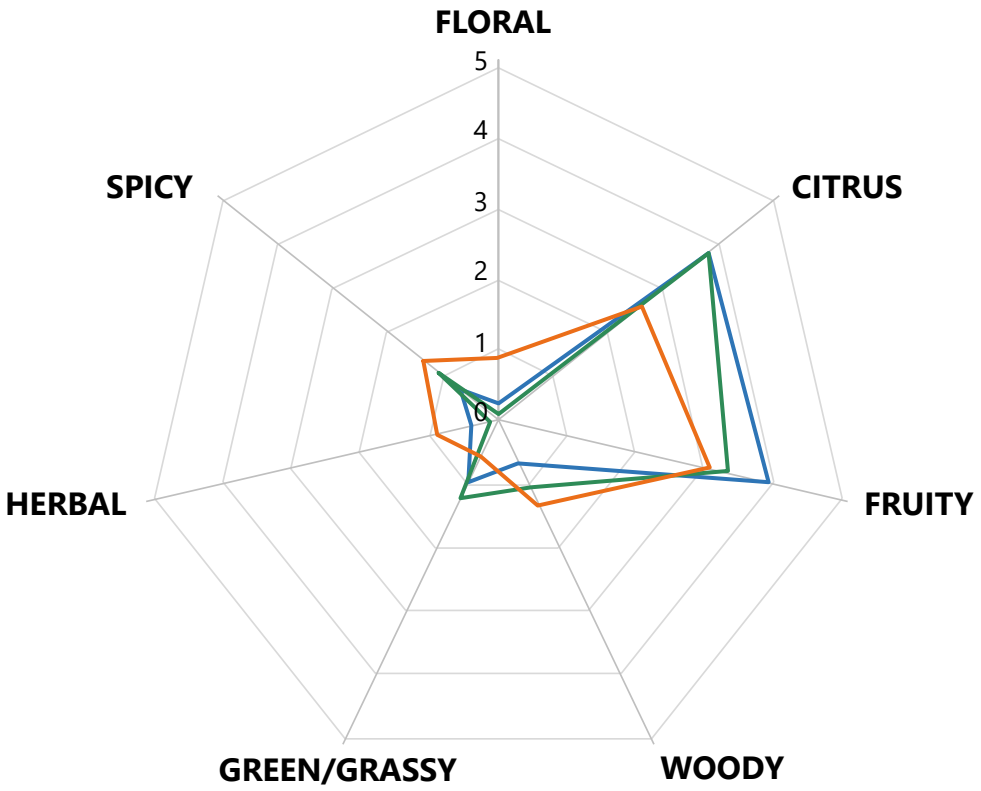
CASE STUDY – CASCADE



	Germany	Australia	WA, USA
CITRUS	grapefruit, tangerine	grapefruit	grapefruit
FRUITY	lychee, apple	tropical fruits	tropical fruits
WOODY		resin	
GREEN			grassy
HERBAL		green tea	
SPICY		pepper	

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CASE STUDY – CASCADE

	Germany	Australia	WA, USA
Bitter intensity			
(score 0-8)	3	5	4
Bitterness quality			
pleasant	16	14	18
neutral	5	5	2
unpleasant	0	1	0
After-bitterness			
pleasant	11	13	18
neutral	8	2	2
unpleasant	0	5	0
not perceivable	2	0	0
Astringency			
(score 0-8)	3	4	3
Global appreciation			
(score 0-10)	5.8	6.3	6.7
	3.47	3.46	3.55

RateBeer

TRIANGLE TESTS

Significant difference between the 3 Cascade beers

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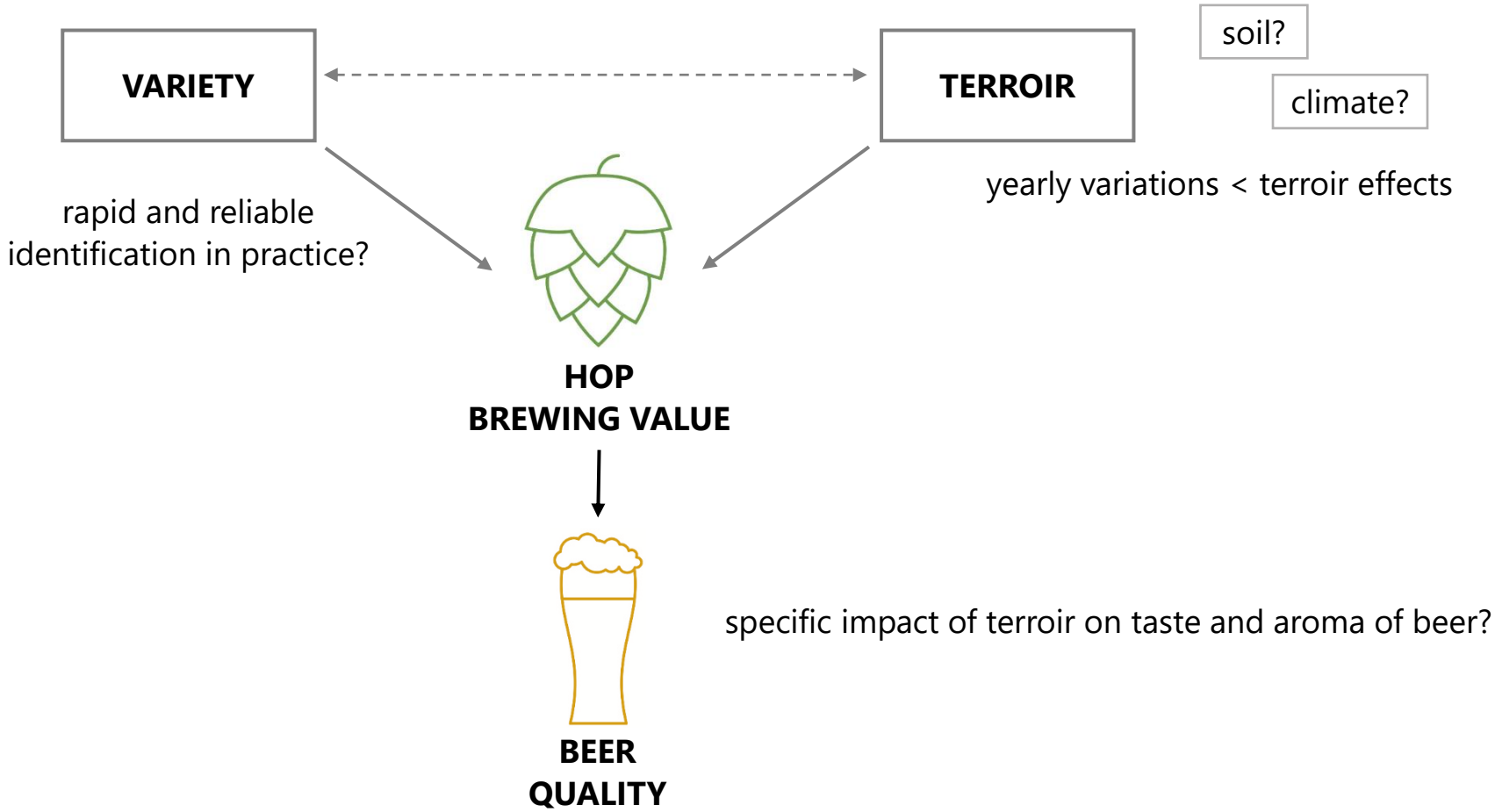
CONCLUSIONS AND FUTURE PERSPECTIVES



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THANKS TO

- De Proefbrouwerij team
- Hopgrowers/-distributors
- Research partners

  prof. Geert Haesaert
  prof. dr. Isabel Roldán-Ruiz
  ereprof. dr. Anita Van Landschoot
  ereprof. dr. Denis De Keukeleire

- YOU FOR YOUR ATTENTION