EVALUATION OF TERROIR EFFECTS ON THE BREWING VALUE OF HOPS

Ann Van Holle, De Proefbrouwerij
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
Specific case: Amarillo single-hop beer

Amarillo hops cultivated in Idaho ↔ Washington State

divergent hop aroma profile

less citrussy aroma, more piney and grassy flavours

Van Holle A., Van Landschoot A., Roldán-Ruiz I., Naudts D., and De Keukeleire D.  
The brewing value of Amarillo hops (\textit{Humulus lupulus} \textit{L.}) grown in northwestern USA: A preliminary study of terroir significance.  
PRELIMINARY STUDY OF TERROIR SIGNIFICANCE
PRELIMINARY STUDY OF TERROIR SIGNIFICANCE

- VARIETY
- TERROIR

- genetic fingerprinting
- biochemical fingerprinting

HOP
BREWING VALUE

BEER QUALITY
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cv. Amarillo
cv. Centennial

Conclusions
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
**Hop Terroir Study | Approach**

**Recipe**

NEIPA style

Original gravity 16°P
Alcohol 7% ABV

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

http://blog.mikkeller.dk/mikkeller-launches-terroir-series
**HOP TERROIR STUDY | METHODOLOGY**

Genetic and biochemical fingerprinting HOPS

- Genetic fingerprinting

<table>
<thead>
<tr>
<th></th>
<th>HOP (Humulus lupulus L.)</th>
<th>HUMAN</th>
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<tbody>
<tr>
<td>Chromosomes</td>
<td>2n=20</td>
<td>2n=46</td>
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<tr>
<td>Genome size</td>
<td>2,57 Gb</td>
<td>3,23 Mb</td>
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<tr>
<td>Genes</td>
<td>± 50,000</td>
<td>± 23,000</td>
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Genetic and biochemical fingerprinting HOPS

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

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)
**Hop Terroir Study | Methodology**

- 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

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

Cluster analysis (Pearson, UPGMA) based on SNP genotyping data
CASE STUDY – AMARILLO

PROEFBRUWERIJ
architectuur in bier

WA, USA
grapefruit, orange, lemon, tropical fruits, lychee, apricot

ID, USA
grapefruit
resin
pepper

Germany
orange, tangerine, green apple, tropical fruits
resin

CITRUS
FRUITY
WOODY
SPICY

CITRUS
grapefruit, orange, lemon

Tropical fruits
lychee, apricot

SPICY

WOODY

HERBAL

GREEN/GRASSY

FRUIT

FLORAL

1 2 3 4 5
## Case Study – Amarillo

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<tr>
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<th>WA, USA</th>
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<th>Germany</th>
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<tr>
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</tr>
<tr>
<td></td>
<td>5</td>
<td>4</td>
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<tr>
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<td>18</td>
<td>11</td>
<td>14</td>
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<td>5</td>
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</tr>
<tr>
<td>unpleasant</td>
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</tr>
<tr>
<td><strong>After-bitterness</strong></td>
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<td>10</td>
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<tr>
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<td>6.4</td>
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**TRIANGLE TESTS**

Significant difference between the 3 Amarillo beers

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<td>Germany</td>
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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
CASE STUDY – CASCADE

Germany
- CITRUS: grapefruit, tangerine
- FRUITY: lychee, apple
- WOODY
- GREEN
- HERBAL

Australia
- grapefruit
- tropical fruits
- resin
- green tea
- pepper

WA, USA
- grapefruit
- tropical fruits
- grassy
CASE STUDY – CASCADE

<table>
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<th></th>
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<th>WA, USA</th>
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TRIANGLE TESTS

Significant difference between the 3 Cascade beers
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Conclusions
CONCLUSIONS AND FUTURE PERSPECTIVES

VARIETY

rapid and reliable identification in practice?

TERROIR

yearly variations < terroir effects

HOP BREWING VALUE

soil?

climate?

BEER QUALITY

specific impact of terroir on taste and aroma of beer?
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