Flavor development in Cheese: a food-omics approach

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Delft, The Netherlands

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DSM: Building on an impressive history

Hoffman La Roche’s Vitamins (1930s)

Gist-Brocades (1869)

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Gist-Brocades (1869)

Vitamins
Omega’s
Carotenoids
Premixes for food & feed
Enzymes
Minerals
Cultures & Yeasts
Nutraceuticals
Pharmaceuticals
Cellulosic bioethanol
Biomedical materials
Bio-plastics
High Performance Plastics
Polyamides and precursors
Resins for coatings and composites
Functional Materials
Solar - advanced surfaces

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Combination of ripening enzyme and DVC adjunct cultures providing original flavor profiles for Continental/Cheddar cheese.

Functional and clean kosher lipase for natural, ingredient and enzyme modified cheeses.

FLAVOR SYSTEMS

Cultures that produce creamier mouth feel, especially in low fat products.

Cultures with fat mimicking properties.

Unique strain diversity that develops better curd integrity.

TEXTURE TOOLBOX

Fast acidifying cultures for high volume cheese producers.

Large rotation reducing phage challenges.

Process Scan service with our coagulant range.

YIELD IMPROVEMENT

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Flavor analysis platform

A powerful tool to profile (flavor) metabolites in cheese to support targeted product development in collaboration with our customers

• Outline of the flavor analysis platform
• Example on Gouda cheese
• Summary and outlook
• Acknowledgements
Flavor analysis platform

Outline

Sensory

Sample preparation: extraction of non-volatile key compounds

Analysis

Analysis of volatile and non-volatile flavors and metabolites using GC-MS, LC-MS (peptides) and NMR spectroscopy

BioIT

Statistical data evaluation and correlation of sensory and analysis

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Flavor analysis platform
Sensory analysis

Analytical sensory research

Descriptive
- Quantitative
- Check-all-that-apply

Discrimination
- 2 or 3 Alternative Forced Choice tests
- Triangle test

- QDA method (QDA®, is one of the main descriptive analysis techniques in sensory evaluation)
- Non-biased and objective: trained external panel
- Powerful: 14 panelists in one panel
- 39 attributes were assessed divided over 6 categories

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Flavor analysis platform

Key analytical techniques

Sample preparation
• Key to obtain analytical data with sufficient quality to use for correlation to sensory

NMR spectroscopy
• Detection of broadest possible range of compound classes in a single measurement
• Easy to set up and automatize, high-throughput and cost-effective

GC-MS of non-volatiles
• Very sensitive method for the detection of a broad range of compound classes

GC-MS of volatiles
• Sensitive method for profiling of volatile metabolites

LC-MS of peptides
• General profiling of peptides of 2 to ~15 amino acids

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Flavor analysis platform
Chemical analysis: a food-omics approach

Initially apply untargeted
- Broadest list of metabolites
- Limited risk of overlooking relevant compounds
- Identity of metabolites not determined
- Minimum analytical data interpretation
- Statistical modelling

Targeted assessment of results
- Select relevant peaks that correlate with sensory attributes
- Identify metabolites using existing data
- Analytical data interpretation only on peaks of interest

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Gouda cheese
Cheese making

Conditions

- Acidifier: CT110
- Milk type: Full fat (48% FDM) and reduced fat (30% FDM)
- Rennet: Maxiren
- Other additions: Annatto, CaCl₂ and sodium nitrate (allowed in the Netherlands to prevent late blowing)
- Adjuncts: 6 different adjunct blends with distinguished flavor profiles
- Ripening: 88% relative humidity; 13°C

Sampling

- Composition analysis at 2 wks
- Flavor platform at 6, 12 and 24 wks
### Gouda cheese
Reproducibility of cheese making

<table>
<thead>
<tr>
<th></th>
<th>SDM (%)</th>
<th>pH</th>
<th>FDM (%)</th>
<th>Moisture (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Control</strong></td>
<td>2.3</td>
<td>5.25</td>
<td>51.3</td>
<td>41.5</td>
</tr>
<tr>
<td>RSD (%)</td>
<td>4.8</td>
<td>0.6</td>
<td>1.9</td>
<td>1.8</td>
</tr>
<tr>
<td><strong>All cheeses</strong></td>
<td>2.3</td>
<td>5.23</td>
<td>51.3</td>
<td>41.9</td>
</tr>
<tr>
<td>RSD (%)</td>
<td>7.4</td>
<td>0.8</td>
<td>1.7</td>
<td>2.0</td>
</tr>
</tbody>
</table>

*Control = CT110 full fat*

*SDM = salt on dry matter*

*FDM = fat on dry matter*
Gouda cheese
Statistical data evaluation

- Raw data of three analytical methods and sensory evaluation by the trained external panel
Gouda cheese
Statistical data evaluation

- Allow combination of very different datasets
- Data processing addresses variability in baselines, retention times, peak positions and sample weights
- Peak tracking & integration and aggregation to the same level as QDA
Gouda cheese
Statistical data evaluation

- **PLS**
  - Partial Least Squares Regression: Multivariate regression stabilized for collinear data using SIMPLS from the Matlab PLS-Toolbox
- **PLS-DA**
  - PLS discriminant analysis that calculates the scores as such that they discriminate maximally between classes (ageing steps)
  - *Explore differences between cheeses during ripening*
  - Identify sensory attributes or metabolites that are linked to ripening
- **PLS2**
  - *Multivariate regression to model odor, mouth feel and flavor sensory attributes as a function of analytical profiles*
Gouda cheese
Complementary value of analytical techniques

<table>
<thead>
<tr>
<th>Attribute</th>
<th>NMR</th>
<th>OS-GC-MS</th>
<th>GC-MS</th>
<th>GC-MS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Salt-fl</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sweet-fl</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Savoury-fl</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Bitter-at</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Creamy-mf</td>
<td>✓</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rubbery-mf</td>
<td>✓</td>
<td></td>
<td></td>
<td>✓</td>
</tr>
</tbody>
</table>

The analytical methods*
- each describe a unique set of sensory attributes
- overlap in describing some sensory attributes

* This is for the models generated with the current set of Gouda cheeses and may be dependent on the type of cheese

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Flavour analysis platform

- Powerful and complete overview of the broadest possible range of non-volatile and volatile (flavor) metabolites in cheese
- Non targeted approach looks for more than the usual suspects
- More extensive platform (e.g. non-volatiles, volatiles and peptides, NMR) than reported in literature
- Ongoing development of the platform to meet future industry needs
- Allows to distinguish our products based on their sensory and analytical flavor development profile during ripening
- Expand Flavor Library for flavor prediction as targeted solution in collaboration with our customers
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