Aroma-impact Components of Italian-type Dry-cured Meat Products

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I. Blank, C. Cerny, B. Zurbrigggen

Nestlé Research Center, Lausanne, Switzerland
Nestlé R&D Center Kemptthal, Kemptthal, Switzerland
Structure of the Presentation

Products: Parma ham
Italian-type salami

Objective: Identification of key aroma compounds

Approach: Sensory directed chemical analysis
  → Isolation (extraction, headspace)
  → Sensory relevance (GC-O, AEDA)
  → Identification (GC-MS, GC-FPD)
Production of Dry-cured Ham

Curing ingredients
Additives

Homogenous distribution of salt

Development of aroma

Pre-salting
Salting
Post salting

Ripening / drying

Rapid process
Slow process

8-11 d, 2-4 °C
93-96 % RH

1-2 months, 2-5 °C
90-95 % RH

4 months, 14-16 °C
70-75 % RH

6-12 months, 5-15 °C
65-85 % RH
Literature Data on Parma Ham Aroma

Giolitti et al. (1971) volatile fatty acids (133 ppm, C₁-C₇),
carbonyl compounds (aldehydes C₁-C₇, ketones)

Barbieri et al. (1992) 122 volatiles identified (dynamic headspace, Tenax),
high content of esters

Careri et al. (1993) short-chain methyl-branched oxy compounds correlate well with the ‘aged’ flavour of Parma ham

Hinrichsen et al. (1995) 73 volatiles identified (dynamic headspace, Tenax),
1st phase: autoxidation, 2nd phase: amino acid catabolism

Bolzoni et al. (1996) 57 volatiles identified (dynamic headspace, Tenax),
high discriminating power of 3-methylbutanal / ethyl esters
Parma ham (200 g) → Liquid N₂ → Waring Blender → Extraction (3 x 250 mL DE, 5 h) → Solvent extract (100 mL)

Sensory evaluation (GC-O, AEDA) → Aroma extract (1 mL) → High vacuum transfer (5x10⁻⁵ mbar, 35 °C)

Basic fraction → Neutral fraction → Acidic fraction

Identification by GC-O and GC-MS (OV-1701, Carbowax)
(Engel et al., *Eur. Food Res. Technol.*, 1999)
FD-Chromatogram of Parma Ham

Linear Retention Index (OV-1701)
Gas chromatogram of Parma Ham (neutral fraction)
Gas chromatogram of Parma Ham (acidic fraction)
<table>
<thead>
<tr>
<th>Odorant</th>
<th>Aroma quality</th>
<th>FD-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>Methional</td>
<td>Cooked potato-like</td>
<td>500</td>
</tr>
<tr>
<td>Butyric acid</td>
<td>Sweaty, cheese-like</td>
<td>500</td>
</tr>
<tr>
<td>1-Octen-3-one</td>
<td>Mushroom-like</td>
<td>200</td>
</tr>
<tr>
<td>(E)-2-Nonenal</td>
<td>Fatty</td>
<td>200</td>
</tr>
<tr>
<td>Sotolone</td>
<td>Seasoning-like</td>
<td>200</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>Acidic, pungent</td>
<td>100</td>
</tr>
<tr>
<td>3-Methylbutyric acid</td>
<td>Sweaty, cheese-like</td>
<td>100</td>
</tr>
<tr>
<td>(Z)-1,5-Octadien-3-one</td>
<td>Geranium-like, metallic</td>
<td>100</td>
</tr>
<tr>
<td>Hexanal</td>
<td>Green</td>
<td>50</td>
</tr>
<tr>
<td>2-Acetyl-1-pyrroline</td>
<td>Roasty, popcorn-like</td>
<td>50</td>
</tr>
<tr>
<td>Furaneol</td>
<td>Caramel-like, sweet</td>
<td>50</td>
</tr>
<tr>
<td>p-Cresol</td>
<td>Musty, phenolic</td>
<td>50</td>
</tr>
<tr>
<td>Odorant</td>
<td>Aroma quality</td>
<td>FD-factor</td>
</tr>
<tr>
<td>--------------------------------------------</td>
<td>---------------------</td>
<td>-----------</td>
</tr>
<tr>
<td>3-Methylbutanal</td>
<td>Malty</td>
<td>20</td>
</tr>
<tr>
<td>Ethyl butyrate</td>
<td>Fruity</td>
<td>20</td>
</tr>
<tr>
<td>Ethyl 2-methylbutyrate</td>
<td>Fruity</td>
<td>20</td>
</tr>
<tr>
<td>Homofuraneol</td>
<td>Caramel-like</td>
<td>20</td>
</tr>
<tr>
<td>Caproic acid</td>
<td>Musty, fatty</td>
<td>20</td>
</tr>
<tr>
<td><em>(E,E)-2,4-Nonadienal</em></td>
<td>Fatty</td>
<td>20</td>
</tr>
<tr>
<td><em>(E,E)-2,4-Decadienal</em></td>
<td>Fatty</td>
<td>20</td>
</tr>
<tr>
<td>Dimethyltrisulfide</td>
<td>Cooked vegetables-like</td>
<td>5</td>
</tr>
<tr>
<td>2-Ethyl-3,5-dimethylpyrazine</td>
<td>Earthy, roasty</td>
<td>5</td>
</tr>
<tr>
<td>2-Ethenyl-3,5-dimethylpyrazine</td>
<td>Earthy</td>
<td>5</td>
</tr>
<tr>
<td>Phenylacetaldehyde</td>
<td>Honey-like</td>
<td>5</td>
</tr>
<tr>
<td>2-Methylbutyric acid</td>
<td>Sweaty</td>
<td>5</td>
</tr>
<tr>
<td><em>trans</em>-4,5-Epoxy-<em>(E)</em>-2-decenal</td>
<td>Metallic</td>
<td>5</td>
</tr>
</tbody>
</table>
no. 13, FD = 200

no. 14, FD = 100

no. 21, FD = 20

no. 20, FD = 200

no. 4, FD = 50

no. 27, FD = 20
Static headspace GC-O

(Guth & Grosch, Getreide Mehl Brot, 1994)
Headspace Aromagram of Parma Ham

Aroma Intensity

Linear Retention Index (OV-1701)

A (2)  B (8)  C (15)
Parma ham aroma: Summary

• Composition:  - Parma ham aroma composed of several key odorants present in a subtle balance
  - a single odorant with a ‘Parma ham’-type note not found

• Formation:  - lipid oxidation
  - Maillard-type reactions
  - enzymatic reactions

• Precursors:  - meat
  - microbial origin
## Literature Data on Fermented Dry-cured Sausage Aroma

<table>
<thead>
<tr>
<th>Author(s)</th>
<th>Number of Volatiles</th>
<th>Methodology</th>
</tr>
</thead>
<tbody>
<tr>
<td>Berger et al. (1990)</td>
<td>68 volatiles</td>
<td>68 volatiles identified (dynamic HS/solvent extraction) lipid precursors and microbial activities essential for aroma</td>
</tr>
<tr>
<td>Berdagué et al. (1993)</td>
<td>80 volatiles</td>
<td>80 volatiles identified (dynamic headspace/Tenax, GC-O), final aroma very much influenced by starter cultures</td>
</tr>
<tr>
<td>Stahnke (1994)</td>
<td>60 volatiles</td>
<td>60 volatiles identified (dynamic headspace/Tenax, GC-O), esters formed via microbial activity, many odorants unknown</td>
</tr>
<tr>
<td>Schmidt &amp; Berger (1998)</td>
<td>126 volatiles</td>
<td>126 volatiles identified (various isolation methods, GC-O), diallyl disulfide and eugenol dominate</td>
</tr>
<tr>
<td>Stahnke (1999)</td>
<td>2-acetyl-1-pyrroline</td>
<td>2-acetyl-1-pyrroline reported as impact odorant (roasty note) Penicillium species on surface as possible origin of 2-AP</td>
</tr>
</tbody>
</table>
Production of Fermented Dry-cured Sausage

Curing ingredients
Additives
Starter cultures

Chopping

Mixing

Filling

Ripening

1st Drying

2nd Drying

Development of
microbial flora

1-2 d, 20-25 °C
90-94 % RH

5-10 d, 18-22 °C
80-90 % RH

1-2 months, 12-15 °C
65-80 % RH

Development of
aroma

Cooling, freezing

Vacuum, -2/+2 °C
Changes during Ripening of Sausages

(Dierick et al., 1974)
Aroma extract (1 mL)

Basic fraction
Neutral fraction
Acidic fraction

Identification by GC-O and GC-MS (OV-1701, Carbowax)
Gas chromatogram of Salami (solvent extract)
FD-Chromatogram of an Italian-type Salami

Linear Retention Index (OV-1701)

FD-factor

A (7)

B (13)

C (7)
<table>
<thead>
<tr>
<th>Odorant</th>
<th>Aroma quality</th>
<th>FD-factor</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-Acetyl-1-pyrroline</td>
<td>Roasty, popcorn-like</td>
<td>≥ 100</td>
</tr>
<tr>
<td>Allyl methyl sulfide</td>
<td><em>Allium</em>-like, garlic</td>
<td>≥ 100</td>
</tr>
<tr>
<td>Dimethyltrisulfide</td>
<td>Cooked vegetables-like</td>
<td>≥ 100</td>
</tr>
<tr>
<td>Methional</td>
<td>Cooked potato-like</td>
<td>≥ 100</td>
</tr>
<tr>
<td>Butyric acid</td>
<td>Sweaty, cheese-like</td>
<td>≥ 100</td>
</tr>
<tr>
<td>Diacetyl</td>
<td>Buttery</td>
<td>≥ 10</td>
</tr>
<tr>
<td>3-Methylbutanal</td>
<td>Malty</td>
<td>≥ 10</td>
</tr>
<tr>
<td>Acetic acid</td>
<td>Acidic, pungent</td>
<td>≥ 10</td>
</tr>
<tr>
<td>1-Octen-3-one</td>
<td>Mushroom-like</td>
<td>≥ 10</td>
</tr>
<tr>
<td>(<em>Z</em>)-1,5-Octadien-3-one</td>
<td>Geranium-like, metallic</td>
<td>≥ 10</td>
</tr>
<tr>
<td>Nonanal</td>
<td>Citrus-like, musty</td>
<td>≥ 10</td>
</tr>
<tr>
<td>(<em>E,Z</em>)-2,6-Nonadienal</td>
<td>Fatty, cucumber-like</td>
<td>≥ 10</td>
</tr>
<tr>
<td>Linalol</td>
<td>Flowery</td>
<td>≥ 10</td>
</tr>
</tbody>
</table>
Gas chromatogram of Salami (basic fraction)
Odorants identified in Italian-type Salami (FD ≥ 100)

- S-S-S- Cabbage-like
- S-H S- $\text{Allium}$-like, garlic
- S-S=O Cooked potato-like
- H-C=O OH Sweaty, cheese-like
- N=O Roasty, popcorn-like
Odorants identified in Italian-type Salami
(FD ≥ 10)

- Malty
- Buttery
- Citrus-like, musty
- Flowery

- Acidic
- Geranium-like
- Mushroom-like
- Cucumber-like
Headspace Aromagram of an Italian-type Salami

Aroma Intensity

Linear Retention Index (OV-1701)

A (1)

B (8)

C (12)
Cabbage-like

Allium-like, garlic

Cooked potato-like

Malty

Flowery

Buttery

Mushroom-like

Geranium-like
Salami aroma: Summary

• Composition: - Italian-type salami aroma composed of several odorants present in a subtle balance
  - a single odorant with a ‘salami’-type note not found

• Formation: - Maillard-type reactions
  - lipid oxidation
  - enzymatic reactions
  - spices

• Precursors: - meat
  - spices
  - microbial origin
Conclusions

• No indication for odorants with a ‘dry cured ham’-type or ‘salami’-type note
  → Quantitative data required for better understanding

• Aroma generation in dry-cured meat products mainly by lipid oxidation and amino acid degradation
  → Aroma modification through technology, spices, and microflora

• Efficient aroma characterisation by Sensory Directed Chemical Analysis
  → Solvent extract and headspace data result in complementary data
Acknowledgement

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