Formation of flavor, color and reducing power in caramel malts

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Chair De Clerck
13 September 2012
Overview

- Introduction
- Experimental
- Sacharification process
- Caramelisation process
- Conclusion
Barley

Barley (Hordeum vulgare L.) (Briggs, 1998)
Pilsner malt

Steeping

Germinating

Kilning
Specialty malts

• Differs from pilsner malt
  – Raw materials
  – Altered process parameters
  – Altered drying process
Specialty malts

Dark specialty malts

– Altered drying process
Dark specialty malts

BARLEY

STEEPING
GERMINATION
KILNING

PILSNER MALT
COLOR MALT
ROASTER
ROASTED MALT

GREEN MALT
ROASTER
CARAMEL MALT

ROASTER
ROASTED BARLEY
Dark specialty malts

High temperatures:
Nonenzymatic browning reactions

Formation of flavor, color and reducing power
Nonenzymatic Browning

- Caramelisation
- Pyrolysis
- Maillard reaction
  - Reducing sugars + amino components
  - Complex
  - Tempered reaction conditions
Flavor

• Maillard reaction
  – Strecker aldehydes
  – O – heterocycles: caramel
  – N – heterocycles: burnt, bread, earthy
  – S – heterocycles: grainy, popcorn
• Oxidation of fatty acids
  – Linear aldehydes
• Fenolic components
Color

- LMW Chromophores
- HMW Melanoidins
- Maillard reaction
Reducing power

- Prevent – delay oxidative processes
- Fenolic components
- Maillard reaction
- Reductones – melanoidins
- Flavour stability
- Pro-oxidant
Production process caramel malt

Green malt 45% RH

Direct heating

Sacharification
T: 50-80°C t: 0-120’

Caramelisation
T: 100-180°C t: 0-90’

Caramel malt
Sacharification phase

- Ventilation shaft
- Valve
- Roasting drum
- Heating element
- Ventilation shaft
Sacharification phase

- Indirect heating
- High moisture content
- Hydrolysis of starch
  - β-amylase & α-amylase
- Breakdown of proteins
  - Endoproteinases en exopeptidases

PRECURSORS MAILLARD REACTION
Sacharification phase

- Glucose

Lowest concentrations at 50°C and 55°C
Sacharification phase

- Glucose

60°C: highest concentration↑
Sacharification phase

- Glucose

At 80°C: Initial fast↑
Sacharification phase

- Maltose

2 Maxima:
70°C – 45’
60°C – 60’
Sacharification phase

- FAN

Highest values: 55°C

Low formation at 70-80°C
Sacharification phase - Conclusion

- Reducing sugars
  - Maltose: reducing sugar with highest concentration
  - Optimum glucose and maltose: 60°C
  - Linked to involved enzymes

- FAN
  - Formation during come-up
  - Optimal formation: 55°C
  - 70-80°C: no net formation
Caramelisation phase

- Valve
- Ventilation shaft
- Roasting drum
- Heating element
- Ventilation shaft
Caramelisation phase – Extract

- Extract content
  - 100°C-120°C: slight decrease
  - Higher T: Strong decrease
  - Evaporation + insoluble

- Moisture content
  - 100°C: above 5%
  - Decrease with increasing T and t
  - Above 160°C: MC <1%

<table>
<thead>
<tr>
<th>Time (min)</th>
<th>Extract content (% m/m dry mass)</th>
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<tbody>
<tr>
<td></td>
<td>100°C</td>
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<tr>
<td>0</td>
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Caramelisation phase - Color

- Increasing $T \Rightarrow$ increasing colour ($100^\circ\text{C} - 160^\circ\text{C}$)
- Linear $100^\circ\text{C}$
- Higher $T$: initial linear increase
- Highest value at $160^\circ\text{C}$
- $180^\circ\text{C}$: decrease
Caramelisation - Flavour

- Furaneol – caramel flavour
  - 100°C: increase
  - Higher T: maximum
  - Moisture content
    - <5% => stop net formation
  - Maltol, norfuraneol

- Not linked with color formation
  - = [ ] , ≠ color
  - Designer malts
Caramelisation - Flavour

- 2-ethyl-3,5-dimethylpyrazine
  - Roasted flavour
  - Low TH
  - Tends 2,3,5-trimethylpyrazine & 2,3-diethyl-5-methylpyrazine
  - 180°C: strong increase
  - No clear relation color-flavor
Caramelisation – Reducing power

- Linear increase of both radical scavenging and redox-reducing capacity at 100°C and 120°C
- 140°C => a maximum was reached
- 160°C and 180°C => strong decrease after initial increase

Development of radical-scavenging ability (left) and redox-reducing activity (right) during the malt caramelization phase.
Caramelisation phase - conclusion

- **Temperature and time**
  - Strong influence on all parameters
  - Formation pyrazines: formation at higher temperatures

- **Moisture content**
  - Influence on formation caramel flavours

- **Development of color and flavor components are not coupled**
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