Important raw materials quality parameters and their influence on beer production

Roland Pahl
### Information from Analytical Data

<table>
<thead>
<tr>
<th>Extraction (Brewing value)</th>
<th>Process behaviour</th>
<th>Wort – and Beer quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture</td>
<td>Viscosity</td>
<td>pH</td>
</tr>
<tr>
<td>Extract</td>
<td>Turbidity</td>
<td>Colour and C.b.w.</td>
</tr>
<tr>
<td>Protein</td>
<td>Friabilimeter</td>
<td>Enzyme activity</td>
</tr>
<tr>
<td></td>
<td>Calcofluor</td>
<td>Kolbach index</td>
</tr>
<tr>
<td></td>
<td>Purity of variety</td>
<td>DMSP</td>
</tr>
</tbody>
</table>

Legal requirements:
- Mycotoxins, Heavy metals, NDMA, Radio nuclides
# Recommended Specifications

## European crop 2-row spring barley malt

<table>
<thead>
<tr>
<th>Malt analysis</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Moisture %</td>
<td>max. 5.0</td>
</tr>
<tr>
<td>Extract fine (d. m.) %</td>
<td>min. 80.5</td>
</tr>
<tr>
<td>Colour of wort EBC</td>
<td>max. 4.0</td>
</tr>
<tr>
<td>Colour of boiled wort EBC</td>
<td>max. 6.0</td>
</tr>
<tr>
<td>pH</td>
<td>5.85</td>
</tr>
<tr>
<td>Viscosity (8.6 %) mPa*s</td>
<td>1.50 – 1.60</td>
</tr>
<tr>
<td>Saccharification time min</td>
<td>max. 15</td>
</tr>
<tr>
<td>Total nitrogen (d. m.) g/100 g</td>
<td>max. 1.9</td>
</tr>
<tr>
<td>Total protein (d. m.) g/100 g</td>
<td>max. 12.0</td>
</tr>
<tr>
<td>Soluble nitrogen (d. m.) g/100 g</td>
<td>0.65 – 0.75</td>
</tr>
<tr>
<td>Soluble protein (d. m.) g/100 g</td>
<td>4.0 – 4.7</td>
</tr>
<tr>
<td>Kolbach index %</td>
<td>36 - 42</td>
</tr>
</tbody>
</table>
# Recommended Specifications

**European crop 2-row spring barley malt**

<table>
<thead>
<tr>
<th>Malt analysis</th>
<th>Specifications</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friability</td>
<td>%</td>
</tr>
<tr>
<td>Whole kernels</td>
<td>%</td>
</tr>
<tr>
<td>Turbidity (20 °C)</td>
<td>EBC</td>
</tr>
<tr>
<td>Sieving test: 2.8/2.5 mm</td>
<td>%</td>
</tr>
<tr>
<td>Sieving test: &lt; 2.5 mm</td>
<td>%</td>
</tr>
<tr>
<td>Grading: rejects</td>
<td>%</td>
</tr>
<tr>
<td>Grading: dust</td>
<td>%</td>
</tr>
<tr>
<td>Share of other barley varieties</td>
<td>%</td>
</tr>
<tr>
<td>Diastatic power</td>
<td>°WK</td>
</tr>
<tr>
<td>DMS-Precursor</td>
<td>ppm</td>
</tr>
<tr>
<td>Calcofluor (modification)</td>
<td>%</td>
</tr>
</tbody>
</table>

* 6-row min. 350
Congress Mash

For more than 100 years (developed in 1907) the congress mash is a standardized procedure in malt analysis in order to determine the extract content of the malt. In the course of this determination also run off time, saccharification, pH, turbidity, colour, colour of boiled wort, viscosity and soluble nitrogen are analysed.

Extract

Extract is the sum of all solids in a watery solution (sugar, protein, minerals etc). The extract content is the essential part of the malt quality, so its determination is absolutely necessary for every malt analysis. Usually, one specifies, with regard to the barley variety, minimum demands of 79,5 to 82 % extract dry matter.
Congress Mash

Mash in with 150 ml of dist. Water at 45-46°C, while permanently stirring.
Mash exactly for 30 minutes at 45 °C
Raise mashing temperature up to 70 °C (rate 1 °C/min)
Fill in 100 ml of dist. water (70 °C)
After 10 minutes check out the saccharification. If it is not saccharified yet, check again every 5 min.
Mash for 1 hour at 70 °C. then cool down to room temperature 20 °C.
Add dist. water to the vessel, so that the total content of the vessel is exactly 450,0 g.
Filter the mash about folded filter reversing the first 100 ml
Brewhouse Yield

\[ A = \frac{V \cdot GV\% \cdot 0,96}{S} \]

OBY 98,5-99,0 % referred to Kongress fine grist yield (Lautertun)

OBY 101 % referred to Kongress fine grist yield (Mashfilter)
Gelatinization of Cereals

Optimum of β-amylase: 62 °C

Temperature of gelatinisation

Barley
Malt
Maize
Rice
Intensive mashing

- Improves brewhouse yield
- Improves possible attenuation
- Degrades protein
  - high FAN content
  - low content in large protein molecules
- Energy intense
Mechanical Analyses: Friability

A quick and simple method, which gives first information on the modification of the malt.

The friability is measured by the use of a mechanical abrasion (grinding) process (during a certain period of time).

Also: Difference between fine and coarse grist in congess mash (not state of the art anymore)
Starch in barley kernels
Modification during malting
Measuring of Homogeneity Using Calcofluor Staining
[‘Carlsberg Method‘]

β-glucan
CORRELATION BETWEEN β-GLUCAN CONTENT AND FILTERABILITY

\[ y = 1E+07x^{-1.953} \]

\[ r = 0.222 \]
CORRELATION BETWEEN β-GLUCAN GEL AND FILTERABILITY

\[ y = 81.388x^{-0.357} \]

\[ r = 0.841^{**} \]
Evaluation of esser Test acc. To MEBAK:

< 50 not good
50 – 100 good
> 100 very good

<table>
<thead>
<tr>
<th>CCV</th>
<th>Filtrate after 60 s [ml]</th>
<th>Filtrate after 300 s [ml]</th>
<th>V_{\text{max}}</th>
<th>Yeast in Suspension [/ml]</th>
<th>ß-Glukan-Gel content</th>
</tr>
</thead>
<tbody>
<tr>
<td>18</td>
<td>24</td>
<td>44</td>
<td>56</td>
<td>1,6 x 10^6</td>
<td>14 ppm</td>
</tr>
<tr>
<td>21</td>
<td>22</td>
<td>34</td>
<td>40</td>
<td>1,5 x 10^6</td>
<td>8 ppm</td>
</tr>
</tbody>
</table>

Analytical error:
~ 10 ppm !
Danger of β-glucan-gel formation
Nitrogen Determination

The determination of the nitrogen contents resp. the different protein fractions in barley, malt, wort and beer is of significant importance, because:
the protein content of barley correlates directly negative with the extract content.

Certain nitrogen fractions in wort and beer are responsible for foam, yeast nutrition and non-biological stability.
AMINO ACIDS AND THEIR CORRESPONDING ALCOHOLS

- Threonine → n-Propanol
- Valine → Isobutylalcohol
- Leucine → Isoamylalcohol
- Isoleucine → Optically active amylalcohol
- Phenylalanine → Phenylethanol
TYPICAL BEHAVIOUR OF TOTAL VDK DURING FERMENTATION

Pattern A

FAN content [ppm]

Fermentation time [h]

Pattern B

Total VDK content [ppm]

Fermentation time [h]
Yeast metabolism

- S-Methyl-methionine (SMM)
- S-Amino acids
- Methionine
- Cystine
- Cysteine
- S
- H₂S
- CO₂ – purge!

Reactions:
- SO₃²⁻
- SO₄²⁻
- S₂O₃⁻
## Minimal amount of FAN

<table>
<thead>
<tr>
<th>FAN-content of pitching wort [ppm]</th>
<th>Yeast multiplication in $10^6$ cells per mL</th>
<th>Average attenuation daily in m%</th>
</tr>
</thead>
<tbody>
<tr>
<td>110</td>
<td>≈ 30</td>
<td>≈1.25</td>
</tr>
<tr>
<td>130</td>
<td>≈ 40</td>
<td>≈1.40</td>
</tr>
<tr>
<td>150</td>
<td>≈ 50</td>
<td>≈1.60</td>
</tr>
</tbody>
</table>
Key parameters of wort boiling

DMS – reformation in Whirlpool

- Kettle-full
- Cast-out
- Middle of cooling

Brewing Conference Bangkok 2011
DMS IN MALT

Formation of Dimethyl sulphide (DMS)

S-methylmethionine formed by protein degradation during germination

Thermal degradation of SMM during kilning

Dimethyl sulphide (DMS)

DMSO !!
Conclusion

Traditional malt analysis tells you if you have a good malt quality.

Certain parameters that might be important for the brewing process are not part of standard analyses.