No Barley, No Beer

Ed Ruble

Great Lakes Hop and Barley Conference
The Soul of Beer

- Color
- Flavor
- Body
- Nutrients for Yeast
  - Vitamins, Minerals, Sugar
Why Barley?

• Evidence of barley dating back 23,000 years.
• First domesticated about 10,000 years ago
  – Very broad environmental range.
• Reinheitsgebot (1487)
  – Specified the only ingredients that could be used in the production of beer were water, barley and hops (no yeast until late 19th century).
  – Prevent price competition with wheat and rye.
The Evolution of Malting Barley

- Proper relationship between protein and starch
- Unique enzyme systems
- Husk to protect malted grain
- Husk to provide filter bed
- Characteristic flavor combination
How do You use Malt?
Upper Hand Brewery – 25bbl

Bell’s Comstock Brewery - 50bbl
Malting Objectives

• Carbohydrate Modification
• Protein Modification
• Accessible Extract
• Sufficient Enzymes
• Desired Color/Flavor
High Quality Barley

• Clean and free of silage and other grains.
• Bright.
• Low moisture ~14% upon delivery to the maltster
• Free of disease:
  – Fusarium Head Blight (FHB or scab) leads to high levels of mycotoxin deoxynovalenol (DON or vomitoxin)
  – Ergot leads to dark shriveled kernels.
• Minimal pre-sprout.
Malting Process

• Steeping (in water)
  – Washes the grain
  – Increases the moisture from $+12\%$ to $+44\%$

• Germination (Sprouting)
  – Sprouting of barley seed
  – Increases enzymes
  – Softens grain

• Kilning (Drying)
Malting Process

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Physical Changes in Germination

Day 1

Day 3

Day 5
Group of women maltsters, Bass, Burton-on-Trent

Date: 6 March 1917

Description: Women maltsters posing with their shovels and forks outside a Bass Malthouse. The picture would have been taken outside either Shobnall, Station Street or Wetmore Road Maltings.
SALADIN MALTING SYSTEM
MANUFACTURED BY
SALADIN MALTING
CONSTRUCTION CO.
MINNEAPOLIS MINN. U.S.A.
Malting Process

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  – Washes the grain
  – Increases the moisture from ± 12% to ± 44%

• Germination (Sprouting)
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• Kilning/Roasting (Drying)
Kilning: Objectives

Arrest or terminate malting process
Reduce moisture to levels suitable for grain storage
Stabilize enzyme complexes developed during malting
Develop color and flavor (both taste and aroma) characteristics as required by the brewer
Direct Fire Kilning
Nitrosamines in Malt

Nitrosamines are highly carcinogenic and are formed in malt that is roasted over open fire.
Nitrogen oxide gases react with amines in the malt to form nitrosamines such as NDMA.
Indirect heating has dropped levels by over 50x
Nitrosamines generated during malt production will pass into beer.
Indirect Kilning
Important Malt Specs

• Extract
  – Coarse Grind, As Is
• Color and Flavor
• Diastatic Power
• Kolbach Index
  – Soluble Protein/Total Protein
• Beta Glucan Level
Extract

• Very dependent on variety and growing region.
• Is consumed during the malting process:
  – Keep to a minimum
  – Critical for color formation in Kilning
Color and Flavor

• Low color factors:
  – Low Protein barley
  – Undermodification
  – Low temperature drying

• Heavily dependent on kilning or roasting process.
Louis Camille Maillard
b.1878 – d.1936
French physician and chemist

Described the very important browning reactions responsible for the flavors of Coffee and Chocolate called the “Maillard reactions”
Melanoidin Flavors

- Off flavours (bitter)
- Off aromas (burnt, onion, cabbage)
- Positive aromas (malty, bread crust-like, caramel, coffee, roasted).
- Sweet, Nutty, Butterscotch

- Molasses, coffee, fermented soy beans, cocoa products, green peas, cooked beef, Gouda, wine grapes, raw asparagus, beets, carrots, lettuce, Bell peppers

No class of flavor compounds has been shown to be as important in foods
Diastatic Power

• Base 2 Row
  – 160 is supper hot
  – <140 is a problem
• 90-110 Pale Ale Malt (3.5 Lov.)
• 45-50 Munich
Malting and Brewing Enzymes

Protein Degradation Enzymes
proteases - proteolytic enzymes

Starch Degrading Enzymes
Amylases - Hydrolyze Starch in the Saccharification Stage
\[ \beta \] - amylase
\[ \alpha \] - amylase
Figure 17. Hydrolysis of Amylopectin by Beta-Amylase. Dotted line delineates extent of hydrolysis.\textsuperscript{(58)}
Barley Protein

• Lower protein barley helps to keep FAN down.
• Total Protein Specification for barley input
  – <10.5 in Europe
• Western Irrigated 2-row Barley is lowest
  – 10-9.8 protein is great.
• Will loose ~0.25% through malting process
### Soluble Protein

<table>
<thead>
<tr>
<th></th>
<th>12.0%</th>
<th>9.5%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Protein</td>
<td></td>
<td></td>
</tr>
<tr>
<td>S/T</td>
<td>48.0%</td>
<td>38.0%</td>
</tr>
<tr>
<td>Soluble Protein</td>
<td>5.8%</td>
<td>3.6%</td>
</tr>
</tbody>
</table>
Beta Glucan

• “Best” measure of carbohydrate modification. Maltster don’t want to be held to this but they run the malt house on it.

• No problems when <140 on 2 row, 120 max. would be good, 80-90 would be best
AMBA

• American Malting Barley Association
  
  — “Encourage and support an adequate supply of high quality malting barley for the malting, brewing, distilling, and food industries and increase our understanding of malting barley”
AMBA Research Grant Program

Direct funding of public sector breeding programs and supporting research

[Map showing locations with stars and universities labeled: OSU, WSU, ARS, MSU, NDSU, UW, UM, UN, CSU, UN, UC-Davis, A&M, VT, ARS, VU, ARS]
Approved 2-Row Varieties

- AC Metcalfe
- CDC Copeland
- CDC Meredith
- Charles
- Conlon
- Conrad
- Expedition
- Harrington
- Hockett
- Merit
- Merit 57
- Moravian 37
- Moravian 69
- Pinnacle
- Scarlett
- Wintmalt.
# Maltig barley breeding guidelines

## Ideal commercial malt criteria

<table>
<thead>
<tr>
<th>AMBA Member Interest*</th>
<th>Six-Row</th>
<th>Adjunct Two-Row</th>
<th>All Malt Two-Row</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Barley Factors</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Plump Kernels (on 6/64)</td>
<td>&gt; 80%</td>
<td>&gt; 90%</td>
<td>&gt; 90%</td>
</tr>
<tr>
<td>Thin Kernels (thru 5/64)</td>
<td>&lt; 3%</td>
<td>&lt; 3%</td>
<td>&lt; 3%</td>
</tr>
<tr>
<td>Germination (4ml 72 hr. GE)</td>
<td>&gt; 98%</td>
<td>&gt; 98%</td>
<td>&gt; 98%</td>
</tr>
<tr>
<td>Protein</td>
<td>≤ 13.0%</td>
<td>≤ 13.0%</td>
<td>≤ 12.0%</td>
</tr>
<tr>
<td>Skinned &amp; Broken Kernels</td>
<td>&lt; 5%</td>
<td>&lt; 5%</td>
<td>&lt; 5%</td>
</tr>
</tbody>
</table>

*Based on a survey of AMBA’s regular members. June, 2014

American Malting Barley Association, Inc.
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<tbody>
<tr>
<td></td>
<td>20%</td>
<td>55%</td>
<td>25%</td>
</tr>
</tbody>
</table>

**Malt Factors**

<table>
<thead>
<tr>
<th>Total Protein</th>
<th>≤ 12.8%</th>
<th>≤ 12.8%</th>
<th>≤ 11.8%</th>
</tr>
</thead>
<tbody>
<tr>
<td>on 7/64 screen</td>
<td>&gt; 60%</td>
<td>&gt; 70%</td>
<td>&gt; 75%</td>
</tr>
</tbody>
</table>

**Measures of Malt Modification**

<table>
<thead>
<tr>
<th>Beta-Glucan (ppm)</th>
<th>&lt; 120</th>
<th>&lt; 100</th>
<th>&lt; 100</th>
</tr>
</thead>
<tbody>
<tr>
<td>F/C Difference</td>
<td>&lt; 1.2</td>
<td>&lt; 1.2</td>
<td>&lt; 1.2</td>
</tr>
<tr>
<td>Soluble/Total Protein</td>
<td>42-47%</td>
<td>40-47%</td>
<td>38-45%</td>
</tr>
<tr>
<td>Turbidity (NTU)</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
<td>&lt; 10</td>
</tr>
<tr>
<td>Viscosity (absolute cp)</td>
<td>&lt; 1.50</td>
<td>&lt; 1.50</td>
<td>&lt; 1.50</td>
</tr>
</tbody>
</table>
# Maltting Barley Breeding Guidelines

## Ideal Commercial Malt Criteria

<table>
<thead>
<tr>
<th>Congress Wort</th>
<th>Six-Row</th>
<th>Adjunct Two-Row</th>
<th>All Malt Two-Row</th>
</tr>
</thead>
<tbody>
<tr>
<td>Soluble Protein</td>
<td>5.2-5.7%</td>
<td>4.8-5.6%</td>
<td>&lt; 5.3%</td>
</tr>
<tr>
<td>Extract (FG db)</td>
<td>&gt; 79.0%</td>
<td>&gt; 81.0%</td>
<td>&gt; 81.0%</td>
</tr>
<tr>
<td>Color (°ASBC)</td>
<td>1.8-2.5</td>
<td>1.6-2.5</td>
<td>1.6-2.8</td>
</tr>
<tr>
<td>FAN</td>
<td>&gt; 210</td>
<td>&gt; 210</td>
<td>140-190</td>
</tr>
</tbody>
</table>

## Malt Enzymes

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<th>Six-Row</th>
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<th>All Malt Two-Row</th>
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</thead>
<tbody>
<tr>
<td>Diastatic Power (°ASBC)</td>
<td>&gt; 150</td>
<td>&gt; 120</td>
<td>110-150</td>
</tr>
<tr>
<td>Alpha Amylase (DU)</td>
<td>&gt; 50</td>
<td>&gt; 50</td>
<td>40-70</td>
</tr>
</tbody>
</table>

### General Comments
- Barley should mature rapidly, break dormancy quickly without pregermination and germinate uniformly.
- The hull should be thin, bright and adhere tightly during harvesting, cleaning and malting.
- Malted barley should exhibit a well-balanced, modification in a conventional malting schedule with four day germination.
- Malted barley must provide desired beer flavor.

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American Malting Barley Association, Inc.
Malt Usage at Bell’s
Some Numbers

• 2015 Anticipated Usage ~25MM lbs
  – Bulk trucks – 50,000 lbs (10/week)
  – Super sacks – 2000 lbs
  – Bags – 50 lbs

• Capacity to store ~1MM lbs on site
  – 16 bulk bins, 2 silos (50k lbs each)
  – 10 specialty bins (4000 lbs each)
Malt Handling

• As gentle as possible
  – Bucket elevators
  – Drag conveyors
  – Chain disc conveyors

• Controlled Pneumatic Transfers
  – Not to fast
  – Long radius elbows
Michigan Malt
Barley Farm

- Bell’s Farm ~200 acres in Shepherd, MI
- Turnwald Farms
- Conrad barley
  - Developed as a Western 2-Row variety
  - Susceptible to higher protein levels
- Testing new varieties.
Barley Harvest
2014
Malting MI Barley

• Up to 80 bushels/acre (depending on season)
• Briess – Waterloo (Pale), Chilton (C-120 and flakes)
• Barley Quality (can vary depending on the season):
  – Higher protein 13.5-15 (nitrogen application)
  – Some staining is typical
  – Lower plumps 80-90%
  – Some pre-sprout is typical
  – Watch for increased DON levels
New Varieties

• Alternate varieties tested:
  – Voyager – AB-I
  – Pinnacle - public
  – ND Genesis – public (still in development)
  – Expedition – MaltEurop

• Seed stock of more traditional MI lines.
NO BARLEY
NO BEER
Credits

• John Mallett
  – Director of Production at Bell’s Brewery
  – Author of *Malt – A Practical Guide from Field to Brewhouse*

• Mike and Kevin Turnwald

• Scott Hiesel - AMBA
Thank You!
eruble@bellsbeer.com
www.bellsbeer.com