Do North American varieties meet the needs of all-malt distillers?

Aaron MacLeod
42ND Barley Improvement Conference
January 10, 2019
Our Mission

- Support **growth** and **innovation** in craft food and beverage production through quality testing, technical support, research & education.
Investment

- The Center was awarded a total of $1,125,000 in start-up funding from federal, state, and private sources
  - Empire State Development
  - USDA Rural Business Development
  - Appalachian Regional Commission
  - George Alden Trust
Megan Douglass

Rachel Truland
## Grain Quality Testing

<table>
<thead>
<tr>
<th>Test Description</th>
<th>Fee</th>
</tr>
</thead>
<tbody>
<tr>
<td>Malting Barley Selection (Moisture, Protein, Plumpness, Test Weight, Germination, RVA, &amp; DON)</td>
<td>$75</td>
</tr>
<tr>
<td>Moisture and Protein</td>
<td>$15</td>
</tr>
<tr>
<td>Starch</td>
<td>$25</td>
</tr>
<tr>
<td>Germination Energy (4mL, 8mL &amp; Capacity)</td>
<td>$20</td>
</tr>
<tr>
<td>RVA (pre-harvest sprout damage)</td>
<td>$25</td>
</tr>
<tr>
<td>Cereal Extract (ASBC Cereals-5)</td>
<td>$100</td>
</tr>
<tr>
<td>β-glucan</td>
<td>$75</td>
</tr>
<tr>
<td>DON (ELISA)</td>
<td>$35</td>
</tr>
</tbody>
</table>
## Malt Quality Testing

<table>
<thead>
<tr>
<th>Service Description</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Full Malt Analysis</strong> — (Moisture, Assortment, Friability, Fine Extract, Coarse Extract, F/C Difference, β-glucan, viscosity, FAN, soluble protein, S/T, DP, α-amylase, color, pH, filtration time, clarity)</td>
<td>$150</td>
</tr>
<tr>
<td><strong>Basic Malt Analysis</strong> — (Moisture, Friability, Fine Extract, β-glucan, FAN, DP, α-amylase, color, filtration time, clarity, pH)</td>
<td>$75</td>
</tr>
<tr>
<td><strong>Enzymes Only</strong> — (Diastatic Power &amp; α-amylase)</td>
<td>$50</td>
</tr>
<tr>
<td><strong>Specialty Malt Analysis</strong> — for high-dried and caramel malt</td>
<td>$25</td>
</tr>
<tr>
<td>(Moisture, Extract, Color)</td>
<td></td>
</tr>
<tr>
<td><strong>Phenol</strong> — for peated malt</td>
<td>$85</td>
</tr>
<tr>
<td><strong>Fermentability</strong> — (Apparent Attenuation Limit)</td>
<td>$125</td>
</tr>
<tr>
<td><strong>Predicted Spirit Yield</strong> — (PSY)</td>
<td>$175</td>
</tr>
<tr>
<td><strong>Gycosidic Nitrile</strong> — (GN)</td>
<td>$225</td>
</tr>
</tbody>
</table>
Micro-malting

- 200 gram to 10 kg sample capacity
- Variety & Agronomic Trials
  - Cornell
  - Penn State
  - Virginia Tech
  - North Carolina Department of Agriculture
  - North Carolina State University
  - UC Davis Extension
  - Oregon State University
  - Washington State University
A Tale of Two Distillers...

- **Grain Whisky**
  - Use primarily un-malted cereals (corn, wheat, rye, etc) as source of fermentable extract
  - A small amount of highly enzymatic malt (and/or exogenous enzymes)

- **All-Malt Whisky**
  - Use 100% malted barley
  - Must provide *both* fermentable extract *and* enzymes
### Functional Malt Needs

<table>
<thead>
<tr>
<th></th>
<th>Grain Distilling</th>
<th>All-Malt Distilling</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Protein, % DB</strong></td>
<td>High</td>
<td>Low</td>
</tr>
<tr>
<td><strong>Extract, % DB</strong></td>
<td>Low</td>
<td>High</td>
</tr>
<tr>
<td><strong>Diastatic Power, °L</strong></td>
<td>Very High</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Alpha Amylase, DU</strong></td>
<td>Very High</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>FAN, mg/L</strong></td>
<td>Very High</td>
<td>Moderate</td>
</tr>
<tr>
<td><strong>Spirit Yield</strong></td>
<td>-</td>
<td>Maximum</td>
</tr>
<tr>
<td><strong>Glycosidic Nitrile</strong></td>
<td>Low</td>
<td>Very Low</td>
</tr>
</tbody>
</table>
Glycosidic Nitrile

- Epiheterodendrin (EPH) is a glycosidic nitrile (GN) produced in a range of concentrations during the malting process.

- The use of malt with high GN content in distilling can produce significant levels of Ethyl Carbamate (EC) which is a potential carcinogen and regulated in some markets (Canada & EU).
How does it happen?

Genetic Control

- EPH pathway leucine derived through action of two cytochrome P450 enzymes, cyp79 and cyp71.
- Classification of geneotypes possible using molecular markers
- Barley varieties are typically categorized according to their propensity to produce GN as follows:
  - Non-producer: < 0.5 g/tonne
  - Low-Producer: 0.5 – 1.5 g/tonne
  - High-Producer: > 1.5 g/tonne
Quantitative Method (EBC 4.21)

- 1 hour mash @ 65° with β-glucosidase
- The cyanide in the form of hydrocyanic acid (HCN) is captured by distillation.
- The resulting CN is determined photometrically by reaction with chloramine-T to give a violet colored complex.
Effect of germination time on GN levels in malt for six different barley varieties.

Effect of germination moisture and temperature on GN levels in malt for three different barley varieties

What did we learn?

- Varieties of malting barley grown in North America exhibit a range of GN levels. There are examples of both non-, low, and high producing varieties.

- The following conditions can increase levels of GN in malt:
  - longer germination time
  - higher germination moisture
  - higher germination temperature

- Varieties responded differently to the changes in processing conditions suggesting a Genotype X Process interaction effect.
Spirit Yield

- Represents alcohol production potential per malt weight
- Reported as Liters Absolute Alcohol / tonne (LAA/tonne)
- Product of Extract & Fermentability
  - Positively correlated with Extract
  - Negatively correlated with grain protein
  - Positively correlated with Fermentability
Variety Comparison
Comparative Extract

Bar chart showing the hot water extract (%) for different products: Genie, Pinnacle, Copeland, Newdale, ND Genesis, Endeavor, Scala, Concerto, Odyssey.
Comparative Fermentability
Effect of grain protein on spirit yield
Variety X Protein interaction effect
Breeding for high spirit yield

- **Factors that promote high extract**
  - Low grain protein
  - Fast modification
  - High alpha amylase
  - Soft grain texture (mealiness)

- **Factors that promote fermentability**
  - Balanced modification
  - Starch structure / gelatinization temperature
  - Diastatic power / Limit dextrinase
  - Heat stable β-amylase?
Two decades of breeding enhancement in the UK

*Brighurst. J. Inst. Brew. 2015; V:121: 1–18*
Current Status

- International varieties are available which meet the standards, but not well adapted to all growing regions
- There are currently no commercialized non-GN winter barley varieties
- North American varieties lag in terms of quality factors for all-malt distilling
- Breeding can be successful:
  - Genetic variation
  - Ability to phenotype / genotype
Next Steps...for all of us!

- Determine the relationships between extract, fermentability, spirit yield and their relationships to other traits & characteristics

- Combine genes for non-GN and high spirit yield in both spring and winter barley genotype with excellent malting quality with adaption for North American growing regions