Falling number in wheat
- How is it calculated and what does it mean to producers?

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Weather is always a challenge beyond our control

“Strange weather patterns persist with snow only falling on states whose names start with an 'N.'”

“Should we blame this on the church or the state?”
Pre-harvest sprouting (PHS)

- Wheat germinates within the grain head prior to harvest.
- Occurs when wet conditions delay harvest.
- White varieties are more susceptible to PHS than red ones under similar environmental conditions.
- Higher PHS risks for genotypes with a short dormancy period.
- Increased hydrolytic enzyme activities such as $\alpha$-amylase, $\beta$-amylase, and protease - starch and protein breakdown.
- Reduced grain yield and quality – economic losses and down-graded wheat.
PHS resistance

Abscisic acid (ABA) is essential for seed maturation and enforces a period of seed dormancy.
- ABA levels decline as grain matures and after ripening.
- Red seed pigments slow the decline of ABA.
- Temperature during grain fill affects ABA levels.

(Cornell Univ.)
Effect of moisture and temperature during grain filling

Drier/cooler conditions generally produce seed with lower sprouting tendency.

(Thomason et al. 2009)
Measurements for PHS

- Visual scoring – official grade in FGIS
- Falling number
- Stirring number using Rapid ViscoAnalyzer (RVA)
- α-Amylase analysis
- Viscosity analysis with RVA or Amylograph
History of falling number method

- 1960  Sven Hagberg developed a rapid, original method for determining \( \alpha \)-amylase activity in sprout-damaged grain.
- 1961  Sven Hagberg named the method “falling-number” with a simple modification.
- 1962  Harald Perten founded Perten Instruments and commercialized falling number apparatus.
- 1968  International Association of Cereal Science and Technology approved the method as ICC Standard No. 107/1
- 1972  The method was implemented as an Official AACC Method 56-81B.
- 1982  The International Organization for Standardization approved the method as ISO 3093.
A kernel of wheat

Composition of flour

- Water: 13 – 14%
- Starch: 70 – 75%
- Protein: 9 – 14%
- Pentosans: < 2%
- Fat: < 1%
- Ash: < 1%
Germination process of seed

Barley Seed Germination

Cotyledon

Epicotyl

Radicle

STARCH

SUGAR

α-amylase

DNA

RNA

GA₃

Seed Coat

Endosperm

Aleurone Cells

Storage Protein

hydrolysis

Amino Acids

H₂O

imbibition

(http://plantphys.info/seedg)
Starch hydrolysis by α-amylase

www.indiana.edu/~oso/animations/An6.html

Amylose (20-30%)

Amylopectin (70-80%)
Effect of α-amylase addition on viscosity
(8% wheat starch paste at 37°C measured in the RVA)

(Ferry et al. 2004)
Starch pasting profiles of flour samples
(8% flour slurry by RVA, Chelsea, SWW wheat)
What is the falling number method?

- Measures the effect of the enzymes on wheat quality in flour or meal.
- Does not measure α-amylase activity directly, but measures the activity indirectly by quantifying the rheological properties of starch hydrolyzed by the enzymes during the test.
- Uses the starch in flour or meal as a substrate, gelatinizes the suspension rapidly in a boiling water bath, and measures the liquefaction of the starch by α-amylase.
- Measures the time in seconds required for a viscometer stirrer to fall a given distance through hot, aqueous flour gel undergoing liquefaction.
The relationship between FN and α-amylase

(Used with permission from Edward Souza)
How is a falling number test performed?

1. Grind sample & measure moisture.
2. Weigh 7 ± 0.05g meal or flour.
3. Dispense 25 ± 0.2 mL distilled water.
4. Add flour.
5. Insert a stirrer.
6. Immerse.
7. Stir & measure.
8. Shake.

Particle size <0.8 mm meal or flour.
How is a falling number calculated?

Falling Number = 5 sec stand + 55 sec stirring + time taken to fall in sec

Example: 300 FN = 5 + 55 + 240
Falling time and viscosity

Clear & watery soup

Faster falling = low FN = high $\alpha$-amylase activity

Slower falling = high FN = low $\alpha$-amylase activity

Creamy & thick soup

Drop a penny?
Factors affected falling number

- Altitude – FN increases as elevation increases.
- Nitrogen fertilization rate – increase or decrease in FN
- Temperature – higher FN in summer
- Late Maturity α-Amylase – lower FN
- Fungicide treatment – decrease in FN, cultivar dependent
- Fusarium infection – minor decrease in FN
- Waxy wheat – lower FN
Tips for reducing variations in FN result

- Prepare representative sample.
  - at least 300g of grain should be ground

- Use a hammer type grinder with a 0.8 mm sieve for preparing wheat meal.
  - particle size depends on grinder types and sieves

- Correct amount of sample
  - adjust moisture content, 7g ± 0.05 (14% moisture basis)

- Shaking method
  - uniform shaking by hand or automatic shaker (Shakematic®)

- Routinely check a reference sample.
  - use lower falling number sample (<300) as a reference
Whole meal FN vs Flour FN
(12 SWW & SRW cultivars, 3 harvest times)

Wheat meal Falling Number (FN) was significantly correlated with flour FN
### Interpretation of falling numbers

<table>
<thead>
<tr>
<th>Falling Number (sec)</th>
<th>Sprouting indication</th>
</tr>
</thead>
<tbody>
<tr>
<td>FN &gt; 300</td>
<td>No sprout damage</td>
</tr>
<tr>
<td>300 &gt; FN &gt; 200</td>
<td>Some sprouting</td>
</tr>
<tr>
<td>200 &gt; FN</td>
<td>Severe sprout damage</td>
</tr>
</tbody>
</table>
Bread quality (hard wheat)

Some α-amylase activity in flour is beneficial due to enhancing yeast fermentation. But, too much α-amylase activity in low falling number flour generates too much sugar which results in sticky dough, dark crumb and crust color, coarser crumb, and sticky and gummy texture.
Pasta/noodle quality

Pasta/noodle made with low FN flour is fragile, soft and mushy. More starch is lost to cooking water, making the water cloudy. Production problems with low FN flour - uneven extrusion, strand stretching, and irregularities in drying.
Japanese-type sponge cake quality

Wheat with a falling number of 140 resulted in a sponge cake volume equal to that of the control. As falling number decreased below 140, cake volume decreased sharply.

(Finney et al. 1981)
# Milling and baking quality of sprouted soft wheat

<table>
<thead>
<tr>
<th></th>
<th>1st harvest</th>
<th>2nd harvest</th>
<th>3rd harvest</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Chelsea</strong> (SWW)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test weight (lb/bu)</td>
<td>58.8</td>
<td>54.1</td>
<td>50.3</td>
</tr>
<tr>
<td>Break flour (%)</td>
<td>35.6</td>
<td>37.8</td>
<td>37.5</td>
</tr>
<tr>
<td>SG flour (%)</td>
<td>76.8</td>
<td>75.3</td>
<td>74.9</td>
</tr>
<tr>
<td>Falling number (sec)</td>
<td>344</td>
<td>211</td>
<td>88</td>
</tr>
<tr>
<td>Cookie dia. (cm)</td>
<td>8.2</td>
<td>8.3</td>
<td>8.5</td>
</tr>
<tr>
<td><strong>Pat</strong> (SRW)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Test weight (lb/bu)</td>
<td>61.9</td>
<td>57.1</td>
<td>54.9</td>
</tr>
<tr>
<td>Break flour (%)</td>
<td>33.6</td>
<td>37.6</td>
<td>38.7</td>
</tr>
<tr>
<td>SG flour (%)</td>
<td>77.5</td>
<td>75.6</td>
<td>75.5</td>
</tr>
<tr>
<td>Falling number (sec)</td>
<td>376</td>
<td>247</td>
<td>99</td>
</tr>
<tr>
<td>Cookie dia. (cm)</td>
<td>8.3</td>
<td>8.1</td>
<td>8.3</td>
</tr>
</tbody>
</table>
Wrap-up

- Falling number test is simple and practical.
- Visual scoring is generally correlated to falling number, but is not the same.
- For reliable FN results, consistent sample preparation and consistent test operation are necessary.
- Further questions on falling number, please contact edward.souza@ars.usda.gov or meera.kweon@ars.usda.gov at SWQL
Acknowledgements

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I can measure falling number now!!!