Falling number in wheat

- How is it calculated and what does it mean to producers?

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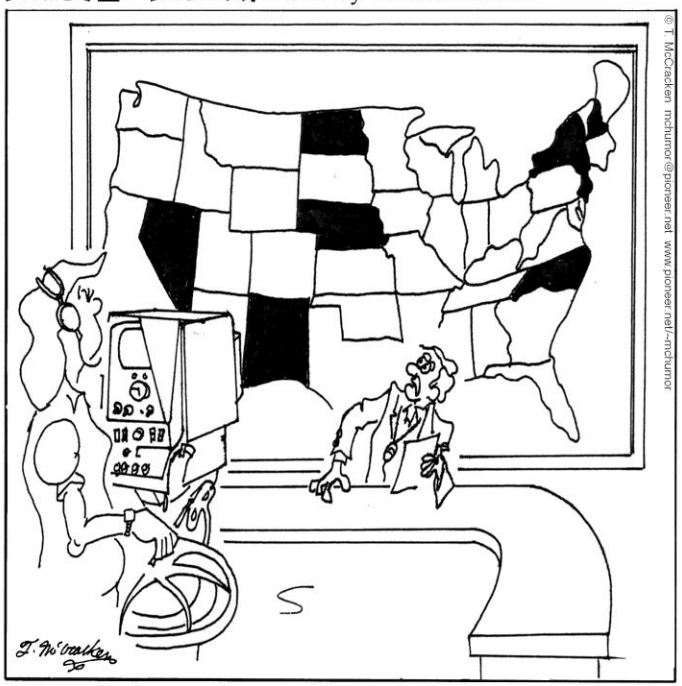
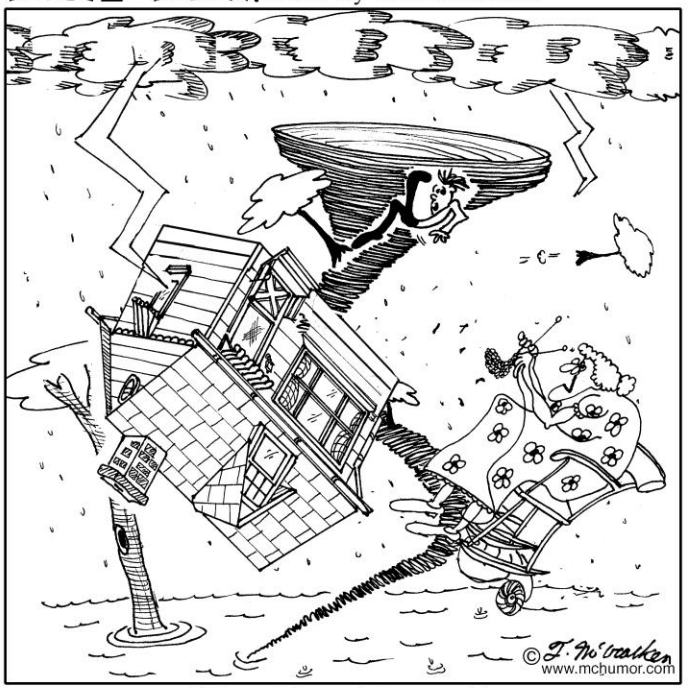
Weather is always a challenge beyond our control



"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)

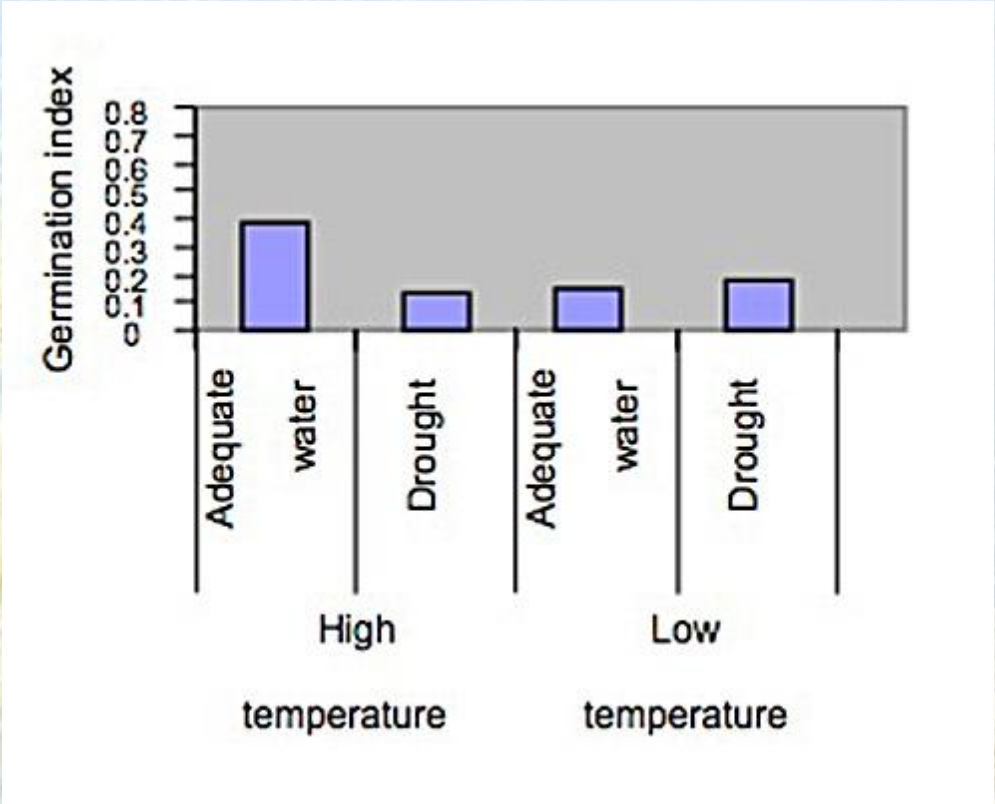
- Wheat germinates within the grain head prior to harvest.
- Occurs when wet conditions delay harvest.
- White varieties are more susceptible to PHS than red ones under similar environmental conditions.
- Higher PHS risks for genotypes with a short dormancy period.
- Increased hydrolytic enzyme activities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

PHS resistance

PHS resistance decreased from left to right (Cornell Univ.)

- 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.

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

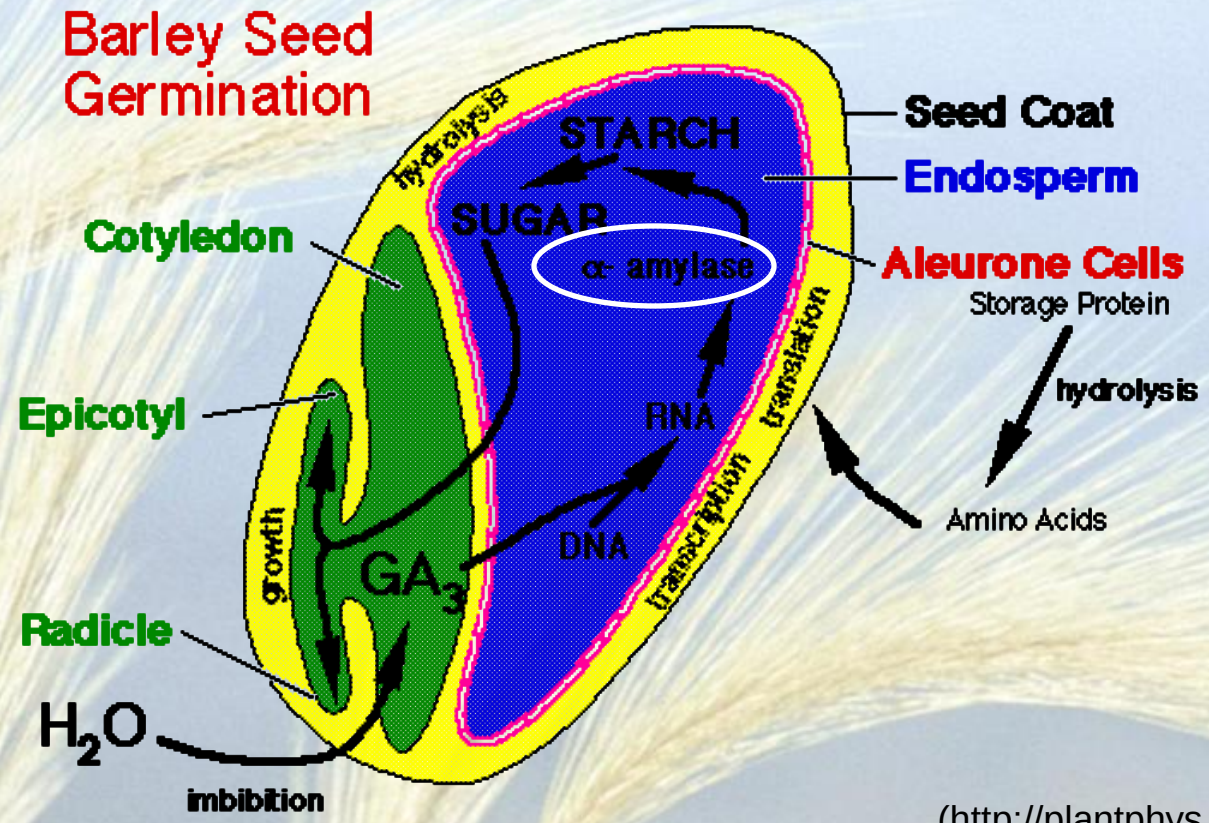
- 1960 Sven Hagberg developed a rapid, original method for determining α-amylase activity in sprout-damaged grain.
- 1961 Sven Hagberg named the method "falling-number" with a simple modification.
- 1962 Harald Perten founded Perten Instruments and commercialized falling number apparatus.
- 1968 International 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 %

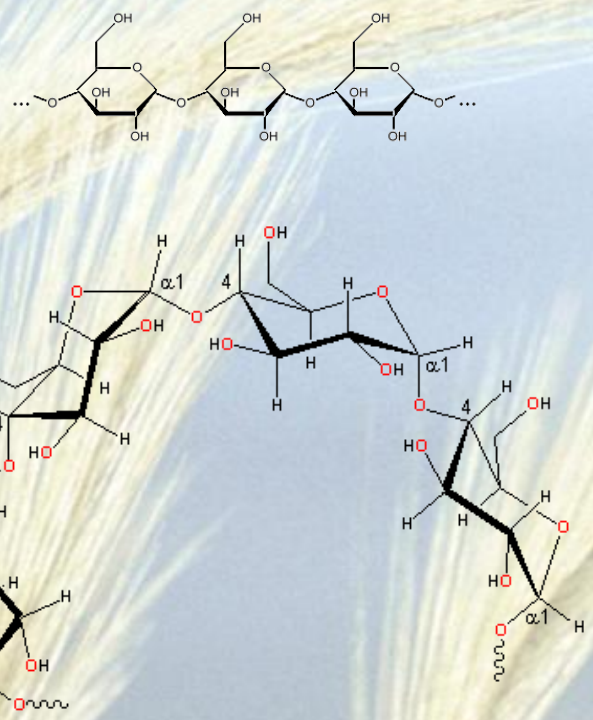
Germination process of seed



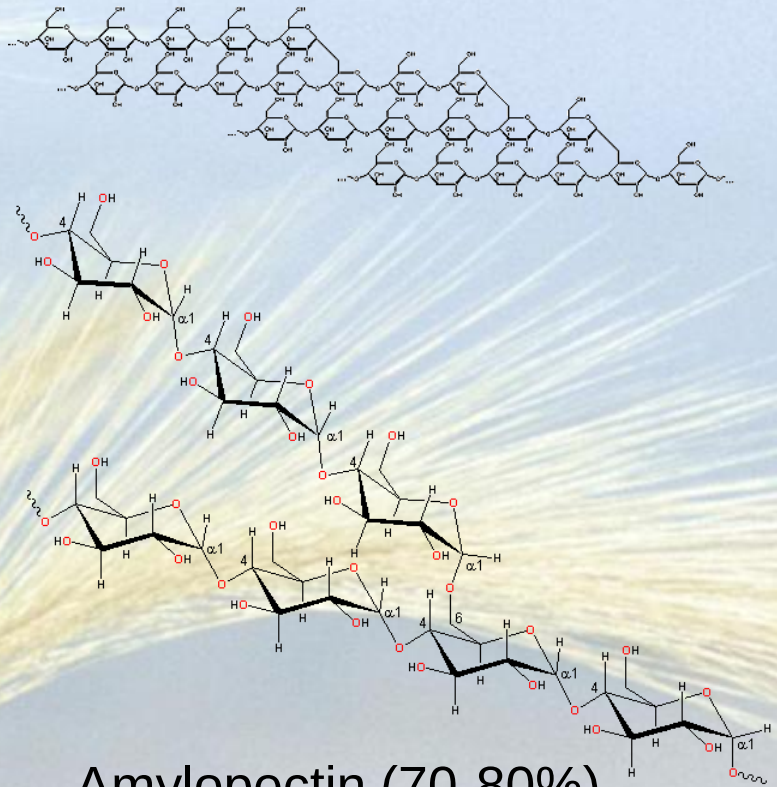
(http://plantphys.info/seedg)

Starch hydrolysis by α-amylase

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



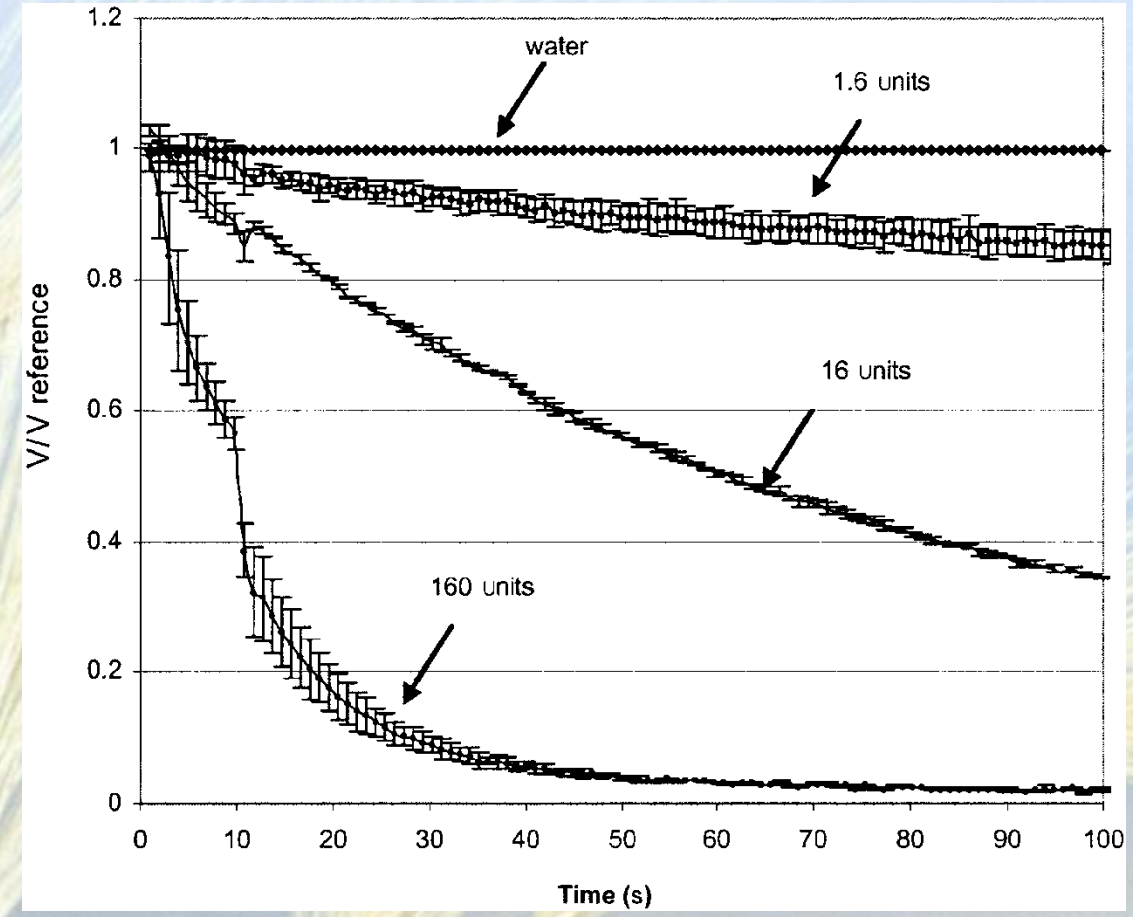
Amylose (20-30%)



Amylopectin (70-80%)

Effect of α-amylase addition on viscosity

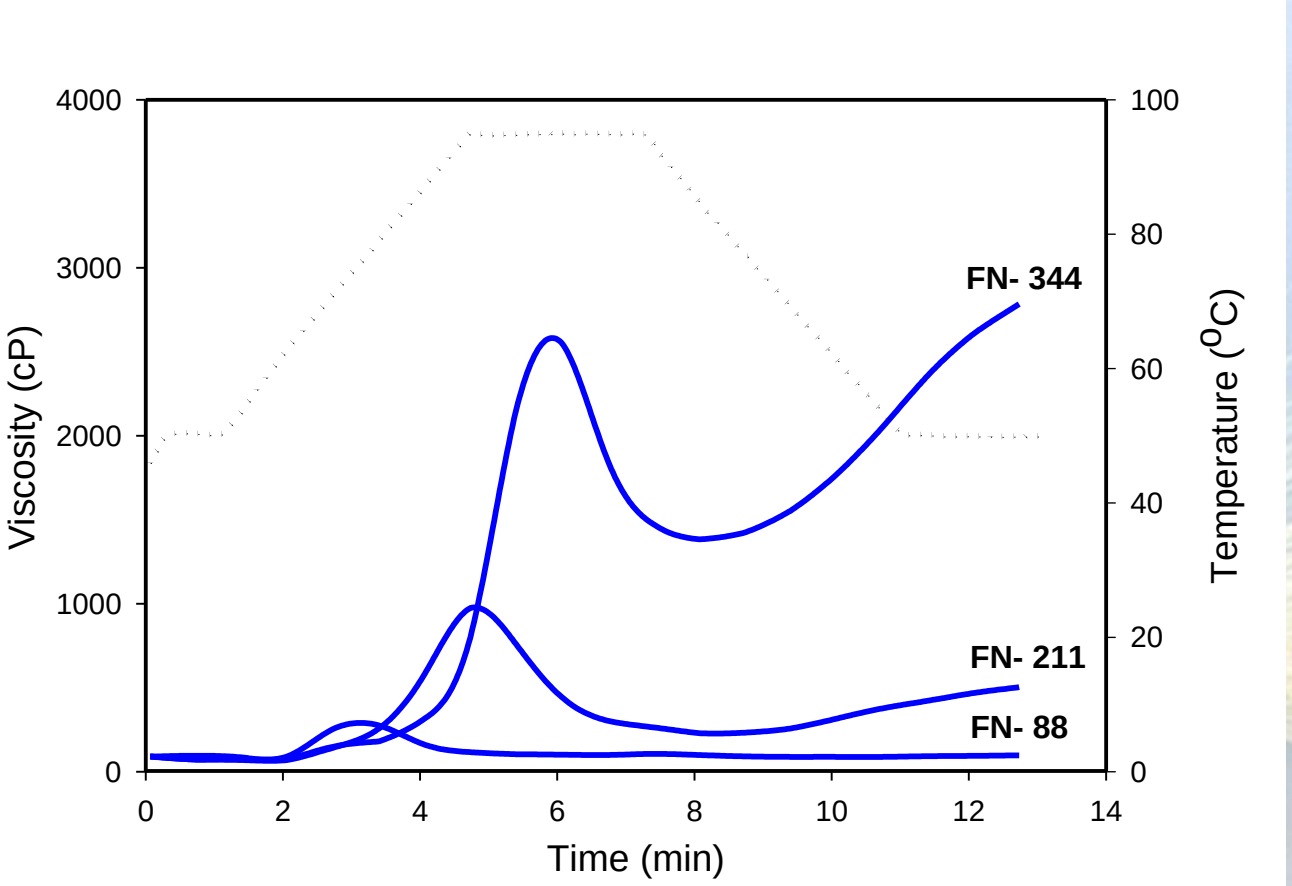
(8% wheat starch paste at 37ºC measured in the RVA)



(Ferry et al. 2004)

Starch pasting profiles of flour samples

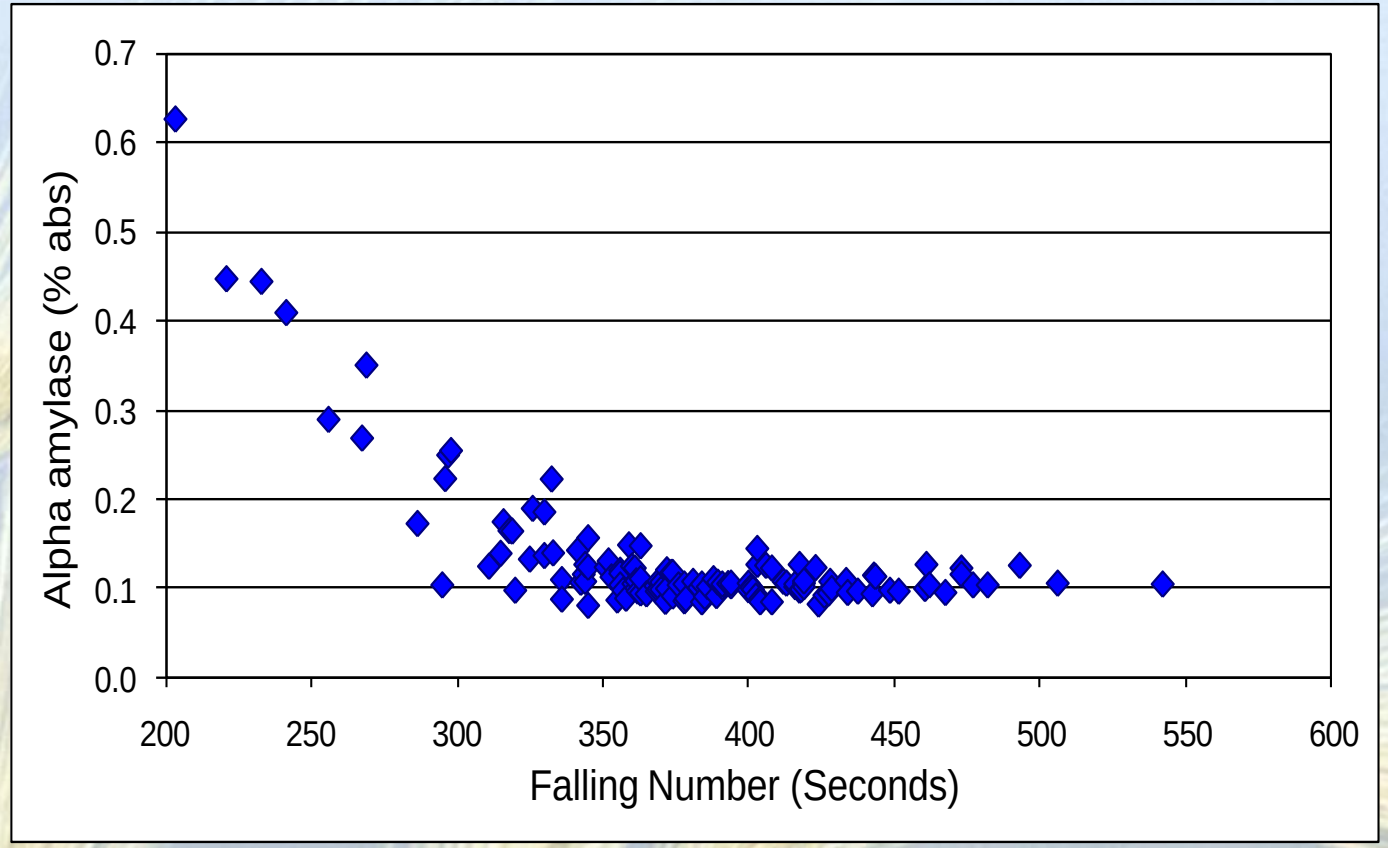
(8% flour slurry by RVA, Chelsea, SWW wheat)



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?

Grind sample & measure moisture.

Particle size <0.8 mm meal or flour

Weigh

7 ± 0.05g meal or flour

Dispense

25 ± 0.2 mL distilled water

Add flour

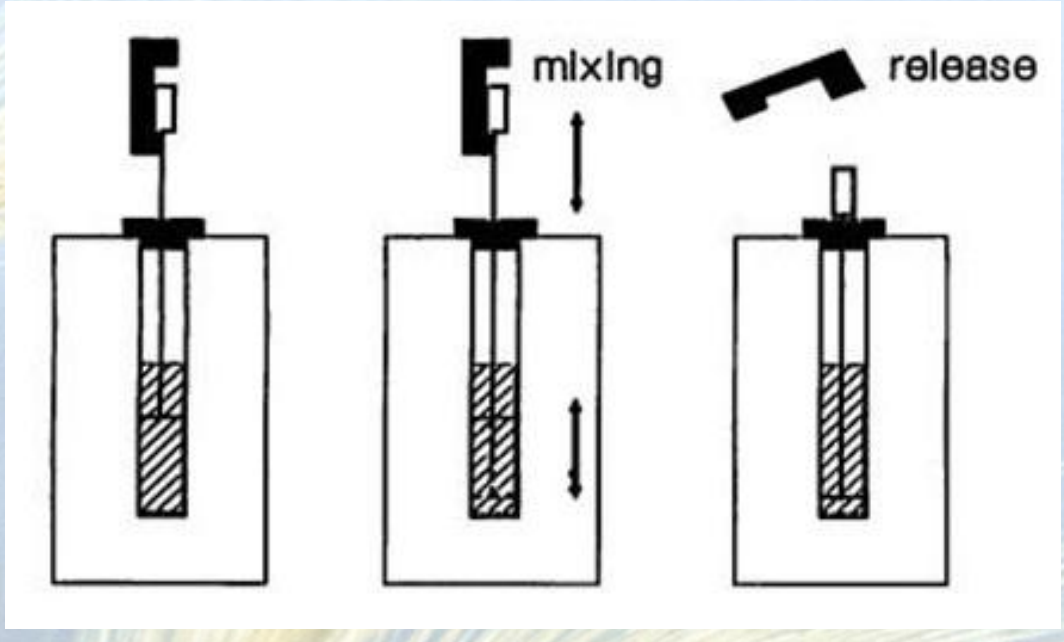
Shake

Insert a stirrer

Immerse

Stir & measure

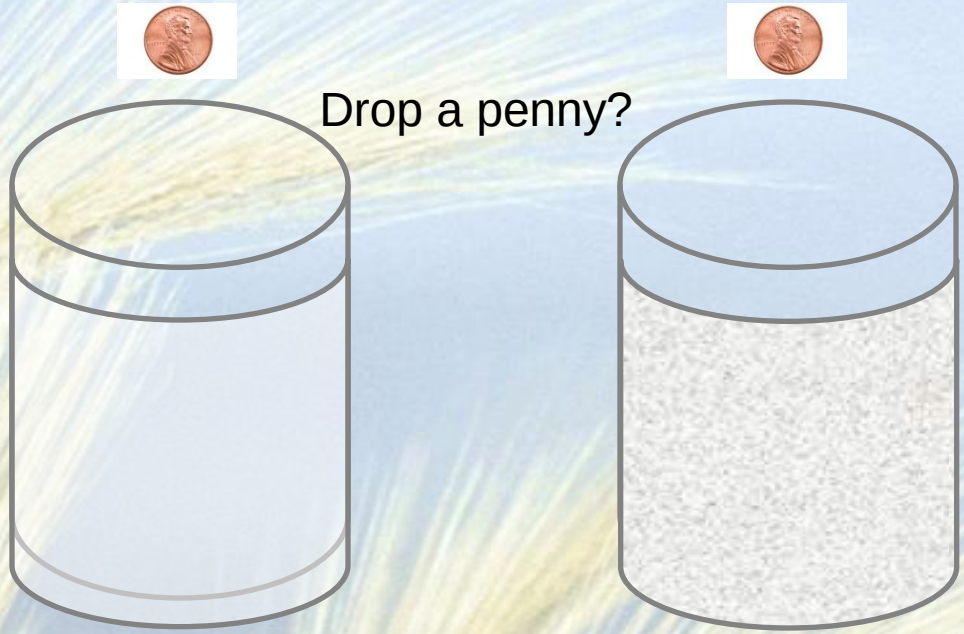
How is a falling number calculated?



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

Example: 300 FN = 5 + 55 + 240

Falling time and viscosity



Faster falling = low FN = high α-amylase activity
Slower falling = high FN = low α-amylase activity

Factors affected falling number

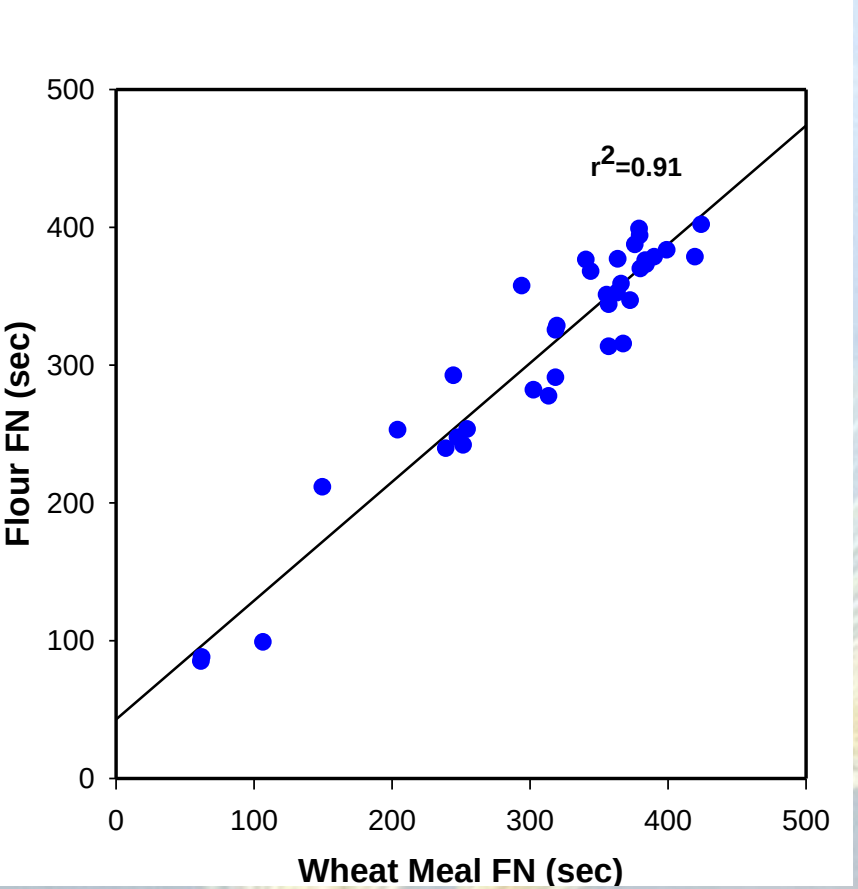
- Altitude –FN increases as elevation increases.
- Nitrogen fertilization rate – increase or decrease in FN
- Temperature – higher FN in summer
- Late Maturity α-Amylase – lower FN
- Fungicide treatment – decrease in FN, cultivar dependent
- Fusarium infection – minor decrease in FN
- Waxy wheat – lower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

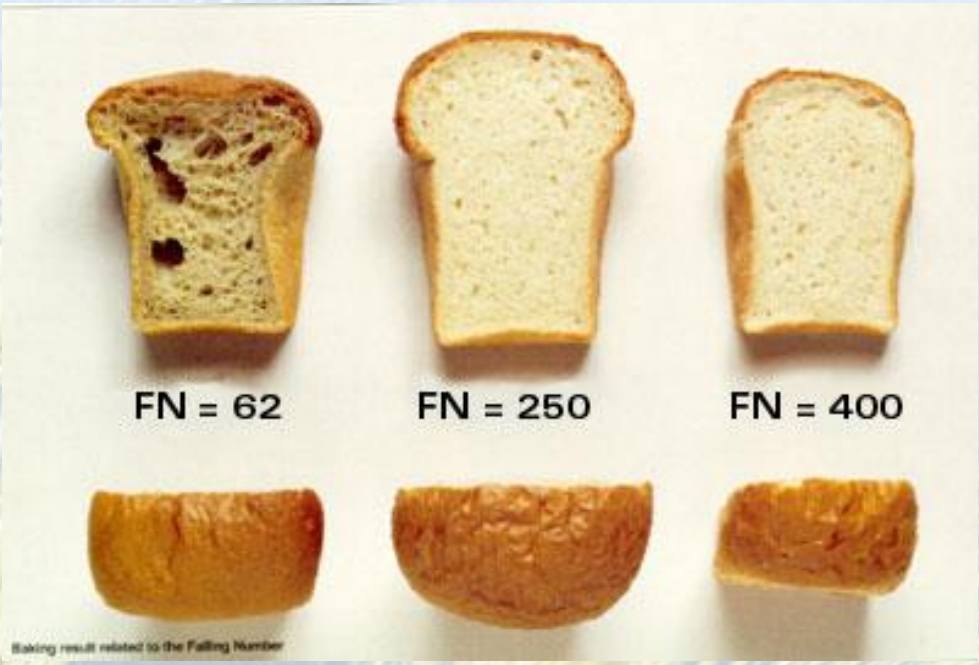


Wheat meal Falling Number (FN) was significantly correlated with flour FN

Interpretation of falling numbers

Falling Number (sec)	Sprouting indication
FN>300	No sprout damage
300>FN>200	Some sprouting
200>FN	Severe sprout damage

Bread quality (hard wheat)

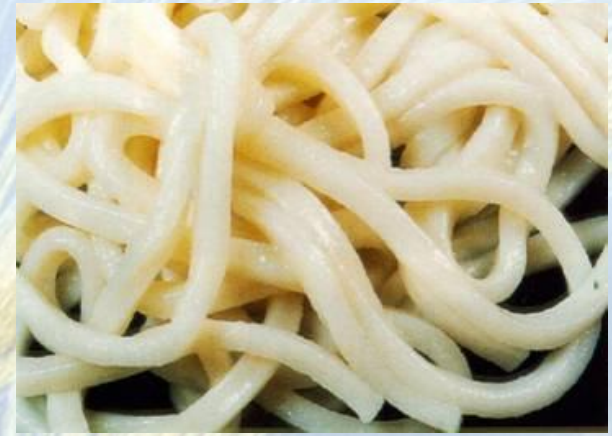


(Perten Instruments)

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



High FN

Low FN

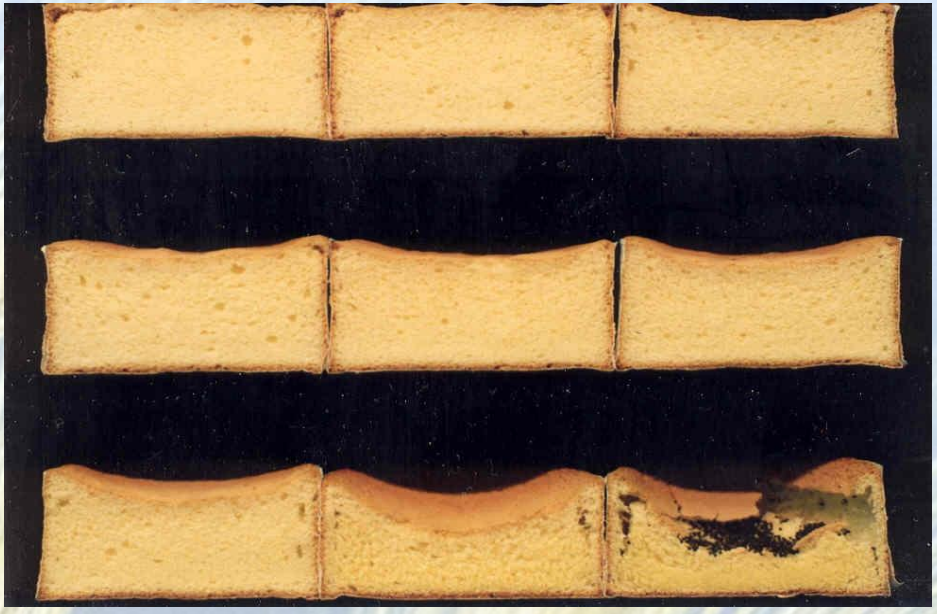
(Perten Instruments)

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



(Western Wheat Quality Lab.)

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

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

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!!!
THANK YOU