Falling number in wheat

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

Http://www.breadlink.co.uk

The Falling Number method was first described by **Hagberg** and Perten in the early 1960's for the purpose of providing a rapid means of determining the extent of sprout damage in wheat or rye (Doty, 1980). It has found widespread acceptance because of its rapid analysis time, simple operation, and high degree of reproducibility (Pyler, 1986). Sprout damage in wheat is of critical concern if the end-use for the flour being milled is bread production. As little as 5% heavily sprouted wheat in a mill mix of otherwise sound grain can make the mixture unacceptable for bread production (Perten, 1985). The Falling Number Test, an internationally standardized method, measures the alpha-amylase enzyme activity in flour to determine how much sprout a grain has achieved and to assure the grain has not been drowned. While a lower falling number indicates high enzyme (sprouting) activity, it is very important to compare the falling number prior to sprouting with the falling number after sprouting to accurately measure how much sprout action has occurred. A grain that started with a falling number of 350 and is now 150 has sprouted more completely than a grain that started at 250 and is now 150. To assure that Breadlink Sprouted Flours contain the highest sprout action, our sprouted flours must always have a final falling number equal to or lower than half of the falling number prior to sprouting. High quality grain that has been sprouted and stabilized resulting in a low falling number is very difficult to achieve so beware of anyone making claims without documentation.

Sprouting in wheat results in a higher than normal level of alpha-amylase in the flour. Wheat that has been harvested before sprouting has occurred contains low levels of alpha-amylase (Posner, 1997).

Alpha-amylase is of greater concern in bread production than ß-amylase for four reasons: (1) it is able to hydrolyze damaged raw starch; (2) it has a higher thermal stability allowing it to act on gelatinizing starch for 3-4 minutes when the interior of the bread loaf is 140-150F, (3) it is stable at the common pH of bread dough: 5.0 - 5.6, and (4) it is activated by calcium ions that inactivate ß-amylase (Pyler, 1986). In addition to this, ß-amylase is only able to act upon the non-reducing ends of starch chains from which it splits off maltose, and it is unable to act upon intact raw starch (Doty, 1980). The activity of ß-amylase is also dependent upon the level of starch damage in the flour as damaged starch has more sites at which ß-amylase can act. Starch is damaged in the milling process and typically accounts for around 8% of the total starch in hard wheat flours (Pyler, 1986).

a-amylase is far more able to reduce the long starch molecules into smaller pieces upon which the ß-amylase can act. a-amylase is able to act upon interior portions of the starch molecules. The result of this is that the ß-amylase now has more open sites upon which is can act and produce more maltose molecules: a source of energy for yeast involved in fermentation. It is the combined action of these two molecules that can convert nearly the entire starch molecule into fermentable sugar (Doty, 1980)

This amylolytic action in dough occurs once the dough ingredients are combined and mixed. The conversion of starch to maltose and other yeast fermentable sugars is critical to the bread baking process. This conversion results in several changes in dough properties including: a decrease in absorption capacity, a slackening of dough consistency, and the development of a stickier dough. The rate at which these changes occur is directly proportional to the amount of starch damage and a-amylase level of the flour. As we noted above, flour milled from sound, un-sprouted wheat has a very low amylase content and requires supplemental a-amylase to have the required functional properties for bread production. Hard wheat flours typically have a total sugar content of 1.5%. This level is initially boosted to 2.0 to 2.5% during mixing by the rapid action of a-amylase upon the damaged starch (Pyler, 1986).

Typically, wheat is harvested once the grain has dried to an appropriate moisture level that takes into consideration both optimality for harvest and suitability for prolonged storage. In a dry, normal growing season this is done before the grain has had a chance to germinate and sprout. The direct implication of this is that alpha-amylase levels are typically quite low and supplementation of the milled flour must occur. The Falling Number Method is used to measure the level of alpha-amylase activity in newly harvested wheat as a means of detecting sprout damage and as a method for determining the proper supplementation rates of barley malt, or other alpha-amylase enrichment (Doty, 1980).

Bread flours with normal diastatic activity (milled from sound, un-sprouted wheat and supplemented with alpha-amylase through the addition of barley malt, or fungal amylase) typically having falling number values in the range of 220 to 250 seconds. Flours deficient in diastatic activity will typically have values in excess of 400 seconds and over supplemented flours or flour milled from sprout damaged wheat can have the minimum value of 60 seconds.
The Falling Number Method is based on the starch liquefying action of alpha-amylase and expresses this as the time in seconds required to stir and allow the stirrer to fall a measured distance through a heated aqueous flour gel that is undergoing liquefaction (Pyler, 1980). The instrument consists of a boiling water bath, a stirring head, and a timer. Also needed are, a test tube and a stirring rod. The stirring head consists of motors and gears which allows for precise and uniform stirring insuring reproducibility of the results (Doty, 1980).

The procedure for flour involves mixing 7 g of flour with 25 mL of distilled water in a test tube. The tube is shaken and the stirring rod is inserted and then the whole assembly is placed in the boiling water bath. The timer is automatically started and a stirring process is activated and continues for 55 seconds and a rate of 2 strokes per second. At the end of 60 seconds the stirring rod is released from the up position and allowed to fall through the heated flour-water slurry. Upon completion of the vertical fall the timer stops and displays the elapsed time in seconds (Pyler, 1986). The descent of the stirring rod through the slurry is related to the amylase activity of the sample. Upon completion of the stirring action the amylase present in the flour starts to break down the gelatinized starch reducing the viscosity of the slurry (Doty, 1980).

If analysis of a wheat sample is required then a 300 g sample is ground in a hammer mill to obtain a flour sample. From here the procedure is the same as above for the flour sample (Doty, 1980).
There are several factors that have the potential to affect the results of the Falling Number Method. These include the sampling method, the preparation of the samples, moisture content of the samples, boiling temperature (affected by altitude), heat treatment of the grain, and the stirring procedure (Perten, 1967). This last issue is not of particular importance today as the Falling Number Instruments most commonly found are fully automated and require little operator input aside from the initial shaking of the sample.

The falling number method as described is an absolutely essential analysis technique in both the milling and baking industries. As alpha-amylase plays such a critical role in baking, the development of this rapid, simple, and highly reproducible technique has proven to be invaluable.

Pre-harvest sprouting (PHS)

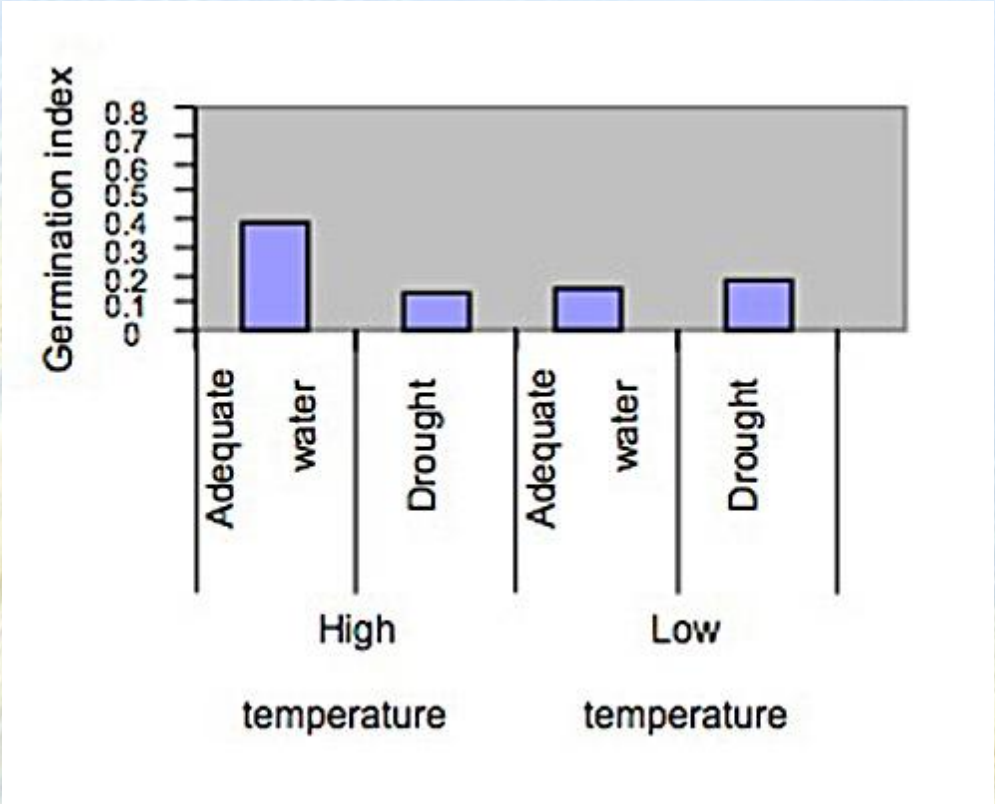
- Wheat germinates within the grain head prior to harvest.
- Occurs when wet conditions delay harvest.
- White varieties are more susceptible to PHS than red ones under similar environmental conditions.
- Higher PHS risks for genotypes with a short dormancy period.
- Increased hydrolytic enzyme activities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

PHS resistance

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

- Abscisicacid(ABA)isessentialforseedmaturationandenforces aperiodofseeddormancy.
- ABAlevelsdeclineasgrainmaturesandafterripening.
- RedseedpigmentsslowthedeclineofABA.
- TemperatureduringgrainfillaffectsABAlevels.

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

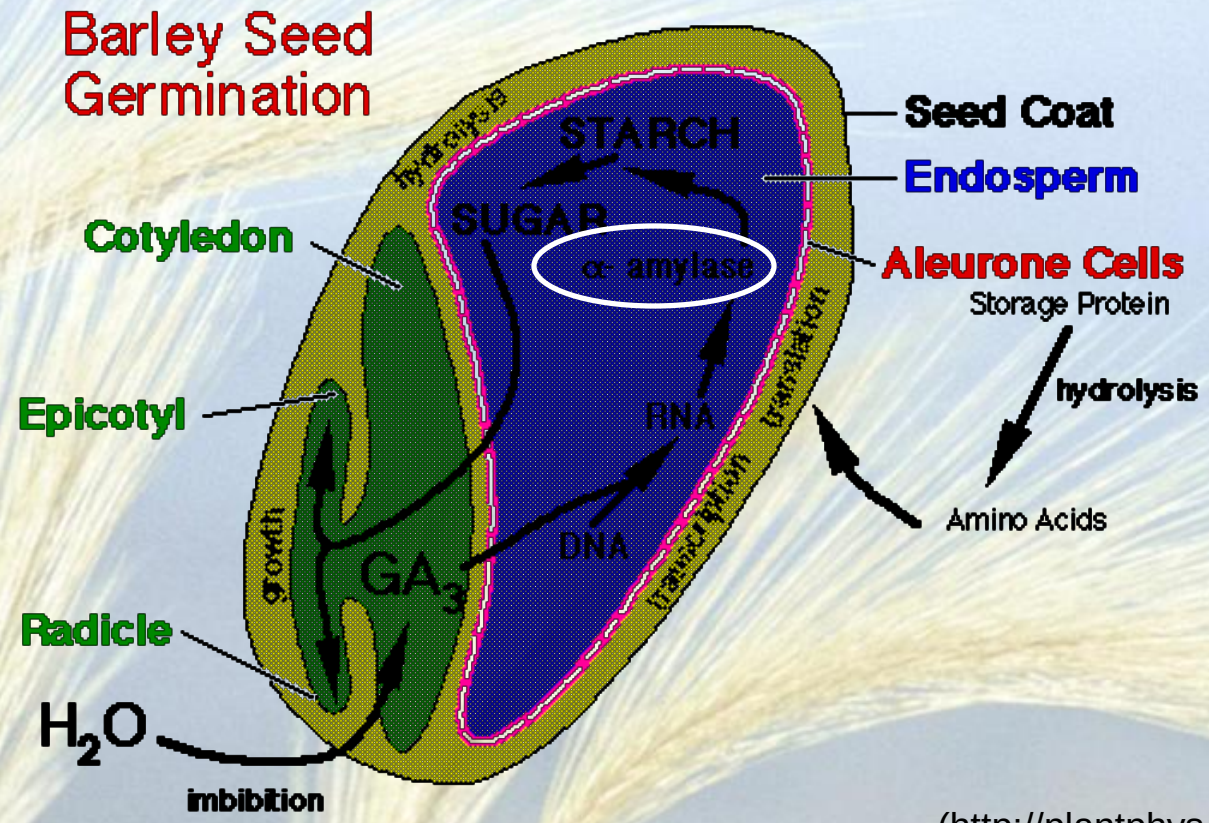
- 1960 Sven Hagberg developed a rapid, original method for determining α-amylase activityin sprout-damaged grain.
- 1961 Sven Hagberg named the method "falling-number" with a simple modification.
- 1962 Harald Perten founded Perten Instruments and commercialized falling number apparatus.
- 1968 International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

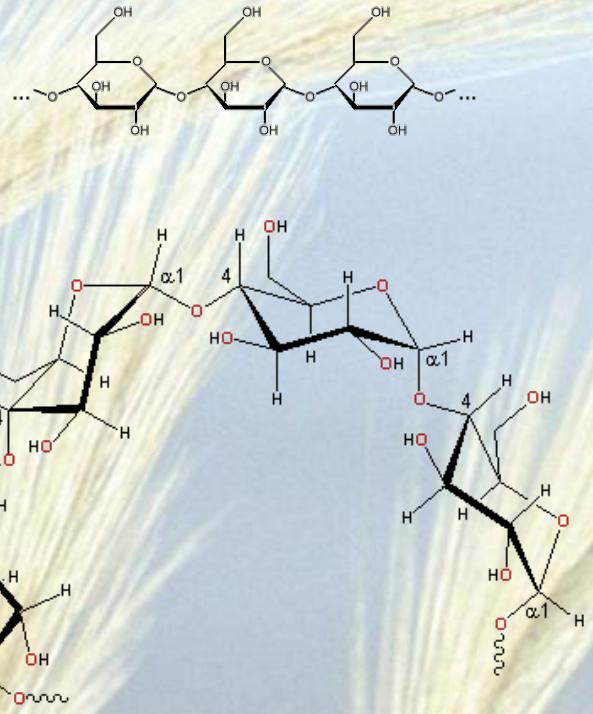
Germination process of seed



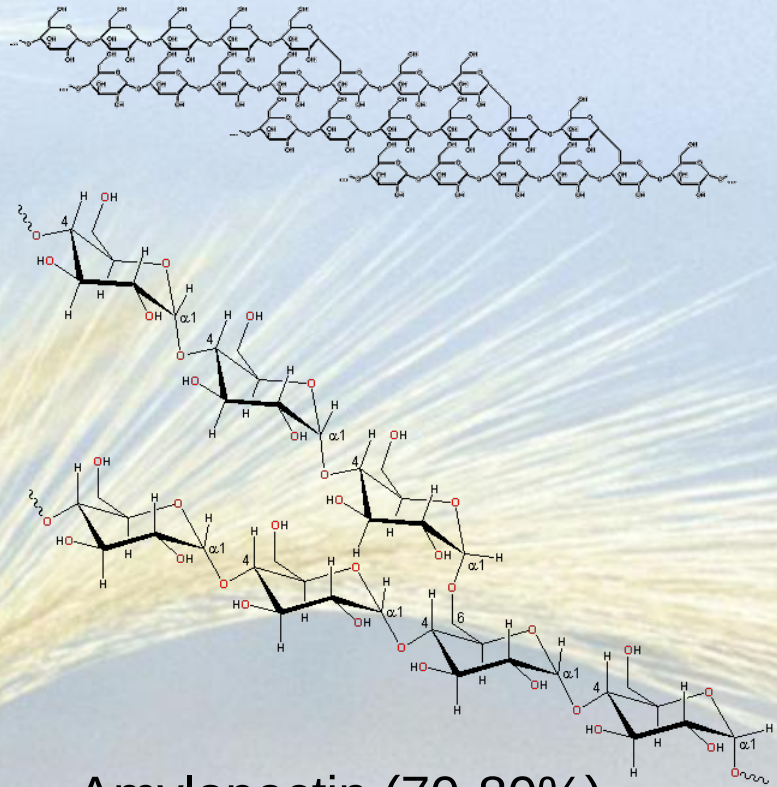
(http://plantphys.info/seedg)

Starch hydrolysis by α-amylase

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



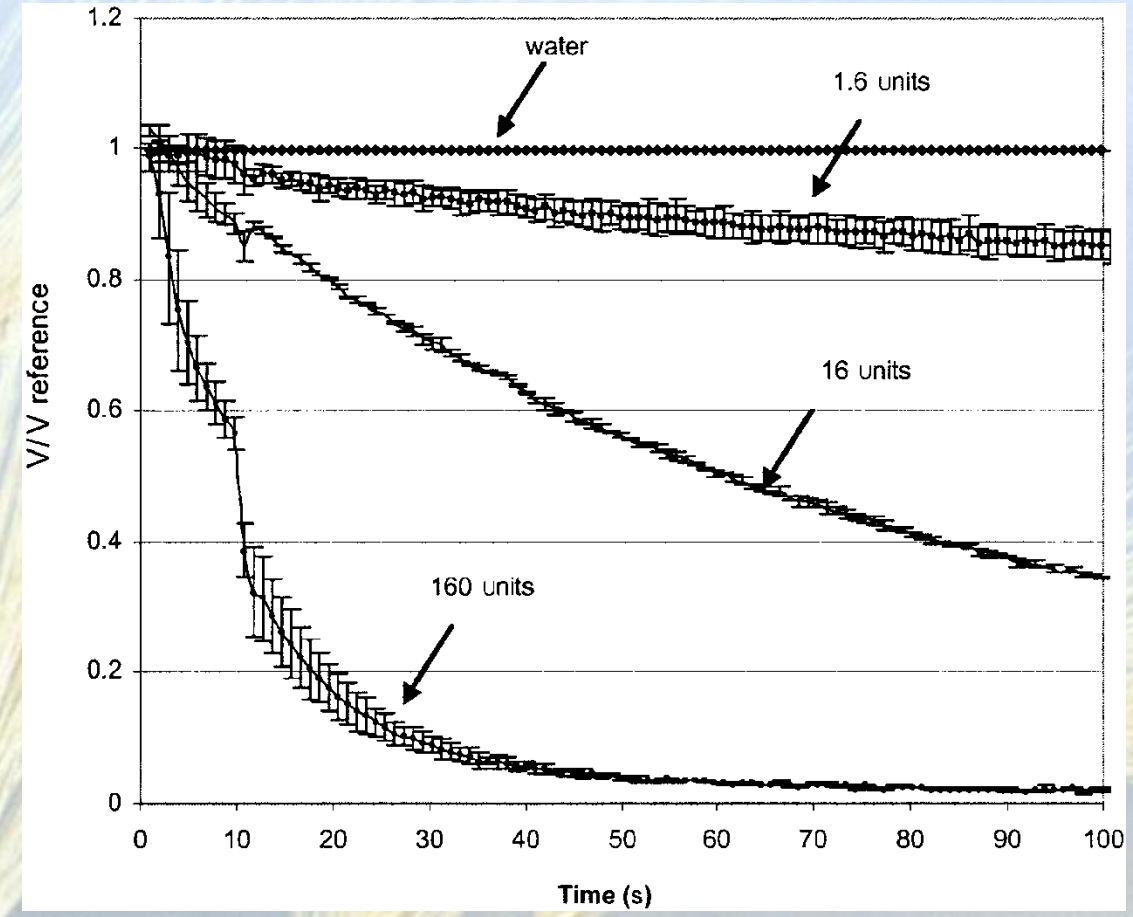
Amylose (20-30%)



Amylopectin (70-80%)

Effect of α-amylase addition on viscosity

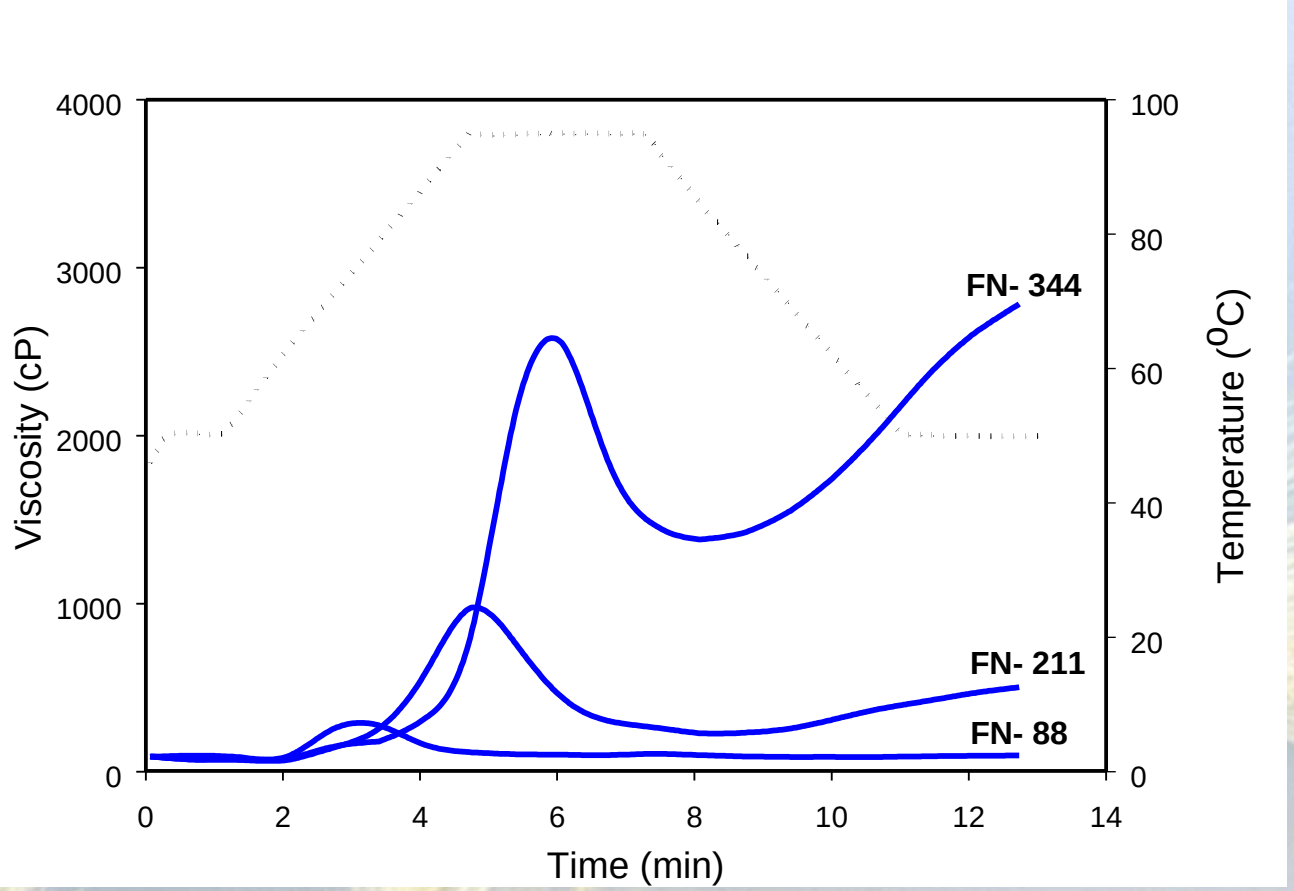
(8% wheat starch paste at 37°C measured in the RVA)



(Ferry et al. 2004)

Starch pasting profiles of flour samples

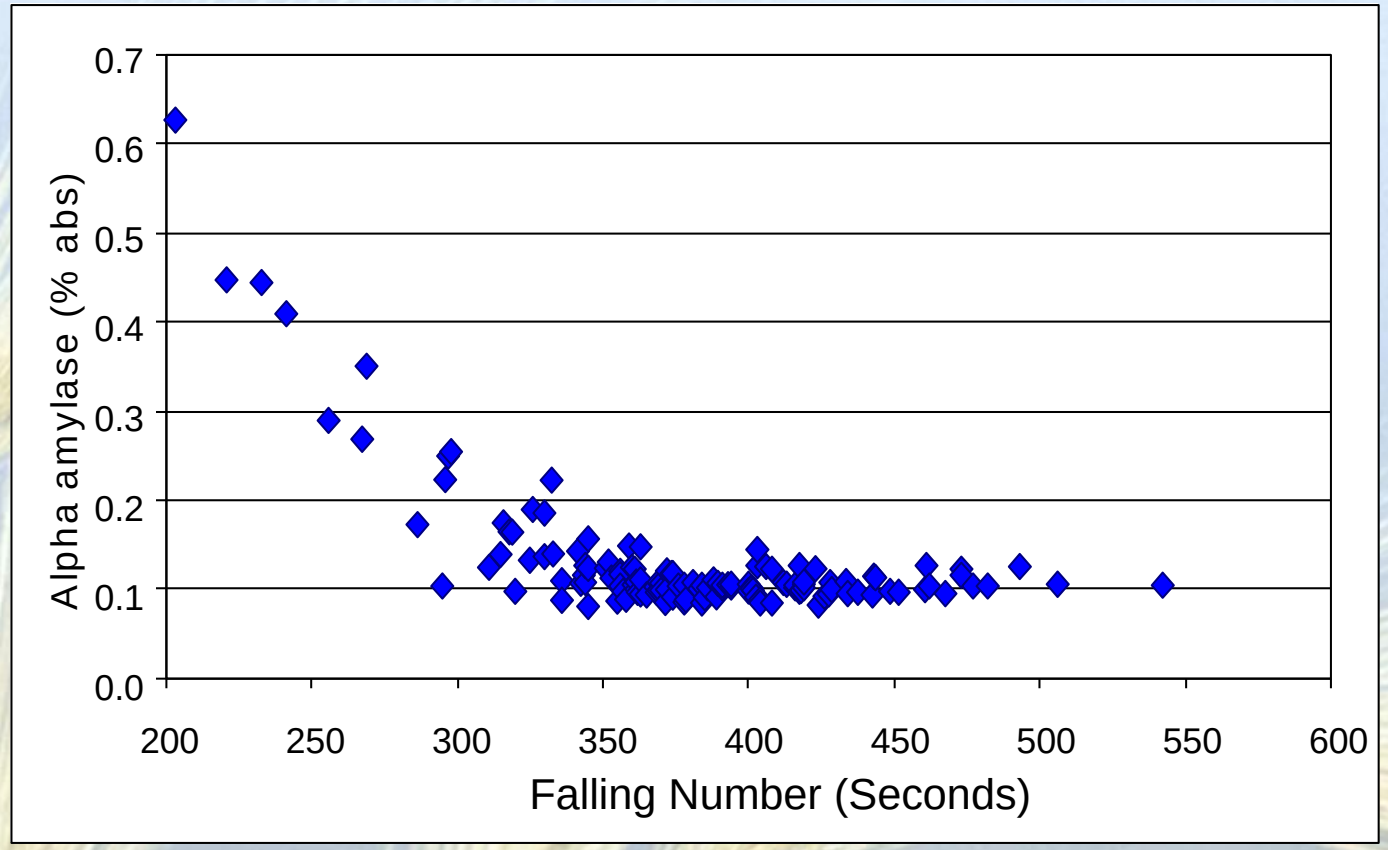
(8% flour slurry by RVA, Chelsea, SWW wheat)



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?

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

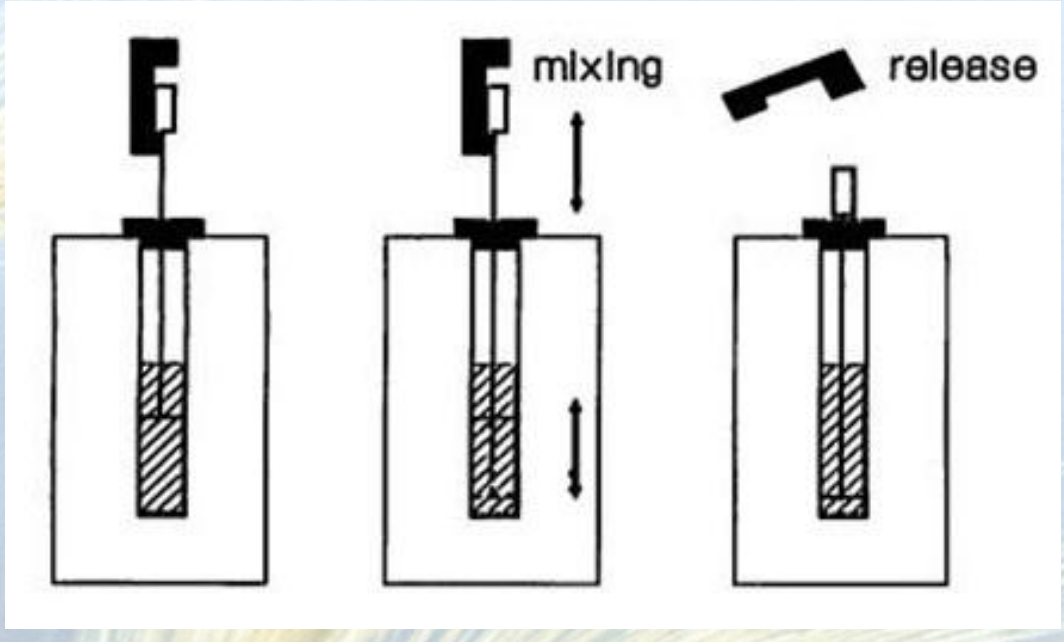
Shake

Insert a stirrer

Immerse

Stir & measure

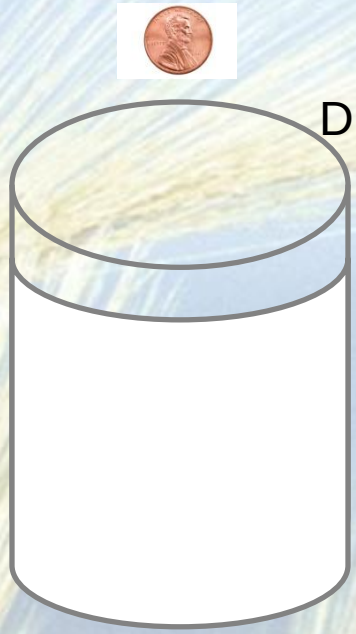
How is a falling number calculated?



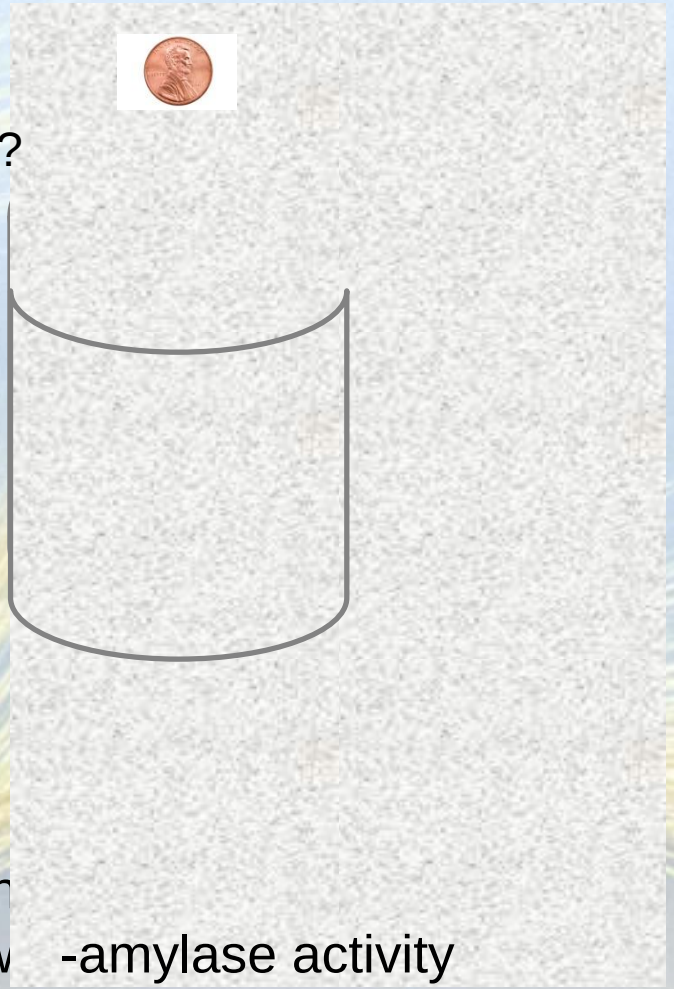
Falling Number = 5 sec stand + 55 sec stirring + time taken to fall in sec

Example: 300FN= 5 + 55 + 240

Falling time and viscosity



Drop a penny?



Clear & watery soup

Faster falling = low FN = high

Slower falling = high FN = low -amylase activity

Factors affected falling number

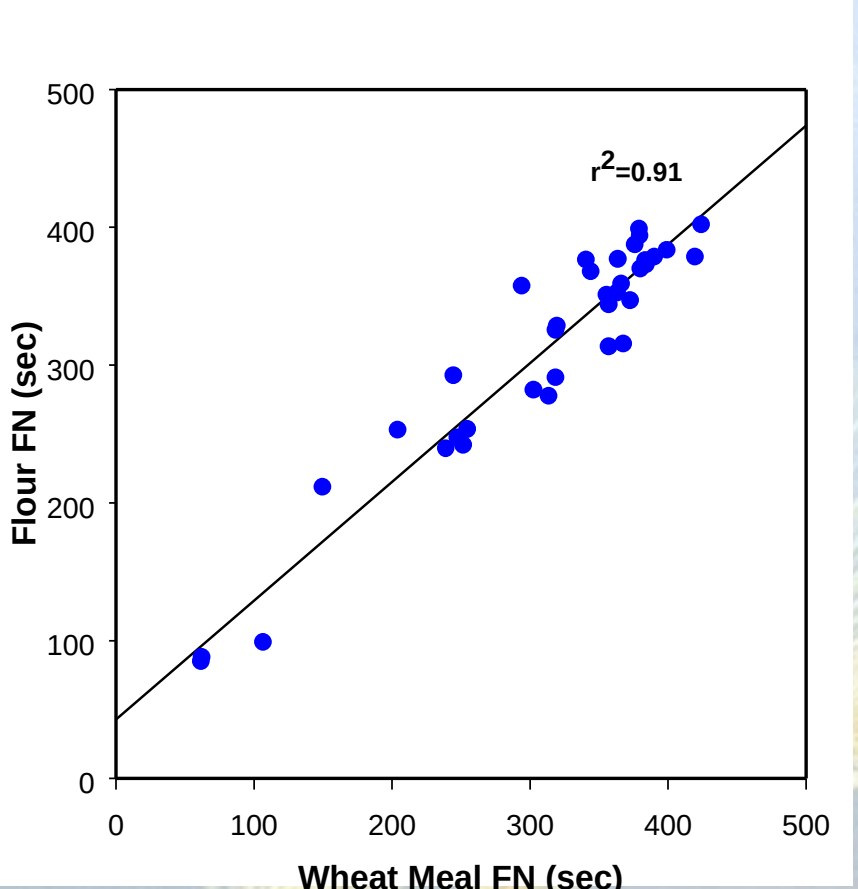
- Altitude –FN increases as elevation increases.
- Nitrogen fertilization rate – increase or decrease in FN
- Temperature – higher FN in summer
- Late Maturity α-Amylase – lower FN
- Fungicide treatment – decrease in FN, cultivar dependent
- Fusarium infection – minor decrease in FN
- Waxy wheat – lower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

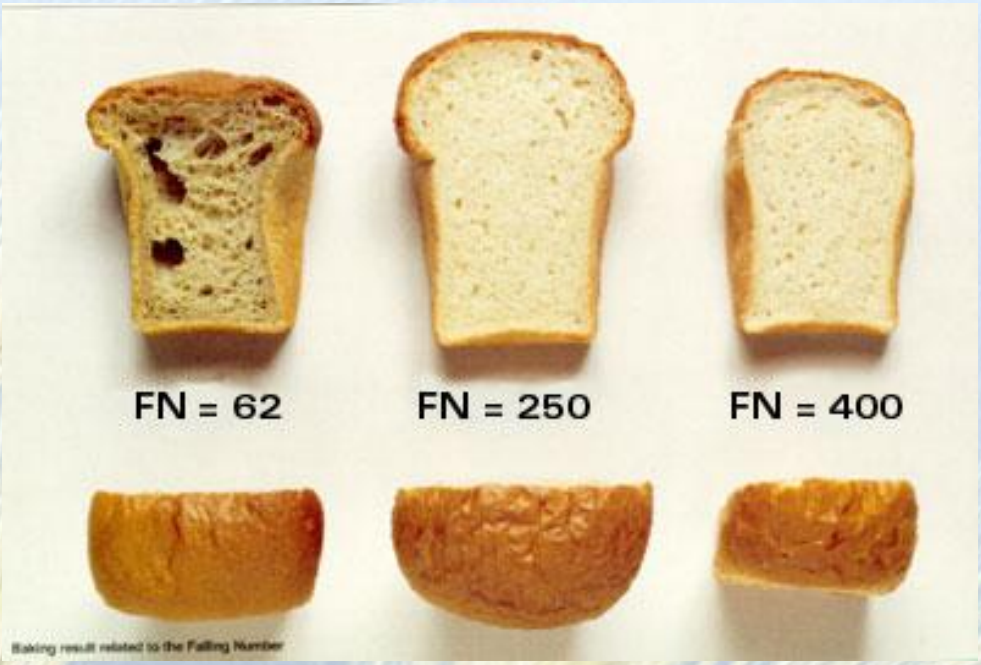


Wheat meal Falling Number (FN) was significantly correlated with flour FN

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)

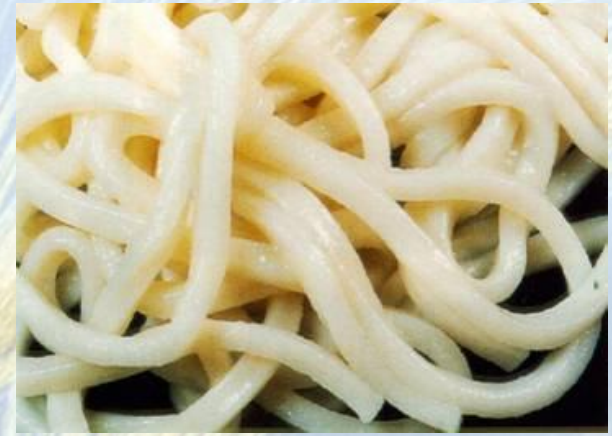


(Perten Instruments)

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

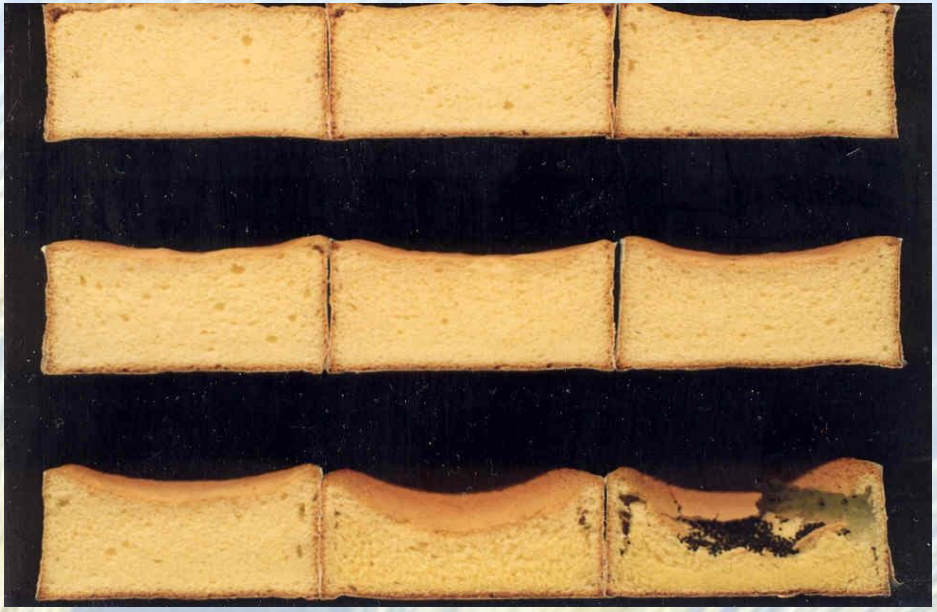
(Perten Instruments)

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 us http://www.breadlink.co.uk/contact.html