

# WHEAT *and* FLOUR TESTING METHODS

*A Guide  
to Understanding  
Wheat and Flour  
Quality*

WHEAT MARKETING CENTER, INC.

*Wheat and Flour Testing Methods: A Guide to Understanding Wheat and Flour Quality* provides an introduction to the analysis of wheat and flour in a clear and concise format. Basic information is presented on standardized testing procedures for wheat and flour quality characteristics as well as dough properties. Results from these tests are explained and applied to processing performance and end product quality. Laboratory testing of a variety of wheat-based finished products is also included. The finished product formulations and processes described are laboratory testing protocols that are used to evaluate flour quality. They are model systems that may be used to predict commercial production for common uses of wheat flour worldwide.

Additional support provided by:



W H E A T   A N D   F L O U R  
T E S T I N G   M E T H O D S

*A Guide to Understanding  
Wheat and Flour Quality*

*Wheat Marketing Center, Inc.*

*Portland, Oregon*

USA

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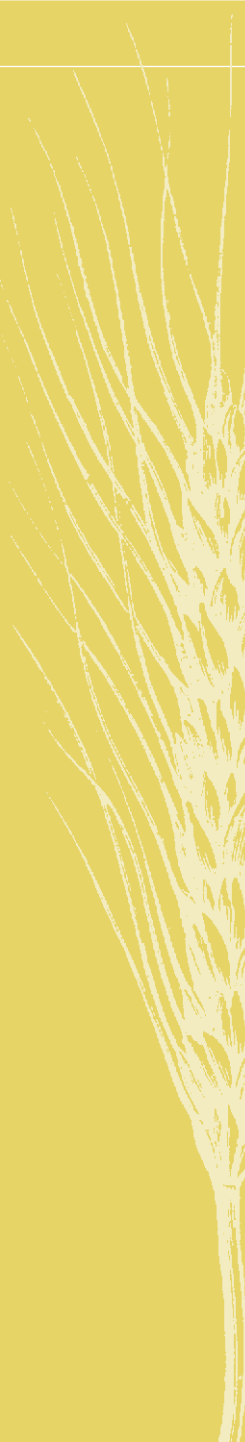
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## Preface



The purpose of this book is to provide an introduction to the analysis of wheat and flour. Basic information on chemical testing, physical testing, and flour milling is presented in Section One. Additional information on the rheological properties of dough is included as well as comparisons of the weak and strong gluten properties.

Laboratory product testing of a variety of wheat-based finished products is presented in Section Two. Formulas and processing steps are briefly described and finished product attributes are presented.

This book is designed to provide basic information in a clear and concise format. The testing methods and finished product pages are organized into three parts. The first part is titled “Method” and outlines the steps involved in performing the analysis or producing the product. The second part is titled “Results” and explains the results of the testing procedures and how they are expressed. The third part is titled “Why is this important?” and discusses the relevance and application of the testing methods and the finished products.



### **North American Export Grain Association, Inc. (NAEGA)**

**N**orth American Export Grain Association (NAEGA) was established in 1912 to promote and sustain the development of commercial export of grain and oilseed trade from the United States. NAEGA is comprised of private companies, public corporations, and farmer-owned cooperatives involved in the bulk grain and oilseed exporting industry. Members of NAEGA ship the vast majority of \$15 billion in exports of U.S. bulk grain and oilseeds. NAEGA acts as a unified voice for the export grain industry to represent its views and concerns. Government agencies and officials rely on NAEGA to communicate U.S. policies and programs to the trade and to gather input on farm and trade policy issues. NAEGA publications provide information and commentary on industry issues, developments, and events. NAEGA committees act in leadership roles to address technical issues affecting the industry, such as grain handling, grades and inspection, and trade and contract matters. NAEGA is active in the international grain and oilseed market and works with the USDA Market Access Program (MAP) to promote exports of U.S. farm products.

### **Wheat Marketing Center, Inc. (WMC)**

**W**heat Marketing Center, Inc. (WMC) was founded in 1989 to provide a bridge between U.S. wheat farmers and wheat consumers worldwide. To meet the needs of the wheat industry, WMC conducts objective wheat utilization research on all classes of wheat and provides timely, relevant research to wheat buyers, processors, and sellers. WMC educates the wheat industry on end-use quality characteristics by developing and delivering dynamic multimedia wheat quality courses, publications, and presentations. WMC partners with all segments of the wheat industry, including North American Export Grain Association, U.S. Wheat Associates, farmers, wheat exporters, wheat organizations, and domestic and international wheat and flour processors, and strives for continuous impact by dynamic responsiveness to market fluctuations. WMC has technical expertise in wheat and flour testing and finished product attributes that is used by wheat processors in Asia, Latin America, North America, and Europe.

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David Shelton  
Executive Director  
Wheat Marketing Center, Inc.

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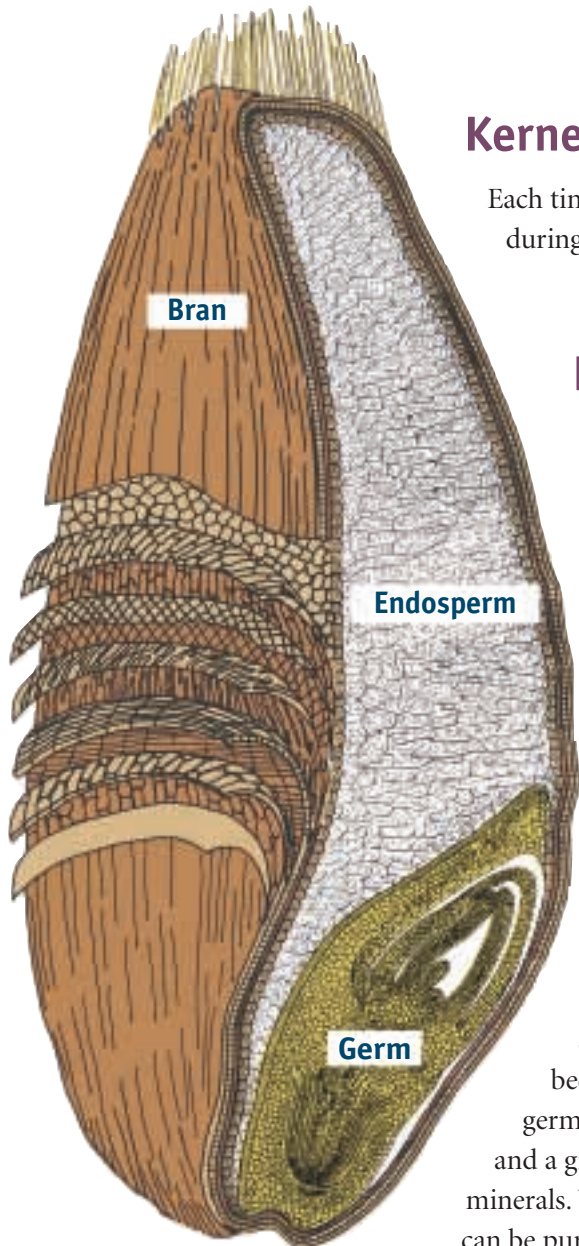
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## A Kernel of Wheat



**Kernel** . . . sometimes called the wheat berry. The kernel is the seed from which the wheat plant grows.

Each tiny seed contains three distinct parts that are separated during the milling process to produce flour.

**Endosperm** . . . about 83% of the kernel weight and the source of white flour. The endosperm contains the greatest share of protein, carbohydrates, and iron as well as the major B-vitamins, such as riboflavin, niacin, and thiamine. It is also a source of soluble fiber.

**Bran** . . . about 14% of the kernel weight. Bran is included in whole wheat flour and can also be bought separately. The bran contains a small amount of protein, trace minerals, and dietary fiber (primarily insoluble).

**Germ** . . . about 2.5% of the kernel weight. The germ is the embryo or sprouting section of the seed. It is often separated from flour because the fat content (10%) limits shelf life. The germ contains minimal quantities of high quality protein and a greater share of B-complex vitamins and trace minerals. Wheat germ is a part of whole wheat flour and can be purchased separately.

## Section One

# W H E A T   A N D   F L O U R T E S T S

**T**he wheat and flour tests described in this section are standardized testing procedures commonly used for quality control purposes. Results from these tests have a direct relationship to finished product quality.

Wheat and flour specifications are communications between buyers and sellers. These specifications are requirements for particular wheat and flour characteristics. To meet these specifications, wheat and flour quality testing is necessary. Specifications for moisture content, ash content, protein content, and falling number are determined with basic tests. Physical tests included in this book are conducted to determine flour color and wheat kernel characteristics specified by wheat processors. The laboratory milling test is used to evaluate the milling performance of wheat and to produce flour for other laboratory tests.

Wheat and flour specifications often require specialized testing to determine how flour will perform during processing. Several tests evaluate dough and gluten strength properties. The farinograph and mixograph tests measure the resistance of dough to mixing. The extensigraph test measures the resistance of dough to stretching. The alveograph test measures the resistance of a bubble of dough to expansion. The wet gluten test measures the amount of gluten protein in flour. The starch properties of flour are measured by the amylograph and the rapid visco analyzer tests.

Section One is intended to provide information on wheat and flour quality tests used by the wheat industry worldwide to promote an orderly marketplace.

# Moisture Content



*Flora Engelmann, Laboratory Technician*

- Low temperature heating
- Measures moisture content

- Method**
1. A small sample of flour or ground wheat (2–3 grams) is weighed and placed in a moisture dish.
  2. The sample is heated at 130°C in an air oven for 1 hour.
  3. The sample is cooled to room temperature and the residue is weighed.

- Results**
- Moisture content is determined by heating a flour or ground wheat sample in an air oven and comparing the weight of the sample before and after heating.
  - The amount of weight loss is the moisture content.
  - Moisture content results are expressed as a percentage. An example of a wheat moisture content is 12%.

**Why is this important?**

Determining moisture content is an essential first step in analyzing wheat or flour quality since this data is used for other tests. Flour millers adjust the moisture in wheat to a standard level before milling. Moisture content of 14% is commonly used as a conversion factor for other tests in which the results are affected by moisture content.

Moisture is also an indicator of grain storability. Wheat or flour with high moisture content (over 14.5%) attracts mold, bacteria, and insects, all of which cause deterioration during storage. Wheat or flour with low moisture content is more stable during storage.

Moisture content can be an indicator of profitability in milling. Flour is sold by weight, grain is bought by weight, and water is added to reach the standard moisture level before milling. The more water added, the more weight and profitability gained from the wheat. Wheat with too low moisture, however, may require special equipment or processes before milling to reach the standard moisture level.

Other methods of determining moisture content are used in the industry. For example, Federal Grain Inspection Service (FGIS) uses the GAC 2100 to measure moisture content of whole wheat kernels.

# Ash Content



*Kevin Marquardt, Laboratory Technologist*

- High temperature incineration
- Measures mineral (ash) content

- Method**
1. A sample of flour or ground wheat (3–5 grams) is weighed and placed in an ash cup.
  2. The sample is heated at 585°C in an ash oven until its weight is stable (usually overnight).
  3. The residue is cooled to room temperature and then weighed.

- Results**
- Ash content is determined by high temperature incineration in an electric muffle furnace.
  - When a sample is incinerated in an ash oven, the high temperature drives out the moisture and burns away all the organic materials (starch, protein, and oil), leaving only the ash. The residue (ash) is composed of the non-combustible, inorganic minerals that are concentrated in the bran layer.
  - Ash content results for wheat or flour ash are expressed as a percentage of the initial sample weight; for example, wheat ash of 1.58% or flour ash of 0.52%. Wheat or flour ash is usually expressed on a common moisture basis of 14%.

**Why is this important?**

The ash content in wheat and flour has significance for milling. Millers need to know the overall mineral content of the wheat to achieve desired or specified ash levels in flour. Since ash is primarily concentrated in the bran, ash content in flour is an indication of the yield that can be expected during milling. Ash content also indicates milling performance by indirectly revealing the amount of bran contamination in flour. Ash in flour can affect color, imparting a darker color to finished products. Some specialty products requiring particularly white flour call for low ash content while other products, such as whole wheat flour, have a high ash content.

# Protein Content



*Tina Tran, Laboratory Technologist*

- High temperature combustion
- Measures protein content



Combustion Nitrogen Analyses (CNA) is one of several methods used to determine protein content in flour or wheat.

### Method

1. A sample of flour or ground wheat (0.15–0.20 grams) is weighed and placed into a CNA protein analyzer.
2. This process is fully automated and begins by dropping the sample into a hot oven where it is burned at 952°C.
3. The amount of nitrogen gas released during burning is measured and a formula is applied to convert this measurement to protein content in the sample.

### Results

- Protein content is determined through high temperature combustion in a protein analyzer. Since protein is the major wheat compound that contains nitrogen, the protein content can be determined by measuring the amount of nitrogen released during burning.
- Protein content results are expressed as a percentage of the total sample weight; for example, 10% protein content on 12% moisture basis for wheat or 8.5% on 14% moisture basis for flour.

### Why is this important?

Protein content is a key specification for wheat and flour purchasers since it is related to many processing properties, such as water absorption and gluten strength. Protein content can also be related to finished product attributes, such as texture and appearance. Low protein content is desired for crisp or tender products, such as snacks or cakes. High protein content is desired for products with chewy texture, such as pan bread and hearth bread.

Bakers use protein content results to anticipate water absorption and dough development time for processes and products, because higher protein content usually requires more water and a longer mixing time to achieve optimum dough consistency.

Combustion Nitrogen Analysis (CNA) is often used to develop calibrations for other protein methods, such as Near Infrared Transmittance (NIRT) or Near Infrared Reflectance (NIRR).

*Adapted from Method 46-30, Approved Methods of the American Association of Cereal Chemists, 10th Edition, 2000. The Association, St. Paul, MN.*

# Falling Number



*Khari Holmes, Laboratory Technician*

- Viscosity analysis
- Measures the effects of sprout damage

**Method**

1. A 7-gram sample of ground wheat or flour is weighed and combined with 25 ml of distilled water in a glass falling number tube with a stirrer and shaken to form a slurry.
2. As the slurry is heated in a boiling water bath at 100°C and stirred constantly, the starch gelatinizes and forms a thick paste.
3. The time it takes the stirrer to drop through the paste is recorded as the falling number value.

**Results**

- The falling number instrument analyzes viscosity by measuring the resistance of a flour and water paste to a falling stirrer.
- Falling number results are recorded as an index of enzyme activity in a wheat or flour sample and the results are expressed in time as seconds.
- A high falling number (for example, above 300 seconds) indicates minimal enzyme activity and sound quality wheat or flour.
- A low falling number (for example, below 250 seconds) indicates substantial enzyme activity and sprout-damaged wheat or flour.

**Why is this important?**

The level of enzyme activity measured by the Falling Number Test affects product quality. Yeast in bread dough, for example, requires sugars to develop properly and therefore needs some level of enzyme activity in the dough. Too much enzyme activity, however, means that too much sugar and too little starch are present. Since starch provides the supporting structure of bread, too much activity results in sticky dough during processing and poor texture in the finished product. If the falling number is too high, enzymes can be added to the flour in various ways to compensate. If the falling number is too low, enzymes cannot be removed from the flour or wheat, which results in a serious problem that makes the flour unusable.

# Flour Color Analysis



*Mia Biberic, Student Intern*

- Color analysis

- Measures flour color

One method used to measure flour color is the Minolta Chroma Meter Test.

### Method

1. A sample of flour is placed on the granular materials attachment and compacted.
2. The Minolta Chroma Meter is inserted into the granular materials attachment.
3. Measurements are taken and recorded.

### Results

- Flour color is determined by measuring the whiteness of a flour sample with the Minolta Chroma Meter.
- Flour color results are reported in terms of 3-dimensional color values based on the following rating scale:

<b>L* value</b>	whiteness	100 white 0 black
<b>a* value</b>	positive values negative values	+60 red color -60 green color
<b>b* value</b>	positive values negative values	+60 yellow color -60 blue color

- The color values of a typical white flour, for example, are:

L\* value +92.5 whiteness  
a\* value -2.4 green color  
b\* value +6.9 yellow color

### Why is this important?

Flour color often affects the color of the finished product and is therefore one of many flour specifications required by end-users. Generally speaking, a bright white color flour is more desirable for many products.

# Single Kernel Characterization System SKCS



*Annette Doan, Laboratory Technologist*

- Kernel analysis
- Measures kernel characteristics

**Method**

1. A sample of wheat kernels (12–16 grams) is prepared by removing broken kernels, weed seeds, and other foreign material.
2. The sample is poured into the access hopper of the Single Kernel Characterization System instrument.
3. The SKCS instrument analyzes 300 kernels individually and records the results on a computer graph.

**Results**

- Wheat kernel characteristics are analyzed for: kernel weight by load cell, kernel diameter and moisture content by electrical current, and kernel hardness by pressure force.
- Averages and standard deviations of these parameters are reported as SKCS results in terms of values: kernel weight is expressed in milligrams (mg); kernel diameter is expressed in millimeters (mm); moisture content is expressed as a percentage; and kernel hardness is expressed as an index of –20 to 120.
- A graph displaying kernel characteristics is shown on the computer monitor in the photo on page 20.

**Why is this important?**

The Single Kernel Characterization System Test evaluates wheat kernel texture characteristics by measuring the weight, electrical current, and force needed to crush the kernels. Kernel characteristics are related to important milling properties, such as conditioning (tempering), roll gap settings, and flour starch damage content.

# Buhler Laboratory Flour Mill



*Khari Holmes, Laboratory Technician*

- **Laboratory-scale flour mill**
- **Determines flour yield and makes flour for other tests**



- Method**
1. A sample of wheat is cleaned and the moisture content is determined.
  2. Water is added to condition (temper) the wheat overnight prior to milling. Soft wheats require less water and less time than hard wheats.
  3. The tempered wheat sample is run through the mill the following day.
  4. The mill fractions, such as flour streams, bran, and shorts, are weighed and recorded.

- Results**
- Wheat samples are milled to evaluate wheat milling properties, including flour extraction and the amount of non-flour components produced, such as bran and shorts.
  - Buhler Laboratory Flour Mill results are expressed as the weight of flour, bran, and shorts. Often, flour extraction is reported as a percentage of flour compared to the total output of other mill products.
  - Flour is produced for other tests.

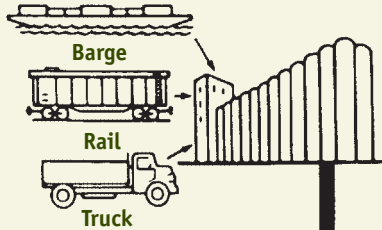
**Why is this important?**

The Buhler Laboratory Flour Mill Test indicates milling properties on small wheat samples. Commercial flour mills can use to this information to adjust mill settings to adjust flour extraction. See “How Wheat is Milled” diagram on pages 24–25.

Small samples of wheat are milled on the Buhler Laboratory Mill to produce flour. This flour is used to evaluate properties, such as ash and protein content, and in gluten strength tests, such as the farinograph.

# How Wheat is Milled

It starts here . . .



**Elevator**  
Storage and care of wheat.

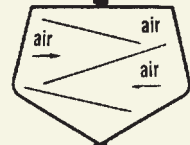
**Product Control**  
Chemists inspect and classify wheat. Blending is often done at this point.



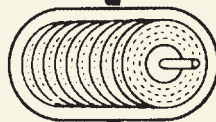
**Separator**  
Reciprocating screens remove stones, sticks, and other coarse or fine materials.



**Aspirator**  
Air currents remove lighter impurities.



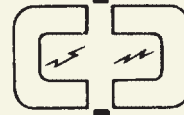
**Disc Separator**  
Barley, oats, cockle, and other foreign materials are removed.



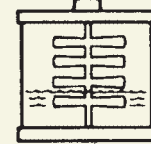
**Scourer**  
Beaters in screen cylinder scour off impurities and roughage.



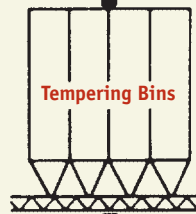
*This flow diagram is greatly simplified. The sequence, number, and complexity of operations vary in different mills.*



**Magnetic Separator**  
Iron or steel articles are removed.



**Washer-Stoner**  
High speed rotors circulate wheat and water. Stones are removed.



**Tempering**  
Water toughens outer bran coats for easier separation, softening or mellowing endosperm.

**Blending**  
Types of wheat are blended to make specific flours.



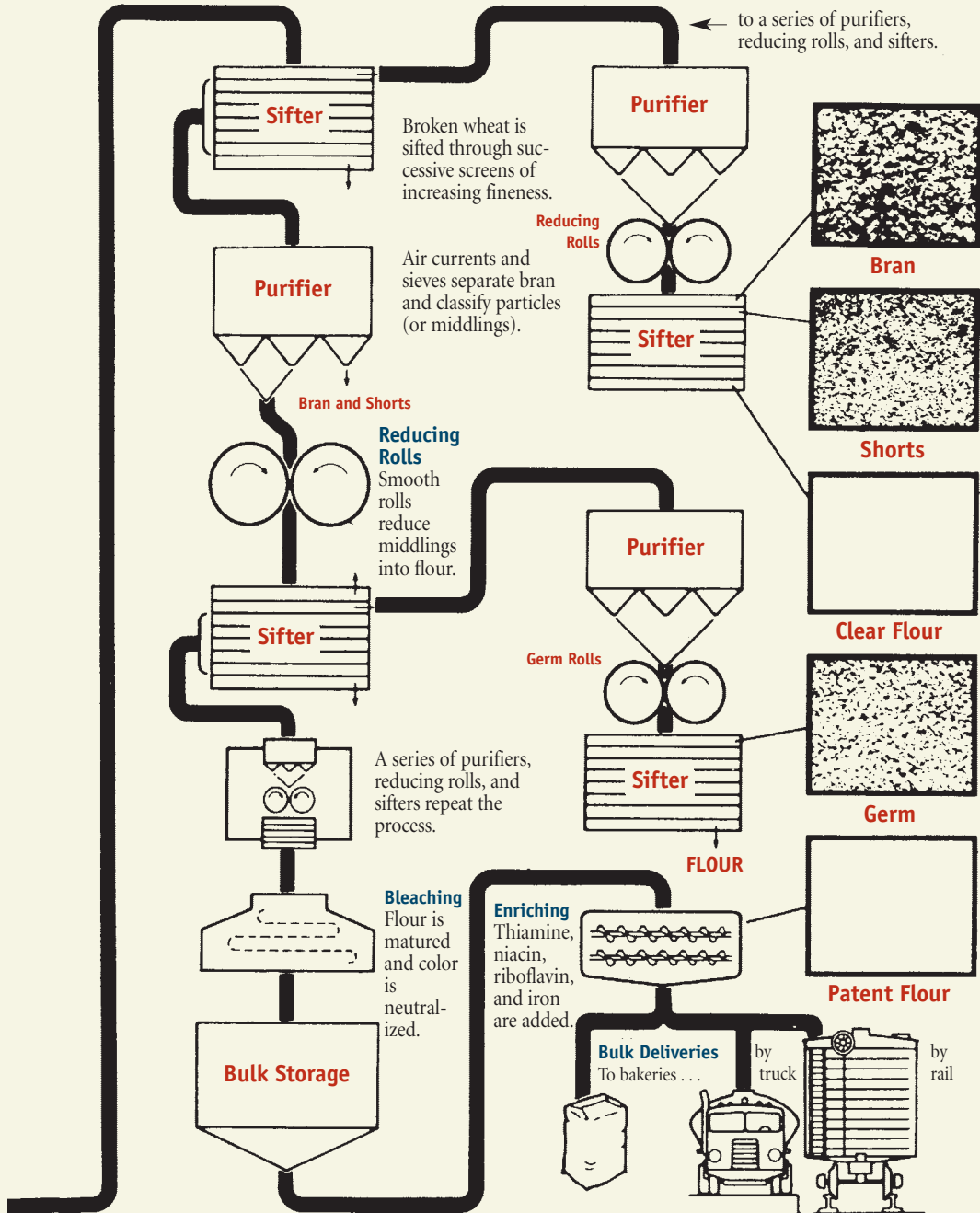
**Entoleter**  
Impact machine breaks and removes unsound wheat.



**Grinding Bin**



**First Break**  
Corrugated rolls break wheat into coarse particles.



# Milling Process

# Glutomatic



*Tina Tran, Laboratory Technologist*

- **Gluten washing**
- **Measures wet gluten content**

**Method**

1. A 10-gram sample of flour or ground wheat is weighed and placed into the glutomatic washing chamber on top of the polyester screen.
2. The sample is mixed and washed with a 2% salt solution for 5 minutes.
3. The wet gluten is removed from the washing chamber, placed in the centrifuge holder, and centrifuged.
4. The residue retained on top of the screen and through the screen is weighed.

**Results**

- Wet gluten content is determined by washing the flour or ground wheat sample with a salt solution to remove the starch and other solubles from the sample. The residue remaining after washing is the wet gluten.
- During centrifugation, the gluten is forced through a sieve. The percentage of gluten remaining on the sieve is defined as the Gluten Index, which is an indication of gluten strength. A high gluten index indicates strong gluten.
- Wet gluten content results are expressed as a percentage on a 14% moisture basis; for example, 35% for high protein, strong gluten wheat or 23% for low protein, weak gluten wheat.

**Why is this important?**

The wet gluten test provides information on the quantity and estimates the quality of gluten in wheat or flour samples. Gluten is responsible for the elasticity and extensibility characteristics of flour dough. Wet gluten reflects protein content and is a common flour specification required by end-users in the food industry.

# Farinograph



*Carla Franzoni, Laboratory Technologist*

- Recording dough mixer
- Measures flour water absorption and dough strength

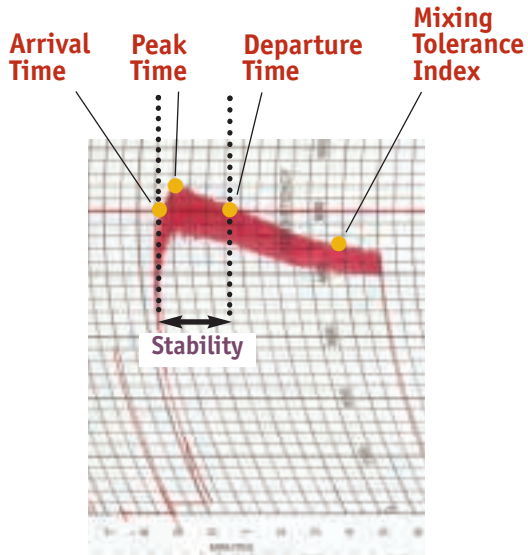
- Method**
1. A flour sample of 50 or 300 grams on a 14% moisture basis is weighed and placed into the corresponding farinograph mixing bowl.
  2. Water from a buret is added to the flour and mixed to form a dough.
  3. As the dough is mixed, the farinograph records a curve on graph paper.
  4. The amount of water added (absorption) affects the position of the curve on the graph paper. Less water increases dough consistency and moves the curve upward.
  5. The curve is centered on the 500-Brabender Unit (BU) line  $\pm 20$  BU by adding the appropriate amount of water and is run until the curve leaves the 500-BU line.

- Results**
- The farinograph determines dough and gluten properties of a flour sample by measuring the resistance of a dough against the mixing action of paddles (blades).
  - Farinograph results include absorption, arrival time, stability time, peak time, departure time, and mixing tolerance index.
  - Farinograph curves are described on pages 30–31.

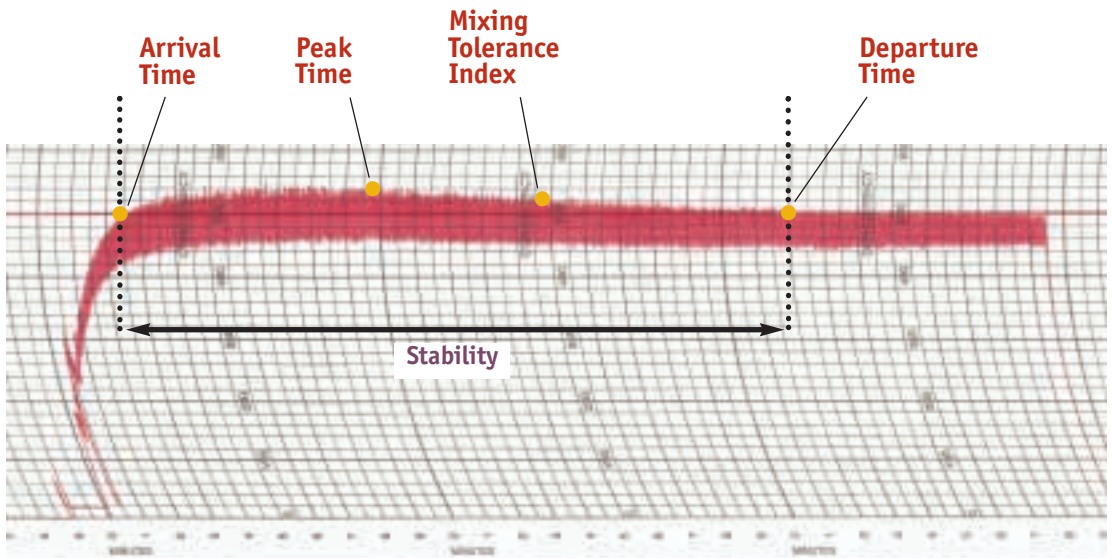
**Why is this important?**

The Farinograph Test is one of the most commonly used flour quality tests in the world. The results are used as parameters in formulation to estimate the amount of water required to make a dough, to evaluate the effects of ingredients on mixing properties, to evaluate flour blending requirements, and to check flour uniformity. The results are also used to predict processing effects, including mixing requirements for dough development, tolerance to over mixing, and dough consistency during production. Farinograph results are also useful for predicting finished product texture characteristics. For example, strong dough mixing properties are related to firm product texture.

# Farinograph



**Weak Gluten Flour**



**Strong Gluten Flour**



**The Farinograph Test** measures and records the resistance of a dough to mixing with paddles.

- **Absorption** is the amount of water required to center the farinograph curve on the 500-Brabender Unit (BU) line. This relates to the amount of water needed for a flour to be optimally processed into end products. Absorption is expressed as a percentage.
- **Peak Time** indicates dough development time, beginning the moment water is added until the dough reaches maximum consistency. This gives an indication of optimum mixing time under standardized conditions. Peak time is expressed in minutes.
- **Arrival Time** is the time when the top of the curve touches the 500-BU line. This indicates the rate of flour hydration (the rate at which the water is taken up by the flour). Arrival time is expressed in minutes.
- **Departure Time** is the time when the top of the curve leaves the 500-BU line. This indicates the time when the dough is beginning to break down and is an indication of dough consistency during processing. Departure time is expressed in minutes.
- **Stability Time** is the difference in time between arrival time and departure time. This indicates the time the dough maintains maximum consistency and is a good indication of dough strength. Stability time is expressed in minutes.
- **Mixing Tolerance Index (MTI)** is the difference in BU value at the top of the curve at peak time and the value at the top of the curve 5 minutes after the peak. This indicates the degree of softening during mixing. Mixing tolerance index is expressed in minutes.

Weak gluten flour has a lower water absorption and shorter stability time than strong gluten flour.

# Extensigraph



*Carla Franzoni, Laboratory Technologist*

- Visco-elastic recorder
- Measures dough extensibility and resistance to extension

**Method****Preparation**

1. A 300-gram flour sample on a 14% moisture basis is combined with a salt solution and mixed in the farinograph to form a dough.
2. After the dough is rested for 5 minutes, it is mixed to maximum consistency (peak time).

**Analyses**

1. A 150-gram sample of prepared dough is placed on the extensigraph rounder and shaped into a ball.
2. The ball of dough is removed from the rounder and shaped into a cylinder.
3. The dough cylinder is placed into the extensigraph dough cradle, secured with pins, and rested for 45 minutes in a controlled environment.
4. A hook is drawn through the dough, stretching it downwards until it breaks.
5. The extensigraph records a curve on graph paper as the test is run.
6. The same dough is shaped and stretched two more times, at 90 minutes and at 135 minutes.

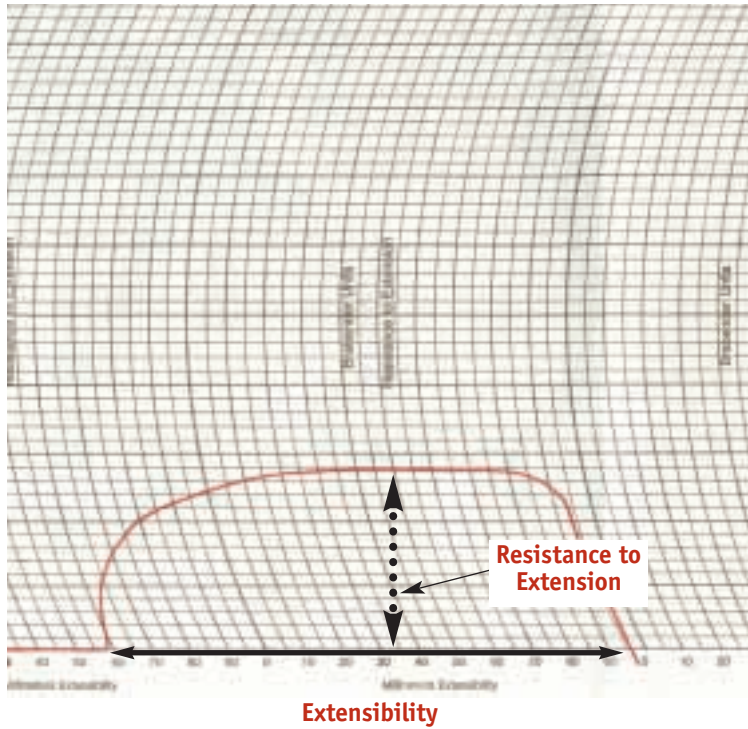
**Results**

- The extensigraph determines the resistance and extensibility of a dough by measuring the force required to stretch the dough with a hook until it breaks.
- Extensigraph results include resistance to extension, extensibility, and area under the curve.
- Resistance to extension is a measure of dough strength. A higher resistance to extension requires more force to stretch the dough.
- Extensibility indicates the amount of elasticity in the dough and its ability to stretch without breaking.
- Extensigraph curves are described on pages 34–35.

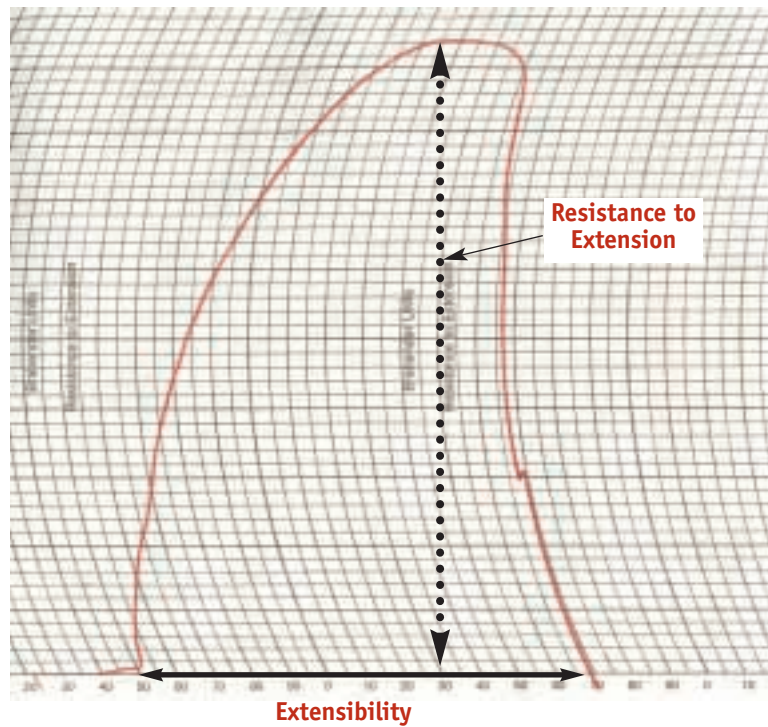
**Why is this important?**

Results from the Extensigraph Test are useful in determining the gluten strength and bread-making characteristics of flour. The effect of fermentation time and additives on dough performance can also be evaluated.

# Extensigraph



**Weak Gluten Flour**



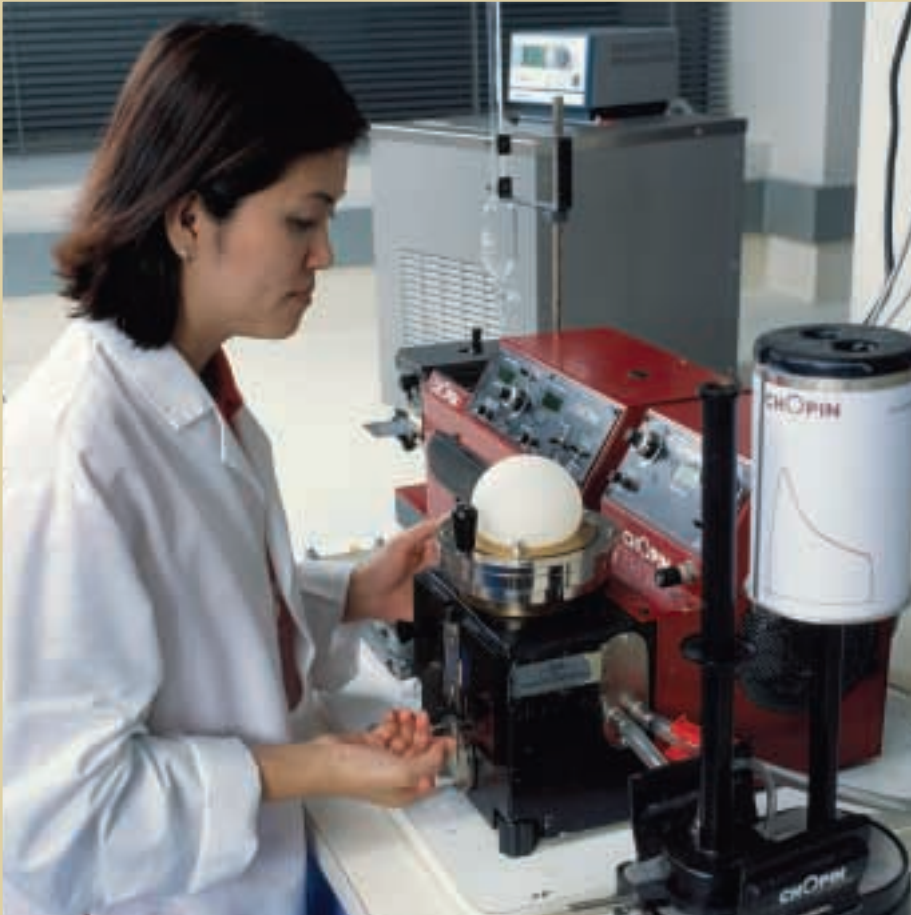
**Strong Gluten Flour**

**The Extensigraph Test** measures and records the resistance of a dough to stretching.

- **Resistance to Extension** is the R value and is indicated by the maximum height of the curve. It is expressed in centimeters (cc), Brabender units (BU), or Extensigraph units (EU).
- **Extensibility** is the E value and is indicated by the length of the curve. It is expressed in millimeters (mm) or centimeters (cm).
- **R/E Ratio** indicates the balance between dough strength (resistance to extension) and the extent to which the dough can be stretched before breaking (extensibility).
- **Area Under the Curve** is a combination of resistance and extensibility. It is expressed in square centimeters (cm<sup>2</sup>).

Weak gluten flour has a lower resistance to extension (R value) than strong gluten flour.

# Alveograph



*Annette Doan, Laboratory Technologist*

- Visco-elastic recorder
- Measures dough strength

**Method**

1. A sample of 250 grams of flour is mixed with a salt solution to form a dough.
2. Five 4.5 cm circular dough patties are formed and then rested in the alveograph in a temperature-regulated compartment at 25°C for approximately 20 minutes.
3. Each dough patty is tested individually. The alveograph blows air into a dough patty, which expands into a bubble that eventually breaks.
4. The pressure inside the bubble is recorded as a curve on graph paper.

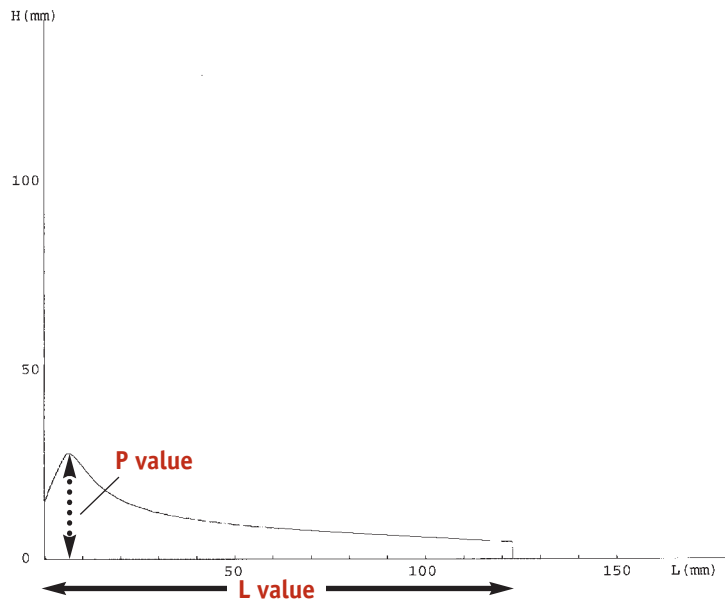
**Results**

- The alveograph determines the gluten strength of a dough by measuring the force required to blow and break a bubble of dough.
- The results include P Value, L Value, and W Value.
- A stronger dough requires more force to blow and break the bubble (higher P value).
- A bigger bubble means the dough can stretch to a very thin membrane before breaking.
- A bigger bubble indicates the dough has higher extensibility, that is, its ability to stretch before breaking (L value).
- A bigger bubble requires more force and will have a greater area under the curve (W value).
- Alveograph curves are described on pp. 38–39.

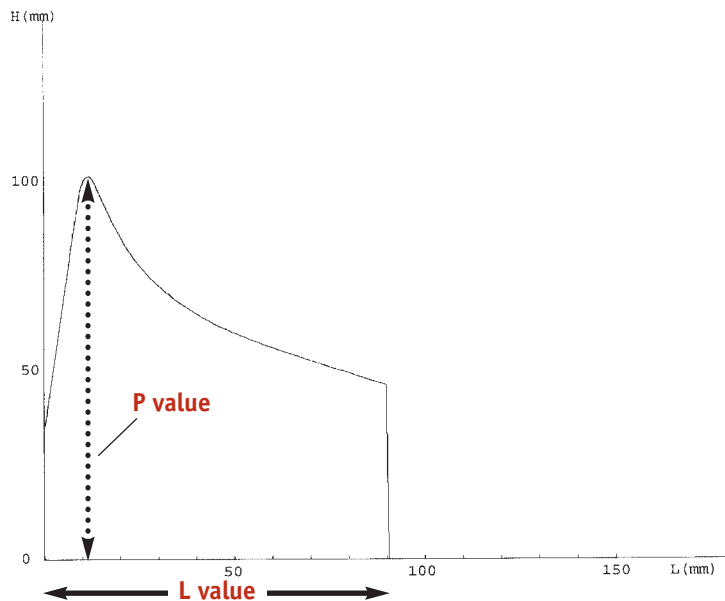
**Why is this important?**

The Alveograph Test provides results that are common specifications used by flour millers and processors to ensure a more consistent process and product. The alveograph is well suited for measuring the dough characteristics of weak gluten wheats. Weak gluten flour with low P value (strength of gluten) and long L value (extensibility) is preferred for cakes and other confectionery products. Strong gluten flour will have high P values and is preferred for breads.

# Alveograph



**Weak Gluten Flour**



**Strong Gluten Flour**



**The Alveograph Test** measures and records the force required to blow and break a bubble of dough.

- **P Value** is the force required to blow the bubble of dough. It is indicated by the maximum height of the curve and is expressed in millimeters (mm).
- **L Value** is the extensibility of the dough before the bubble breaks. It is indicated by the length of the curve and is expressed in millimeters (mm).
- **P/L Ratio** is the balance between dough strength and extensibility.
- **W Value** is the area under the curve. It is a combination of dough strength (P value) and extensibility (L value) and is expressed in joules.

Weak gluten flour has lower P values than strong gluten flour.

# Mixograph



*Bon Lee, Laboratory Supervisor*

- Recording dough mixer
- Measures flour water absorption and dough mixing characteristics

**Method**

1. A sample of 35 grams of flour on a 14% moisture basis is weighed and placed in a mixograph bowl.
2. Water is added to the flour from a buret and the bowl is inserted into the mixograph.
3. The flour and water are mixed together to form a dough.
4. As the dough is mixed, the mixograph records a curve on graph paper.

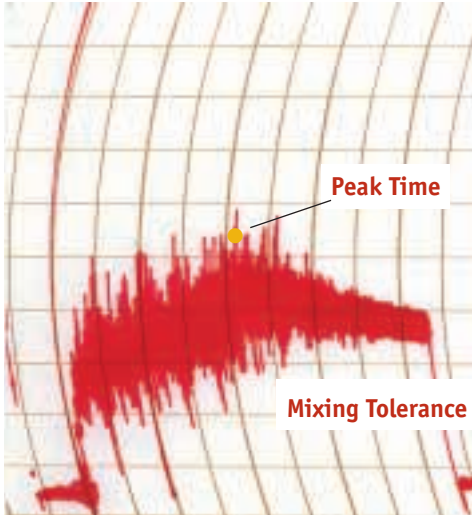
**Results**

- The mixograph determines dough and gluten properties of a flour by measuring the resistance of a dough against the mixing action of pins.
- Mixograph results include water absorption, peak time, and mixing tolerance.
- The mixograph curve indicates gluten strength, optimum dough development time, mixing tolerance (tolerance to over-mixing), and other dough characteristics.
- The amount of water added (absorption) affects the position of the curve on the graph paper. Less water increases dough consistency and moves the curve upward.
- Mixograph curves are described on pages 42–43.

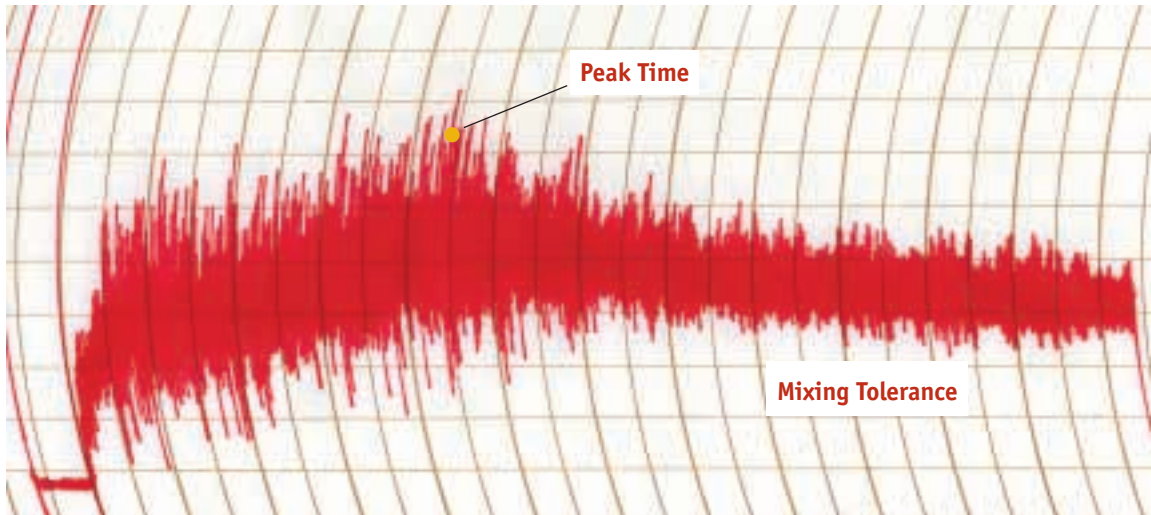
**Why is this important?**

The Mixograph Test quickly analyzes small quantities of flour for dough gluten strength. Wheat breeders use mixograph results to screen early generation lines for dough gluten strength. Flour water absorption measured by the mixograph often serves as bake absorption in bread baking tests.

# Mixograph



**Weak Gluten Flour**



**Strong Gluten Flour**

**The Mixograph Test** measures and records the resistance of a dough to mixing with pins.

- **Peak Time** is the dough development time, beginning the moment the mixer and the recorder are started and continuing until the dough reaches maximum consistency. This indicates optimum mixing time and is expressed in minutes.
- **Mixing Tolerance** is the resistance of the dough to breakdown during continued mixing and affects the shape of the curve. This indicates tolerance to overmixing and is expressed as a numerical score based on comparison to a control.

Weak gluten flour has a shorter peak time and less mixing tolerance than strong gluten flour.

# Amylograph



*Kevin Marquardt, Laboratory Technologist*

- **Viscosity analysis**

- **Measures flour starch properties**

- Method**
1. A sample of 65 grams of flour is combined with 450 ml of distilled water and mixed to make a slurry.
  2. The slurry is stirred while being heated in the amylograph, beginning at 30°C and increasing at a constant rate of 1.5°C per minute until the slurry reaches 95°C.
  3. The amylograph records the resistance to stirring as a viscosity curve on graph paper.

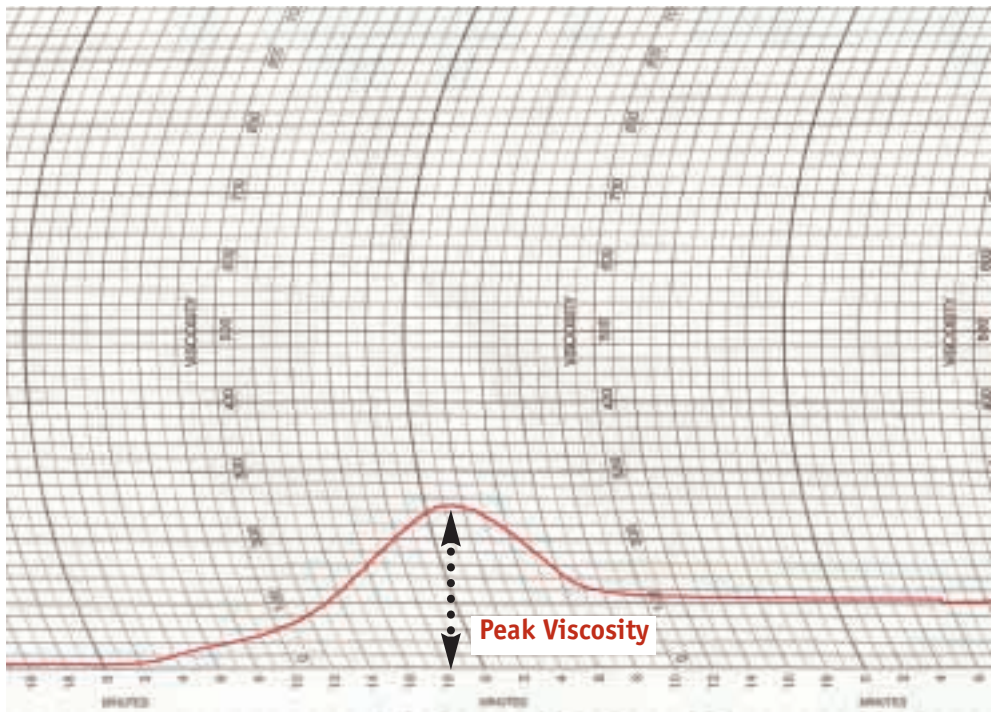
- Results**
- The amylograph analyzes viscosity by measuring the resistance of a flour and water slurry to the stirring action of pins or paddles.
  - When the slurry is heated, the starch granules swell and the slurry becomes a paste.
  - A thicker slurry has more resistance to the pins during stirring and has a higher peak viscosity. Generally, a thicker slurry indicates less enzyme activity and makes better products.
  - Amylograph results include peak viscosity.
  - Amylograph curves are described on pages 46–47

**Why is this important?**

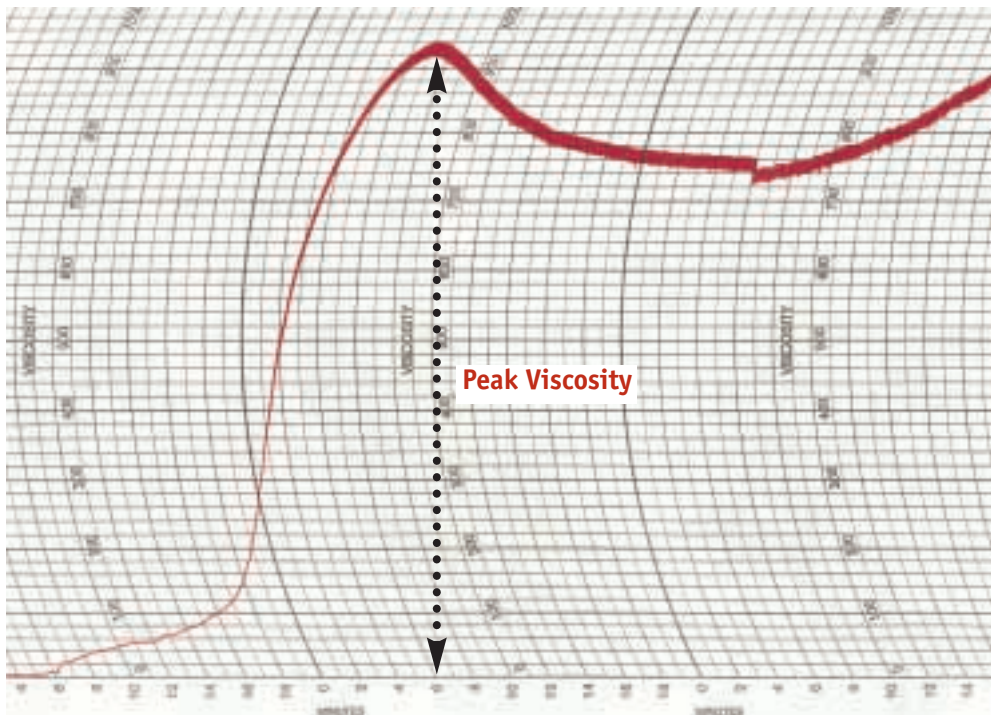
The Amylograph Test measures flour starch properties and enzyme activity which results from sprout damage (alpha amylase enzyme activity). Sprouting in wheat, as indicated by high enzyme activity, produces sticky dough that can cause problems during processing and results in products with poor color and weak texture. For Asian noodle products, flour of medium to high peak viscosity is preferred because it gives noodles better texture characteristics.

Both the amylograph and the rapid visco analyzer (RVA, pp. 48–49) measure starch viscosity properties. The amylograph is more commonly used throughout the world. The RVA uses a smaller sample and takes less time than the amylograph.

# Amylograph



**Sprouted Wheat Flour**



**Sound Wheat Flour**



**The Amylograph Test** measures and records the resistance of a heated slurry (a flour and water paste) to the stirring action of pins.\*

- **Peak Viscosity** is the maximum resistance of a heated flour and water slurry to mixing with pins. It is expressed in Brabender Units (BU).

Sprouted wheat flour has a lower peak viscosity than sound flour.

\* *Some laboratories use paddles rather than pins.*

# Rapid Visco Analyzer



*Flora Engelman, Laboratory Technician*

- **Viscosity analysis**

- **Measures flour starch properties**

**Method**

1. A sample of 3.5 grams of flour is mixed with 25 ml of water to form a slurry.
2. The rapid visco analyzer stirs the slurry as it is heated from 60–95°C in 6 minutes.
3. The maximum viscosity (peak viscosity) is recorded as a curve by the rapid visco analyzer.

**Results**

- The rapid visco analyzer indicates starch viscosity by measuring the resistance of a flour and water slurry to the stirring action of a paddle.
- When the slurry is heated, the starch granules swell and make the slurry thicker.
- A thicker slurry has more resistance to the paddle during stirring and has a higher peak viscosity.
- The highest point during the heating cycle is the peak viscosity.
- Rapid visco analyzer results include peak viscosity and are expressed in rapid visco units (RVU).
- A viscosity curve is shown on the computer monitor in the photo on page 48.

**Why is this important?**

The Rapid Visco Analyzer Test measures flour starch properties. For Asian noodle products, flour of medium to high peak viscosity is preferred because it gives noodles better texture characteristics.\*

The rapid visco analyzer can also be used to determine the stirring number, which is related to sprout damage. A stirring number test is performed to measure enzyme activity that results from sprout damage (alpha amylase enzyme activity). Sprouting in wheat results in flour that produces sticky dough that can cause problems during processing. Sprout-damaged flour also produces products with poor color and weak texture.\*\*

\*Adapted from *RVA-4 Series Operation Manual*, Newport Scientific Pty. Ltd. 1995.

\*\*Adapted from *Method 22-08, Approved Methods of the American Association of Cereal Chemists, 10th Edition*. 2000. The Association, St. Paul, MN.

## Section Two

# LABORATORY PRODUCT TESTS

**W**heat, which is often thought of as the *staff of life*, is enjoyed by consumers throughout the world in a wide variety of forms; for example, breads are consumed as pan bread, hearth bread, or flat bread. Steamed breads are made by steaming the dough pieces rather than baking. Cookies are commonly eaten in a number of countries under a variety of names, including biscuits. Noodle products may be extruded or sheeted and are available in numerous shapes, textures, and colors. Sponge cake is a common confectionery item in many countries.

The finished product formulations and processes described in this section are laboratory testing protocols used to evaluate flour quality. They are model systems that may be used to predict commercial production for common uses of wheat flour world-wide. While standard protocols are available, each wheat and flour quality laboratory may develop its own finished product procedures specific to customer requirements in diverse markets.

Section Two is intended to be a brief overview of laboratory product tests for wheat products from different parts of the world.

# Pan Bread



Wheat Foods Council

<b>Formula</b>	Flour*	100 grams
	Dry yeast	1 gram
	Sugar	6.0 grams
	Salt	1.5 grams
	Shortening	3.0 grams
	Water	Variable (58–70 grams)
	Malted barley	0.2 grams

*\*14% moisture basis*

*Additional ingredients may include oxidants or dough conditioners. In baking formulas, ingredients are expressed as a percentage of flour weight.*

- Procedure**
1. Flour and other ingredients are mixed with a yeast suspension to form a dough.
  2. The dough is mixed until it reaches optimum dough development.
  3. The dough is rounded and placed into a fermentation cabinet at 30°C and 85% relative humidity for 105 minutes.
  4. *First Punch* – The dough is passed through a sheeter, folded twice, and returned to the fermentation cabinet for 50 minutes.
  5. *Second Punch* – The dough is passed through a sheeter, folded twice, and returned to the fermentation cabinet for 25 minutes.
  6. The dough is molded into a cylinder shape and proofed in a pan for 62 minutes.
  7. The dough is baked in a 215°C oven for 24 minutes and then cooled to room temperature.

- Results**
- Pan bread is evaluated for processing characteristics, external and internal characteristics, and texture. The results are expressed as a numerical score based on comparison to a control sample.
  - Pan bread dough is evaluated during processing for strength, extensibility, and stickiness.
  - Pan bread is weighed and measured for volume. Results are expressed in grams for weight and in cubic centimeters (cc) for volume. Specific volume is the ratio of volume to weight.
  - Pan bread is scored for exterior appearance, internal uniform crumb grain, and texture.

**Why is this important?**

The Pan Bread Test provides end-users with information on flour quality characteristics. Bakers need flours that perform consistently, especially in high-speed commercial operations. Consumers desire a consistent product that meets expectations for volume, color, and texture.

# Hearth Bread



## Baguette Pre-ferment Dough

Formula		
	Flour	120 grams
	Water	80 grams
	Salt	2.5 grams
	Instant yeast	0.2 grams

1. Flour is combined with yeast and blended for 10 seconds.
2. Water and salt are added and mixed for 5 minutes to form a pre-ferment dough.
3. The pre-ferment dough is covered and rested for 3–12 hours at room temperature.

**Baguette Dough****Formula**

Flour	1,000 grams
Pre-ferment dough	200 grams
Water	680 grams
Salt	22 grams
Instant yeast	10 grams

**Procedure**

1. Flour is combined with yeast and blended for 10 seconds. Water and salt are added and mixed to form a dough.
2. The pre-ferment dough is added slowly and mixed.
3. The dough is covered and rested for 20 minutes, then divided, shaped into cylinders, and rested again.
4. The cylinders are covered and proofed for 90 minutes.
5. A few evenly placed cuts are made on top of the shaped dough.
6. The shaped dough is baked for 25 minutes at 240°C top heat and 200°C bottom heat.

**Results**

- Hearth bread is evaluated for processing characteristics, external and internal characteristics, appearance, and texture. The results are expressed as a numerical score based on comparison to a control sample.
- Dough properties are evaluated for strength and extensibility.
- Hearth bread is weighed and measured for volume. Results are expressed in grams for weight and in cubic centimeters (cc) for volume. Specific volume is the ratio of volume to weight.
- Hearth bread is scored for appearance, crumb structure, and texture.

**Why is this important?**

The Hearth Bread Test provides information that can be used to optimize processing conditions prior to commercial-scale baking. Final product attributes, such as appearance, flavor, and texture, can be evaluated on small dough batches with this test.



# Flat Bread



## Egyptian Baladi Flat Bread

<b>Formula</b>	Flour*	100 grams
	<i>80-95% extraction</i>	
	Compressed yeast	1.5 grams
	Salt	1.0 grams
	Water	65–70 grams
	<i>enough to make a sticky dough</i>	

\*14% moisture basis

**Procedure**

1. Flour is combined with a yeast suspension and a salt solution and mixed to optimum dough development.
2. The dough is placed in a fermentation cabinet at 28°C and 85% relative humidity for 40–50 minutes.
3. After removal from the fermentation cabinet, the dough is divided into equal pieces and formed into balls by hand.
4. The dough pieces are rested for 10 to 20 minutes and then dusted with flour and compressed by hand or in a sheeter.
5. The dough pieces are returned to the fermentation cabinet and proofed for 30–45 minutes.
6. The dough pieces are baked in a 450–500°C oven for 1–2 minutes.

**Results**

- Flat bread is evaluated for processing performance and consumer expectations. The results are expressed as a numerical score based on comparison to a control sample.
- Dough is evaluated for stickiness during processing, extensibility, and strength.
- Flat bread is evaluated for texture, flexibility, shape, color, and shelf life.
- Flat bread is scored for appearance, uniform crumb grain, and texture.

**Why is this important?**

Flat bread is a diverse product, including a broad range of items such as tortillas in Mexico, chappati in India, and shaobin in China. Consumers desire a consistent product that meets expectations for color and texture. Bakers need flours that perform consistently, especially in high-speed commercial operations. The Flat Bread Test provides information to manufacturers on processing performance of flour. The stickiness of a dough is a significant factor in flat bread production since flat bread baked in a tandoor oven must be sticky to adhere to the oven during baking. Flat bread baked in a conventional oven must not stick to the oven during baking.

# Asian Steamed Bread



Gary Hou, Technical Manager and Asian Foods Specialist

<b>Formula</b>	Flour*	400 grams
	Dry yeast	4.0 grams
	Water	180–208 grams

*\*14% moisture basis*

*Additional ingredients that affect texture and flavor may be added:*

Sugar  
Shortening  
Baking powder  
Starches

**Procedure**

1. Flour and other ingredients are combined with a yeast suspension and water and then mixed to form a dough.
2. The dough is covered and rested in a bowl for 10 minutes at room temperature.
3. The dough is folded into thirds and compressed in a sheeter 12 times, or until it is uniformly smooth, and then rolled into a cylinder and cut into pieces 30 grams each.
4. The dough pieces are proofed and then steamed in a steamer for 7 minutes. Last, they are cooled for 30 minutes.

**Results**

- Asian steamed bread is evaluated for processing performance, volume, weight, internal and external characteristics, eating quality, and flavor. The results are expressed as a numerical score based on comparison to a control sample.
- Asian steamed bread is weighed and measured for volume. The results are expressed in grams for weight and in cubic centimeters (cc) for volume. Specific volume is the ratio of volume to weight.
- Processing performance is evaluated for mixing, sheeting, rolling, cutting, and proofing.
- External characteristics are scored for appearance and color.
- Internal characteristics are evaluated for structure, uniform crumb grain, and color (whiteness and brightness).
- Eating quality is scored for chewiness, bite, and non-stickiness. Flavor is scored for natural wheat flavor.

**Why is this important?**

Steamed bread is a major use of wheat throughout Asia. It is often eaten with a meal as a staple food or as a snack or dessert. The performance of flour in processing is important to steamed bread manufacturers because it has an impact on end-product quality. The Asian Steamed Bread Test determines processing characteristics by evaluating the balance between gluten strength and dough extensibility during sheeting. Superior steamed bread has a smooth skin, a firm and chewy texture, and a white fine-grain interior that is desired by consumers.

*Protocols developed at Wheat Marketing Center, Portland, Oregon.*

# Sugar Snap Cookie



*Kevin Marquardt, Laboratory Technologist*



<b>Formula</b>		
	Flour*	40 grams
	Sugar	24 grams
	Shortening	12 grams
	Nonfat dry milk	1.2 grams
	Sodium bicarbonate	0.4 grams
	Solution of sodium bicarbonate	0.32 grams
	Solution of ammonium chloride and salt	0.2 grams 0.18 grams
	Water	Variable (0.3–2.1 ml)
	<i>*14% moisture basis</i>	

**Procedure**

1. Sugar, nonfat dry milk, and sodium bicarbonate are sifted together, combined with the shortening, and creamed.
2. A sample of 37.6 grams of creamed mass is weighed out and combined with water, a solution of sodium bicarbonate, and a solution of ammonium chloride and salt.
3. Flour is added and mixed in to form a dough.
4. The dough is rolled out to a consistent thickness, cut into circles, and placed on a greased cookie sheet.
5. The cookies are baked at 205°C for 11 minutes.
6. The cookies are cooled on the cookie sheet for 5 minutes before removing to a cooling rack.

**Results**

- Sugar snap cookies are evaluated for cookie spread (diameter) and top grain appearance. The results are expressed as a numerical score based on comparison to a control sample.
- Cookie spread is measured and the results are expressed in centimeters (cm).
- Top grain is evaluated by visual examination of the pattern of cracks and “islands” on the top surface of the cookie and a numerical score is given.

**Why is this important?**

The Sugar Snap Cookie Test is used worldwide to evaluate the performance of wheat flour for use in a wide range of confectionery products. Flour with low protein and weak gluten, which produces cookies with a high cookie spread and numerous cracks on the surface, usually performs well for these products.

# Sponge Cake



<b>Formula</b>	Flour*	100 grams
	Eggs	100 grams
	Sugar	100 grams
	Water	40 grams

*\*14% moisture basis*

**Procedure**

1. Eggs, water, and sugar are mixed together with gentle heating to achieve a foamy batter with a consistent viscosity (target specific gravity:  $25 \pm 1$  grams/milliliters; temperature:  $30 \pm 1^\circ\text{C}$ ).
2. Flour is folded into the batter and poured into a round cake pan with a paper liner.
3. The cake is baked at  $180^\circ\text{C}$  for 30 minutes.
4. The cake is removed from the oven and placed on a wire cake rack to cool.

**Results**

- Sponge cake is evaluated for volume, external and internal characteristics, and texture. The results are expressed as a numerical score based on comparison to a control sample.
- Sponge cake is weighed and measured for volume. The results are expressed in grams for weight and in cubic centimeters (cc) for volume.
- External characteristics are evaluated by visual examination for shape, crust color, and cake appearance.
- Internal characteristics are evaluated by visual examination for cell uniformity, cell size, and cell wall thickness.
- Texture can be determined for softness with the TA.XT2 Texture Analyzer (see pp. 68–69).

**Why is this important?**

Sponge cake is a popular dessert in Asia. Sponge cake production is a typical use of weak gluten flour, which is used for many confectionery products. The Sponge Cake Test allows manufacturers to evaluate the suitability of the flour for these products. Flour with low protein content, low ash content, and weak gluten characteristics makes good quality sponge cake.



# Extruded Pasta



Wheat Foods Council

<b>Formula</b>	Semolina*	100 grams
	Water	31.5 grams

*\*Note: Semolina is a coarse milled product made from durum wheat.*

**Procedure**

1. A sample of semolina is weighed and placed in a mixing bowl.
2. Semolina is mixed at low speed as water is added over a 30-second period and then mixed at high speed for 4 minutes to form a dough.
3. The dough is transferred to the extruder and extruded into pasta product.
4. The extruded pasta product is cut to length and dried.

**Results**

- Extruded pasta is evaluated for processing performance, texture, color, external characteristics, and cooking qualities. The results are expressed as a numerical score based on comparison to a control sample.
- Processing performance is determined for dough strength and extensibility.
- External characteristics are determined for surface smoothness and appearance, including color, clarity, specks, and cracks.
- Cooked pasta is evaluated by sensory analysis for cooking qualities, such as firm bite (“al dente”), non-stickiness, flavor, and mouthfeel.
- Texture can be determined with an instrument test; for example, the TA.XT2 Texture Analyzer (similar to Asian Noodle Texture Test; see pp. 70–71).

**Why is this important?**

Processing conditions can be optimized with the Extruded Pasta Test prior to commercial-scale operations. Final product attributes, such as stickiness, texture, and color, can be predicted on small-scale equipment.

Strength and extensibility of dry pasta is a key factor in pasta production since the product must be mechanically strong to maintain its size and shape during cutting, packaging, handling, and shipping.

Preferred characteristics of extruded pasta, such as color and texture, are determined by consumer desires and expectations.

# Asian Sheeted Noodles



*Mia Biberic, Student Intern, and Gary Hou, Technical Manager and Asian Foods Specialist*

## White Salted Noodles

Formula		
	Flour*	1,000 grams
	Salt	12–20 grams
	Water	280 to 400 grams

*\*14% moisture basis*

*Additional ingredients that affect color or texture may be added:*

Eggs

Sodium hydroxide

Sodium or potassium carbonate (kansui)

Starches

Gums

**Procedure**

1. Flour is combined with a salt and water solution and mixed for 12 minutes to form a crumbly dough.
2. The dough is rested for 30 minutes to thoroughly redistribute moisture.
3. The dough is compressed between two pairs of rollers with a 3 mm gap in a noodle machine.
4. Two dough sheets are combined and passed through rollers with a 4 or 5 mm gap.
5. The dough sheet is rested for 30 minutes to thoroughly redistribute moisture.
6. The dough sheet continues to be sheeted at progressively reduced gaps until desired thickness (1–2 mm) is achieved.
7. The dough sheet is slit to specified size and shaped for noodle type.

**What do the results mean?**

- Asian noodles are evaluated for processing performance, color, and texture. The results are expressed as a numerical score based on comparison to a control sample.
- Processing performance is determined by dough handling properties such as extensibility, ease of processing, dough smoothness, non-stickiness, and ease of slitting.
- Color is evaluated by visual examination for whiteness, yellowness, and brightness. Color can also be measured with the Minolta Chroma Meter Test and expressed as L\*, a\*, and b\* values (see pp. 70–71).
- Cooked noodle texture is evaluated by sensory analysis to score for bite, chewiness, springiness, and mouthfeel. Texture can also be determined by the TA.XT2 Texture Analyzer Test to provide texture parameters such as hardness, springiness, cohesiveness, and chewiness (see pp. 68–69).

**Why is this important?**

Noodle makers need a balance of gluten strength and extensibility to keep the dough sheet from tearing during processing. Specifications for noodle color and texture vary by noodle type. Preferred characteristics are determined by consumer desires and expectations in each market. The Asian Sheeted Noodle Test predicts properties that are important for commercial noodle processors.

# Asian Noodle Texture Analysis



*Gary Hou, Technical Manager and Asian Foods Specialist*

**Texture measurement of cooked noodles is performed with a texture analyzer.**

One method used to analyze texture in laboratory tests and commercial products, such as sheeted noodles, extruded pasta, and sponge cake, is the TA.XT2 Texture Analyzer Test.

### Procedure

1. A 100-gram sample of noodles is cooked in 1 liter of boiling water for 3–5 minutes.
2. The noodles are rinsed with cool tap water and drained.

### Textural Measurement

1. A sample of 5 noodle strands are randomly selected and cut into 5–7 cm pieces.
2. The 5 noodle pieces are laid side by side on the TA.XT2 Texture Analyzer instrument platform.
3. A 2-bite (compression) test is performed using a special plastic tooth. Compression is performed to 70% of noodle thickness.

### Results

- Asian noodle texture is determined as hardness, springiness, cohesiveness, and chewiness with the TA.XT2 Texture Analyzer.
- Hardness indicates noodle bite and is expressed as hard bite or soft bite.
- Springiness indicates the degree of recovery after the first bite.
- Cohesiveness is a measure of noodle structure.
- Chewiness is a single parameter that incorporates firmness, cohesiveness, and springiness.
- A typical Chinese raw noodle has the following measurements: springiness 0.96, hardness 1,200 grams, cohesiveness 0.66, and chewiness 750 grams.

### Why is this important?

Noodle texture is an important quality characteristic. Based on the noodle type and the marketplace, noodle texture can be hard bite or soft bite. For example, Udon noodles are usually softer and more elastic while other noodles are harder and chewier in bite.

# Asian Noodle Color Analysis



**Noodles range in color from white to yellow based on type of noodles consumed in each market.**

One method used to analyze product color in laboratory tests and commercial products, such as sheeted noodles and other products, is the Minolta Chroma Meter Test. To determine Asian noodle color, the dough sheet is analyzed as follows.

### Procedure

1. A sample of 3 Asian noodle dough sheets are cut just prior to slitting and then stacked together.
2. Measurements are taken in two locations on both the top and bottom on 2 out of 3 dough sheets with the Minolta Chroma Meter, and an average  $L^*$ ,  $a^*$ , and  $b^*$  are recorded.
3. Two readings are taken at 0 and 24 hours on each side of two dough sheets, and an average  $L^*$ ,  $a^*$ , and  $b^*$  are recorded.

### Results

- Asian noodle color is determined by measuring the color components of a noodle sample with the Minolta Chroma Meter.
- Asian noodle color results are reported in terms of color values based on the following rating scale:

<b><math>L^*</math> value</b>	whiteness	100 white 0 black
<b><math>a^*</math> value</b>	positive values negative values	+60 red color -60 green color
<b><math>b^*</math> value</b>	positive values negative values	+60 yellow color -60 blue color

- Typical Asian noodle color is described as bright white, creamy white, pale yellow, or intense yellow. For example, a good color Chinese raw noodle should have a minimum  $L^*$  value of 72.0 at 24 hours after production.

### Why is this important?

Noodle color is one of the most important Asian noodle product quality characteristics because it is the first attribute perceived by consumers. Asian noodle color may be white or yellow depending upon the noodle type, but it should be bright.





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