Section 3: Wheat and Milling Tests

Moisture Content

Method

1. A small sample of flour or ground wheat (2 to 3 grams) is weighed and placed in a moisture dish.
2. The sample is heated at 130 degrees Celsius 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 percent.

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 percent 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 (greater than 14.5 percent) attracts mold, bacteria, and insects, all of which cause deterioration during storage. Wheat or flour with low moisture content is more stable during storage.

Sample dishes in moisture oven.

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.

Adapted from Method 44-15A, Approved Methods of the American Association of Cereal Chemists, *10th Edition. 2000. St. Paul, MN.*

- **Low temperature heating**
- **Measures moisture content**

Ash Content

Method

1. A sample of flour or ground wheat (3 to 5 grams) is weighed and placed in an ash cup.
2. The sample is heated at 585 degrees Celsius 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 percent or flour ash of 0.52 percent. Wheat or flour ash is usually expressed on a common moisture basis of 14 percent.

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.

Ash crucibles and furnace.

Adapted from Method 08-01, Approved Methods of the American Association of Cereal Chemists, *10th Edition. 2000. St. Paul, MN.*

- **High temperature incineration**
- **Measures mineral (ash) content**

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 to 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 degrees Celsius.
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 percent protein content on 12 percent moisture basis for wheat or 8.5 percent on 14 percent 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 also can 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 machine.

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. St. Paul, MN.

- **High temperature combustion**
- **Measures protein content**

Falling Number

Method

1. A 7-gram sample of ground wheat or flour is weighed and combined with 25 milliliter 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 degrees Celsius 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.

Falling number apparatus.

Adapted from Method 56-81B, Approved Methods of the American Association of Cereal Chemists, *10th Edition. 2000, St. Paul, MN.*

- **Viscosity analysis**
- **Measures the effects of sprout damage**

Sedimentation

Method

1. A small sample of flour or ground wheat (3.2 grams) is weighed and placed in 100-milliliter glass-stoppered graduated cylinder.
2. Water (50 milliliter) is added to the cylinder and mixed for 5 minutes.
3. Lactic acid solution is added to the cylinder and mixed for 5 minutes.
4. The cylinder is removed from the mixer and kept in upright position for 5 minutes.
5. The sedimentation volume is recorded.

Results

- The sedimentation test is conducted by holding the ground wheat or flour sample in an acid solution.
- During the sedimentation test gluten proteins of ground wheat or flour swells and precipitate as a sediment.
- Sedimentation values can be in the range of 20 or less for low-protein wheat with weak gluten to as high as 70 or more for high-protein wheat with strong gluten.

Why is this important?

- The sedimentation test provides information on the protein quantity and the quality of ground wheat and flour samples. Positive correlations were observed between sedimentation volume and gluten strength or loaf volume attributes. The sedimentation test is used as a screening tool in wheat breeding as well as in milling applications.

Adapted from Method 56-61A, Approved Methods of the American Association of Cereal Chemists, *10th Edition. 2000. St. Paul, MN.*

Sedimentation cylinders.

Deoxynivalenol (DON) – Lateral Flow Strip

Method

Levels of deoxynivalenol (DON), also referred to as vomitoxin, are measured in the marketing channels with commercially available test kits. Test kits are based on immunochemical technology. GIPSA tests and approves mycotoxin test kits, including DON, for use in the U.S. official inspection system. These kits must meet GIPSA accuracy and precision requirements when compared to HPLC reference methods in order to be approved.

General

1. Prepare sample by weighing a portion sample of ground wheat and mixing the ground wheat sample with distilled water and shake.
2. Dilute the mixture as directed by the manufacturer's directions
3. Place test strip in incubator, peel back the tape, and add a portion of the diluted solution.
4. Close the lid of the incubator and wait.
5. Evaluate the results according to the manufacturer's directions.

Results

- The lateral flow strips used in test kits provide a yes or no answer to whether the sample tested contains DON above a certain amount.
- Usually within 5 to 15 minutes the results can be read.
- All tests include an internal procedural control line that is used to validate the test result.
- The appearance of two lines indicates a positive result, while a negative test produces only one line.

Why is this important?

DON is a toxin produced by fusarium fungi. DON occurs in feed grains when grown under certain climatic conditions. Illnesses have been observed in livestock that have consumed feed grains containing high levels of DON concentrations.

DON lateral test strips and HPLC vials.

- **Quick test**
- **Detects levels of vomitoxin**

Single–Kernel Characterization System (SKCS)

Method

1. A sample of wheat kernels (12 to 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.

SKCS analyzer.

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.

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.

Adapted from Method 55-31, Approved Methods of the American Association of Cereal Chemists, *10th Edition. 2000. St. Paul, MN.*

- **Kernel analysis**
- **Measures kernel characteristics**

Laboratory Wheat Milling

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 wheat requires less water and less time than hard wheat.
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.
- Laboratory flour mill results are generally 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; however extraction could be reported as the percentage of flour from the sample of wheat milled.
- Flour produced can be used for other tests.

Why is this important?

Laboratory flour milling tests indicate milling properties on small wheat samples. Commercial flour mills can use this information to adjust mill settings and optimize flour extraction.

Small samples of wheat can be milled on a number of different laboratory mills 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. The most common laboratory mills are the Brabender Quadramat Flour Mills and the Buhler Laboratory Flour Mill.

The Brabender Quadramat is available in two models, the Quad Jr. and the Quad Sr. Both mills use a series of three rolls to grind the wheat. The main difference between the two models is the Quad Jr. is a single pass machine and the Quad Sr. has a double pass grinding flow.

Buhler MLU-202 laboratory mill.

Both models are best used for as micro-milling or the milling of very small samples.

Micro-milling is important for wheat breeding programs. Early generation wheat varieties need to be tested for milling and baking qualities, but very small samples are available for testing. Samples as small as 50 grams can be processed using either of the Quadrumat milling systems.

The normal sample size is 100 grams to produce enough flour for further analysis.

The Buhler Laboratory Flour Mill is the most common laboratory mill used by milling companies and grain quality

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

laboratories to evaluate commercial wheat samples. The Buhler Laboratory mill has six grinding passages, three fluted roll break passages and three smooth roll reduction passages. This mill operates at about 125 grams per minutes and can handle much larger samples, commonly up to five kilograms. The larger sample size produces sufficient flour to run additional flour functionality tests such as the farinograph and alveograph and product test baking.

Adapted from Methods 26-21A, 26-30A, 26-31, 26-41, Approved Methods of the American Association of Cereal Chemists*, 10th Edition. 2000. St. Paul, MN.*

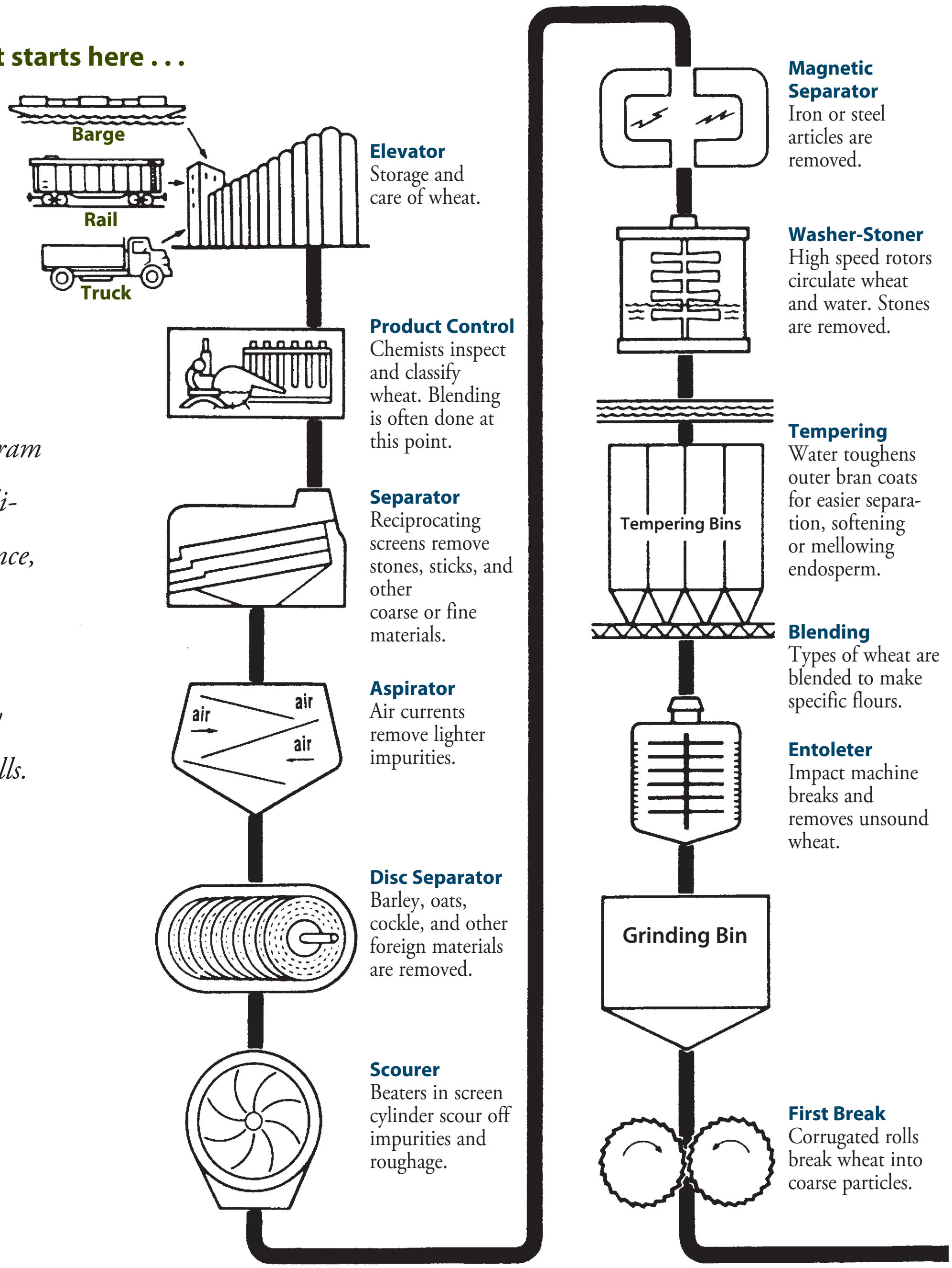
Brabender Quadramat Jr. laboratory mill.

Brabender Qudramat Sr. laboratory mill.

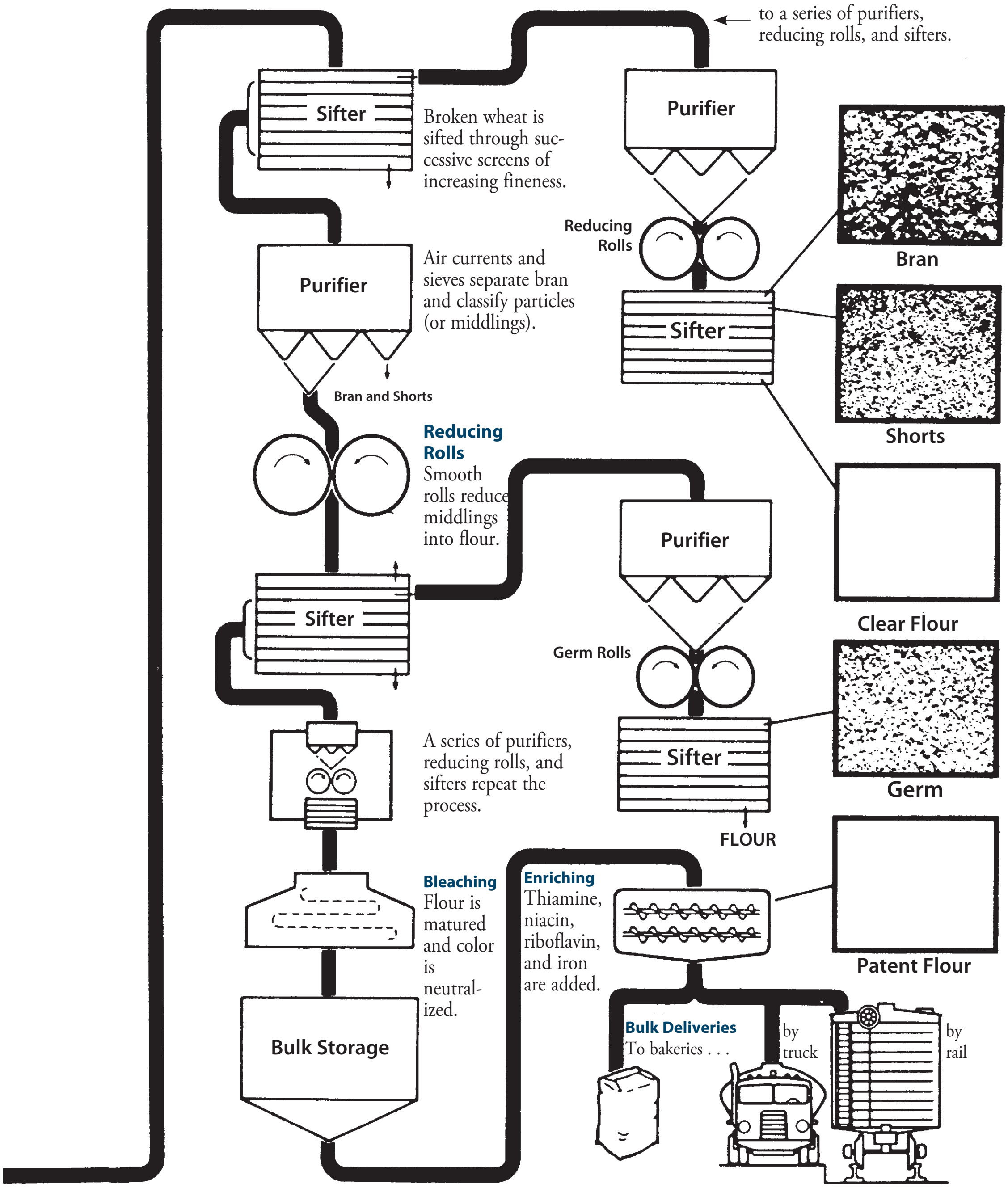
Brabender Qudramat Sr. grinding rolls.

Simplified Milling Process Diagram

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



Courtesy of Wheat Foods Council, 10841 S. Crossroads Drive, Suite 105, Parker, Colorado 80138.


to a series of purifiers, reducing rolls, and sifters.
Sifter
Broken wheat is sifted through successive screens of increasing fineness.
Purifier
Reducing Rolls
Bran
Purifier
Air currents and sieves separate bran and classify particles (or middlings).
Sifter
Shorts
Bran and Shorts
Reducing Rolls
Smooth rolls reduce middlings into flour.
Purifier
Clear Flour
Sifter
Germ Rolls
Germ
Sifter
A series of purifiers, reducing rolls, and sifters repeat the process.
FLOUR
Bleaching
Flour is matured and color is neutralized.
Enriching
Thiamine, niacin, riboflavin, and iron are added.
Patent Flour
Bulk Storage
Bulk Deliveries
To bakeries . . .
by truck
by rail