ANALYSIS METHODS

WHEAT GRADE FACTORS

The U.S. grade of a sample is a numeric value from 1 to 5 or the designation "Sample Grade" which reflects the physical condition of a sample and thus may indicate its general suitability for milling. All numeric factors other than test weight are reported as a percentage by weight of the sample. (See table on page 3.) Grade determining factors include:

TEST WEIGHT is a measure of density in pounds per bushel (lb/bu) or kilograms per hectoliter (kg/hl). Test weight may be an indicator of potential milling yield and the general condition of the sample. Problems during growing season or at harvest often reduce test weight.

DAMAGED KERNELS show signs of disease, insect activity, frost or sprouting and may adversely affect milling or flour quality.

FOREIGN MATERIAL is any material other than wheat that remains after dockage is removed. Because foreign material is not easily removed, it may have an adverse effect on milling and flour quality.

SHRUNKEN AND BROKEN kernels have a shrunken or shriveled appearance or were broken in handling and may reduce milling yield.

TOTAL DEFECTS is the sum of damaged kernels, foreign material and shrunken and broken kernels.

VITREOUS KERNELS in hard red spring wheat are uniformly dark and have no spots that appear chalky or soft. In durum, vitreous kernels have a glassy and translucent appearance without any spots that appear chalky.

WHEAT NON-GRADE FACTORS

DOCKAGE is the percentage by weight of material removed from a sample by the Carter Dockage Tester. Being easy to remove, dockage should not affect milling quality but may have other economic effects for buyers. Grade factors are determined after dockage is removed.

MOISTURE content is the percentage of water by weight of a sample and is an important indicator of profitability in milling. Flour millers add water to adjust wheat moisture to a standard level before milling. Lower wheat moisture allows more water to be added, increasing the weight of grain to be milled at virtually no cost. Moisture content is also an indicator of grain storability as wheat and flour with low moisture are more stable during storage. Because moisture can be readily added to or removed from a sample, other analysis results are often mathematically converted to a standard moisture basis (mb), such as 14%, 12% or dry matter, so results can be compared.

PROTEIN content is the percentage of protein by weight in a sample. Because there is no rapid method for determining wheat protein quality, protein quantity is used as an indicator in trade and by millers of the suitability of wheat or flour for various products and is an important factor in determining the value of wheat. High protein is usually desired for products such as pan breads, pasta, buns and frozen yeast-raised products. Low protein is usually desired for products such as snacks or cakes.

ASH content is the percentage of minerals by weight in wheat or flour. In wheat, ash is primarily concentrated in the bran and is an indication of the flour yield that can be expected during milling. In flour, ash content indicates milling performance by

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indirectly revealing the amount of bran contamination in flour. Ash in flour can impart a darker color to finished products. Products requiring white flour call for low ash content, while whole wheat flour has higher ash content.

KERNEL SIZE is a measure of the percentage by weight of large, medium and small kernels in a sample. Large kernels or a more uniform kernel size may help improve milling yield.

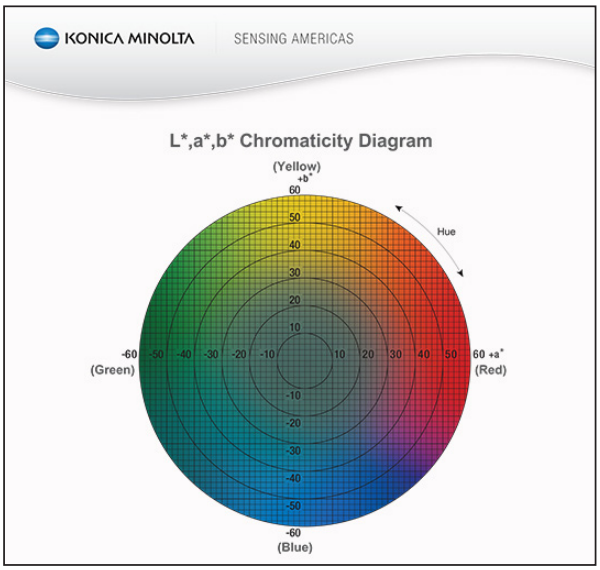
1000 KERNEL WEIGHT is the weight in grams of 1,000 kernels of wheat and may indicate grain size and expected milling yield.

SINGLE KERNEL CHARACTERIZATION SYSTEM (SKCS) measures 300 individual kernels from a sample for size (diameter), weight, hardness (based on the force needed to crush) and moisture. Detailed SKCS results (not reported in this booklet) include the distribution of these factors, which may be an indicator of the uniformity of the sample and help millers experienced with the system to optimize flour milling yields. Kernel characteristics may help millers optimize tempering or adjust roll gap settings.

SEDIMENTATION value is a measure of the volume of sediment that results when lactic acid is added to a sifted, ground wheat sample. High sedimentation volume indicates strong gluten while low sedimentation volume indicates weaker gluten.

FALLING NUMBER is the time required for a plunger to fall through a heated mixture of flour and water and is a measure of enzyme activity. Sprouted wheat forms alpha-amylase which breaks down starch into sugars. High falling number values indicate low alpha-amylase activity. Some alpha-amylase is required for certain products such as yeast-raised bread. However, excessive alpha-amylase in wheat cannot be removed and is difficult to reduce by blending. Flour with excessive amylase activity produces a sticky dough that can cause processing problems and products with poor color and weak texture. Falling number usually correlates closely with amylograph results.

DON (DEOXYNIVALENOL), produced by Fusarium fungi, is the most common mycotoxin in wheat.



COLOR measures a sample's lightness (L*) on a scale of 0 to 100 and "chromaticity" or hue on two scales from -60 to +60 for green to red (a*) and blue to yellow (b*). High L* values indicate a bright color, and higher b* values indicate more yellow. Flour color is influenced by endosperm color, particle size and ash content and often affects the color of the finished product. Durum semolina color is heavily influenced by particle size.

FLOUR DATA

EXTRACTION is the percentage by weight of flour obtained from a wheat sample. The extraction rate is critically important to a commercial mill's profitability. In a laboratory, milling with the Buhler laboratory mill is done mainly to obtain flour for other tests. The Buhler laboratory mill extraction rate is always significantly lower than the rate that can be obtained on a commercial mill.

WET GLUTEN is a measure of the quantity of gluten in wheat or flour samples as determined using the Glutomatic System. Gluten forms when water is added to the protein in wheat and is responsible for the elasticity and extensibility characteristics of flour dough.

GLUTEN INDEX is also determined by the Glutomatic System and is a measure of gluten strength regardless of the quantity of gluten present. Gluten index is used commercially to select durum samples with strong gluten characteristics. In bread (hard) wheat, a variety of factors other than gluten quality can affect the results, though very low gluten index may be an indication of protein damage from insect or disease activity.

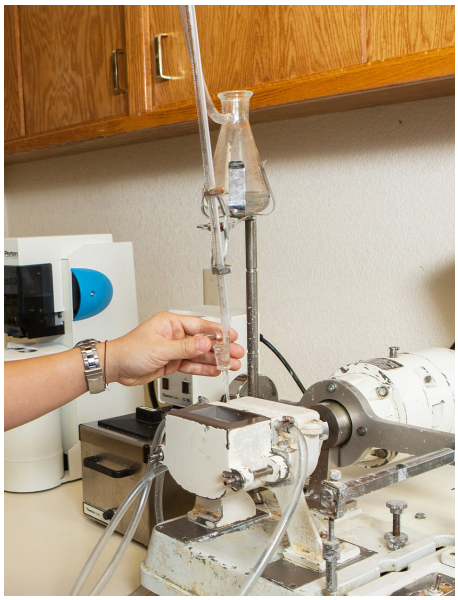
AMYLOGRAPH measures flour starch pasting properties that are important to products such as sheeted Asian noodles. Amylograph also measures enzyme (alpha-amylase) activity which usually is from sprout damage. Amylograph results usually correlate closely with falling number results.

STARCH DAMAGE, the percentage by weight of damaged starch in a flour sample, is a measure of the physical damage done to starch granules during milling. Bread wheat flour typically has higher starch damage than soft wheat flour. Highly damaged starch readily absorbs more water, which affects dough mixing and other processing properties. Because starch damage depends on how the sample was milled, starch damage is important for interpreting other results reported.

SOLVENT RETENTION CAPACITY (SRC) is the weight, expressed as percentages, of four solvents held by flour after centrifugation to the original flour weight on a 14% mb. The solvents, distilled water, sucrose (measuring pentosans), lactic acid (measuring glutenins) and sodium carbonate (measuring starch damage), indicate the ability of flour to absorb water during mixing and release water during baking. Specific ranges of lower SRC values are desirable for specific soft wheat products while higher SRC values are desirable for bread products. Gluten performance index (GPI), a calculation of three SRC values – lactic acid/(sodium carbonate + sucrose) – is a good predictor of overall performance of flour glutenins, especially for bread wheat flour.

ANALYSIS METHODS

DOUGH PROPERTIES



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FARINOGRAPH generates a curve that indicates the power used over time as flour and water are mixed into dough. The results describe the mixing properties of the dough and include:

- **PEAK TIME** is the time interval from the first addition of water to the maximum consistency immediately prior to the first indication of weakening. Long peak times indicate strong gluten and dough properties while short peak times may indicate weak gluten.
- **STABILITY** is the interval between the point where the top of the curve first intersects the 500-BU line (called the “arrival time”) and the point where the top of the curve departs the 500-BU line (“departure time”). Long stability times also indicate strong gluten and dough properties, useful in products such as yeast-raised breads, while short stability times indicate weaker gluten useful in many confectionary products.
- **ABSORPTION** is the amount of water (as a percent by weight on a 14% mb) required to center the curve peak on the 500-BU line. High water absorption provides economic advantages for producing more dough pieces than flour with lower water absorption.

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ALVEOGRAPH generates a curve indicating the air pressure necessary to inflate a piece of dough like a bubble to the point of rupture and indicates the gluten strength and extensibility of dough. Values reported include:

- **P** (“overpressure” or resistance), measured in millimeters to the maximum height of the curve, reflects the maximum pressure while blowing the bubble of dough and indicates dough resistance to extension.
- **L** (length), the length of the curve measured in millimeters, reflects the size of the bubble and indicates dough extensibility.
- **W** (the area under the curve) reflects the amount of energy needed to inflate the dough to the point of rupture and indicates dough strength.

The alveograph is well suited for measuring the dough characteristics of weaker gluten wheat and, with adapted hydration and mix time, of stronger wheats including durum. Requirements differ depending on intended flour use. Low P values (indicating weak gluten) and long L values (high extensibility) are preferred for cakes and confectionery products; P/L close to 1 and high W values (strong gluten) are preferred for pan breads; and P/L values close to 0.75 are favored for durum for pasta semolina.

MIXOGRAPH generates a graph that records the force needed to mix flour or semolina and water into dough. The mixograph is similar to the farinograph but is quicker and uses a pin mixer and a smaller flour sample. Peak height and peak time are common mixing parameters that are determined by the mixograph.

- **CLASSIFICATION** indicates dough characteristics for durum milled fractions on a scale of 1 to 8 with higher values indicating stronger dough properties.
- **PEAK TIME** is the interval from the first addition of water to when the curve peaks and is considered an indicator of both the rate of dough development and hydration rate. Short peak time indicates a quick hydration rate and long peak time a slow hydration rate.
- **PEAK HEIGHT** is the height of the curve at peak time measured from the bottom of the mixogram paper to the middle of the band width at the curve peak. Peak height is primarily a function of protein content but is affected by water absorption and dough strength. Peak height increases with protein content and dough strength, decreases with water absorption and is measured in "mixograph units (MU)". An MU is one rectangle on the mixogram.

EXTENSOGRAPH generates a force-time curve for a piece of dough that is stretched until it breaks. Results include:

- **RESISTANCE**, measured at the maximum curve height in Brabender Units (BU), reflects the maximum force applied and indicates the resistance of the dough to extension.
- **EXTENSIBILITY**, measured as the total length of the curve at the base line in centimeters, reflects how far the dough was stretched.
- **AREA** is the area under the curve reported in square centimeters.

These factors help describe the gluten strength and dough extensibility characteristics of flour for a wide range of end products. The extensograph can also evaluate the effects of fermentation time and additives on dough performance.

EVALUATION OF END-PRODUCTS

BAKING ABSORPTION is the water required for optimum dough mixing performance, expressed as a percent of flour weight on a 14% mb.

CRUMB GRAIN AND TEXTURE is determined on a scale of 1 to 10 by visual comparison to a standard using a constant illumination source. Higher scores are preferred.

LOAF VOLUME is the volume of a test loaf after baking. Higher loaf volumes indicate better baking performance for pan breads.

SPECKS are visually counted in a semolina sample and reported as the number in 10 square inches. These small particles of bran or other material that escaped the wheat cleaning and semolina purifying process reflect the milling process and the characteristics of the durum and can detract from pasta appearance and desirability.

SUGAR SNAP COOKIE, SPONGE CAKE, CHINESE SOUTHERN-TYPE STEAMED BREAD, SPAGHETTI AND HARD WHITE NOODLE AND STEAMED BREAD tests all use standardized methods to evaluate the suitability of the sample for that product or similar products.

THE HARVEST AND CARGO SAMPLES FOR EACH CLASS ARE EVALUATED USING THE FOLLOWING METHODS. FLOUR OR SEMOLINA PRODUCED AS DESCRIBED IN "LABORATORY MILLING EXTRACTION" IS ANALYZED TO PROVIDE FLOUR, SEMOLINA AND END-USE PRODUCT DATA.

WHEAT AND GRADE DATA

GRADE: Official U.S. Standards for Grain.

DOCKAGE: Official USDA procedure using the Carter Dockage Tester.

MOISTURE: HRW, HRS, SW, HW – Official USDA Conductance method; Durum – AACCI 44-11.01 (Motomco Moisture Meter) and AACCI 44-15.02 (air oven method); SRW – AACCI 44-15.02.

TEST WEIGHT: AACCI 55-10.01; test weight is converted to hectoliter weight: for durum – kg/hl = lb/bu x 1.292 + 0.630, for other classes – kg/hl = lb/bu x 1.292 + 1.419.

PROTEIN: HRW, HRS, SW, HW – AACCI 39-25.01 (NIR method); all other classes – AACCI 46-30.01 (Dumas combustion nitrogen analysis or CNA method).

SINGLE KERNEL CHARACTERIZATION: AACCI 54-31.01 using Perten SKCS 4100.

SEDIMENTATION: HRS, HRW (Midwestern), SRW, SW, HW – AACCI 56-61.02; Durum – AACCI 56-70.01; HRW California (CA) – AACCI 56-63.01.

1000 KERNEL WEIGHT: HRS, Durum, SRW – based on a 10 gram (g) clean wheat sample counted by an electronic counter; SW, HW – based on the average weight of three 100-kernel samples expressed on a 14% moisture basis (mb); HRW – average of SKCS kernel weight times 1,000.

ASH: AACCI 08-01.01 expressed on a 14% mb.

FALLING NUMBER: AACCI 56-81.03; average value is a simple mean of sample results.

DON: All analysis is on ground wheat. HRS, Durum – gas chromatograph with electron capture detector as described in the Journal of AOAC International 79,472 (1996). SRW, HRW (CA) – Neogen ELISA; HRW (Midwestern) – Charm ROSA DonQ2 Quantitative Test.

VITREOUS KERNELS: HRS and Durum – percentage by vitreous kernels weight handpicked from a 15 g clean wheat sample.

KERNEL SIZE DISTRIBUTION: HRS, Durum (Northern) – Cereal Foods World (Cereal Science Today) 5:(3), 71 (1960). HRW (Midwestern), SW, HW, SRW – Wheat is sifted with a RoTap sifter using Tyler No. 7 (2.82 mm) and No. 9 (2.00 mm) screens. HRW (CA), Durum (Pacific Southwest) – uses U.S. Standard Sieves No. 7 (2.80 mm) and No. 10 (2.00 mm). Kernels remaining on the No. 7 screen are "Large," passing through the No. 7 screen but not the No. 9 or No. 10 (HRW (CA), Pacific Southwest Durum) are "Medium," and passing through the No. 9 or No. 10 screen are "Small."

ANALYSIS METHODS

FLOUR DATA

LABORATORY MILLING EXTRACTION: Samples are cleaned and tempered according to AACCI 26-10.02. All samples other than HRW (CA) are milled with standardized mill settings on a Buhler laboratory mill using these methods: SW – AACCI 26-31.01; HRW (Midwestern), SRW, HRS and HW – AACCI 26-21.02. SRW – uses a 183 micron sieve. HRW (CA) is milled on a Brabender® Quadrumat Senior Mill using the Brabender® procedure. All extraction rates are calculated against total products on an "as is" mb.

ASH: AACCI 08-01.01, reported on 14% mb.

COLOR: HRW (Midwestern) – Minolta method using Minolta Chroma Meter CR-110 with Granular-Materials Attachment; HRW (CA) – CR-210; HRS, SW, SRW, HW – CR-410 with Granular-Materials Attachment CR-A50. CIE 1976 L*a*b* color system: L* indicates white-black, a* – red-green and b* – yellow-blue.

PROTEIN: HRW, HRS – AACCI 39-10.01 (NIR method); all other classes – AACCI 46-30.01 (Dumas CNA method).

WET GLUTEN AND GLUTEN INDEX: HRW, HRS, SRW, HW – AACCI 38-12.02; SW – AACCI 38-12.02 (water reduced from 4.8 to 4.2 ml).

FALLING NUMBER: AACCI 56-81.04; average value is a simple mean of sample results.

FARINOGRAPH: AACCI 54-21.02 (Constant Flour Method) with 50 g bowl. Absorption is reported on 14% mb.

ALVEOGRAPH: AACCI 54-30.02. SW, HW, HRS, Durum – Alveolab.

AMYLOGRAPH: AACCI 22-10.01 modified to use 65 g flour (14% mb) and 450 ml distilled water with paddle (HRS) or pins (other classes).

EXTENSOGRAPH: AACCI 54-10.01, modified 45 and 135 min rest for HRS, HRW and HW; 45 min rest for SW and SRW.

STARCH DAMAGE: SRW – AACCI 76-30.02; all other classes – AACCI 76-33.01 (SDmatic method).

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SOLVENT RETENTION CAPACITY (SRC): SW, HW – SRC machine (Chopin); all other classes – AACCI 56-11.02.

SEMOLINA DATA

LABORATORY MILLING EXTRACTION: Samples are milled using a Brabender® Quadrumatic Junior Semolina Mill. Grain is tempered to 15.5% moisture one day before milling. Semolina extraction rates are calculated against total products on an "as is" mb. Pacific Southwest samples are milled on a Modified Chopin CD2 Mill. Extraction rates are calculated against total products on an "as is" mb.

ASH: AACCI 08-01.01 on 14% mb.

COLOR: Minolta Method using Minolta Chroma Meter CR-410 (Northern) or CR-210 (Pacific Southwest) with Granular-Materials Attachment. CIE 1976 L*, a*, b* color space.

PROTEIN: AACCI 46-30.01 (Dumas CNA method).

WET GLUTEN AND GLUTEN INDEX: AACCI 38-12.02 (Glutomatic procedure).

SPECKS: Sample is pressed under a 3 x 4 inch glass plate and the specks within a one-inch square marked on the plate are counted. Average of three determinations is expressed as specks per 10 square inches.

MIXOGRAPH: Northern – 10 g of semolina are mixed in a 10 g bowl with 5.8 ml of distilled water to give maximum dough consistency. Pacific Southwest – 35 g of semolina are mixed in a 35 g bowl with optimum water absorption using the formula y = 1.5*X + 43.6; X = semolina protein (14% mb). The spring setting is 8 (Northern) and 10 (Pacific Southwest). A classification incorporating peak height and general curve characteristics is assigned based on comparison with eight reference mixograms; the higher the classification number, the stronger the curve type.

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