MEASURING WHEAT PROTEIN OR GLUTEN QUALITY

Background

While developing a quick assay for either protein or gluten quality has been on the wheat industry's wish list for quite some time, it is becoming increasingly urgent that we evolve this technology. This is primarily due to (1) a more sophisticated buyer demanding tighter end-use specifications in both domestic and international wheat markets; (2) advancements and acceptance of high-yielding/low quality wheat varieties; and (3) for differentiating certain varieties of wheat of one class that can be used for different products, such as Hard White wheat (HDWH) used for noodles or bread.

Defining protein/gluten quality has proven a difficult task as several different technologies have historically been utilized and recognized by various factions within the industry. Use of instruments such as the Farinograph, Glutomatic, Alveograph, Extensograph, etc. all have their proponents and detractors. Trying to get industry to agree on which methodology best defines protein quality has proven nearly impossible. Further, in order to be readily accepted by industry, any new protein/gluten quality assay must be relatively inexpensive and easy to use, especially at first point-of-sale facilities. One thought has been to develop a set of calibrations correlated to one or more of the above mentioned "graph" tests and utilize NIR instruments already in use throughout the industry to perform the analysis for protein quality. Use of the NIR could pave the way for an industry recognized protein/gluten analysis that would subsequently allow for basic quality segregation at the country elevator or first point-of-sale. Whether or not this is practical or possible remains to be seen.

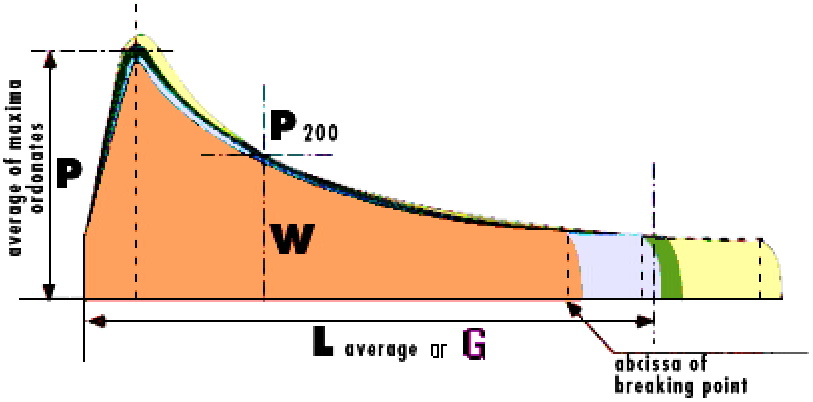
In response to industry's demands, GIPSA has identified the development of a quick and repeatable protein/gluten quality assay as a high priority. In order to assist in this endeavor, the following is a brief overview of current methods currently used by the U.S. wheat industry for quality determinations. (Listed alphabetically, not by relevance or importance to the trade):

ALVEOGRAPH (AACC Method 54-30A)

Instrument function: The alveograph measures resistance of dough to extension and extent to which it can be stretched under conditions of the method. A sheet of dough of definite thickness prepared under specified conditions is expanded by air pressure into a bubble until it is ruptured. This simulates the dough deformation by the gas produced during fermentation. The internal pressure in the bubble is graphically recorded on moving paper. A 250-gram sample of flour is mixed with water to form a dough ball.

The Alveograph includes 3 parts: a mixer/extruder for preparation of the dough with salt water, the bubble blowing unit and a curve recording manometer or a user-friendly recorder/calculator called an Alveolink.

A typical alveogram is illustrated below:



The recorded parameters are:

P = tenacity (max. pressure reached blowing the dough piece to rupture),
L = extensibility (length of the curve),
W = strength of the flour (area of the curve),
P/L = configuration ratio of the curve,
Ie = P200/P Elasticity (P200 = pressure after 200ml blowing or 4cm from origin of the curve).

Cost of the instrument, each analysis: Instrument: $26,500. Time and labor is the cost of the analysis.

Manufacturer: Chopin.

Level of expertise required: One-day training.

Analysis length: 25 to 30 minutes.

Benefits of this instrument: Tests gluten strength.

Negatives or limitations of this instrument: It is an old test, though still commercially available. The analysis needs to be carried out at a constant temperature (25 degrees C). Daily calibration is recommended.

Repeatability: Test is highly operator dependent, requiring a lot of hand manipulation of dough pieces, which can be a source of variability.

Marcel Chopin developed this test in the 1920s. It is used widely in European cereal labs for estimating the quality of wheat, control of the milling process and for control of the production of flour by selecting blends of wheat and verifying the action of approved additives on flour behavior.

AMYLOGRAPH (AACC Method 22-10)

Instrument function: The Brabender Amylograph is a torsion viscometer which provides a continuous record of changes in viscosity of 50-grams of flour mixed with 450 ml of buffer solution at a uniform rate of temperature increase and constant stirring. It measures the gelatinization properties of flour, including their a-amylase content, which influences a flour's behavior during the baking process, as well as the crumb structure, the degree of firmness and the shelf life of the finished product. The method provides a good estimation of the performance of starch in flour during the baking process. This is similar to the Rapid Visco Analyzer (RVA) referenced below.

Cost of the instrument, each analysis: The standard ViscoAmyloGraph is $17,135 and the new Micro ViscoAmyloGraph is $20,795 (plus computer). There are no consumables, but requires careful weighing and mixing. Labor and milling time are the primary analysis costs.

Manufacturer: Brabender.

Level of expertise required: Since the method requires careful weighing and preparation of the initial slurry, the method requires a fair amount of expertise since variability in preparation of the initial slurry can introduce errors. Typically, maximum viscosity is read from a chart, although newer versions are computerized (at a higher cost).

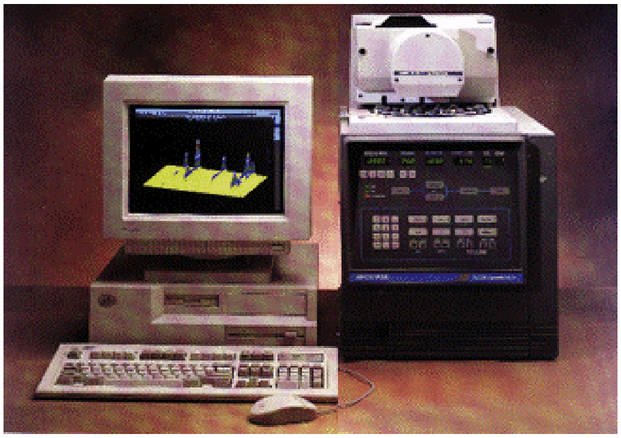
Analysis length: Typically, the cooking portion takes 20 minutes. Add sample slurry preparation and the messy clean up, and it can take 30 to 60 minutes.
Benefits of this instrument: The method is good at emulating the change in starch that occurs during baking and estimating baking performance for rye flours. The curve height indicates potential crumb grain quality (bread texture).

Negatives or limitations of this instrument: There are several including operator error and length of time for analysis. It requires cooling water, is a single analysis and requires a flour sample (not wheat meal). Further, interpreting the curve data is tricky.

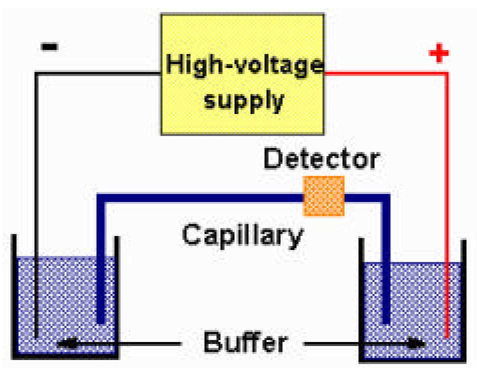
Repeatability: Good.

NOTE: This is an aged method and has been gradually replaced by the Falling Number and RVA methods which provide information much more quickly with less expertise.

CAPILLARY ELECTROPHORESIS



Instrument function: Methods of electrophoresis identify specific protein components based on their molecular weight. Some 250-mg of ground sample are extracted in a 5-minute procedure to produce a solution of proteins. A specific volume (a few nanoliters) of this solution of proteins is then automatically loaded onto a capillary column by the instrument and an electrical current is applied. Different proteins move at different rates and as they pass a clear window, the concentration of protein is measured with a standard UV light absorption system. The pattern obtained is a graph of protein content versus time. The pattern is variety specific.



Cost of the instrument, each analysis: $40,000 and $0.10 respectively.

Manufacturer(s): Several, including Hewlett Packard and Beckman Coulter.

Level of expertise required: A highly trained technician.

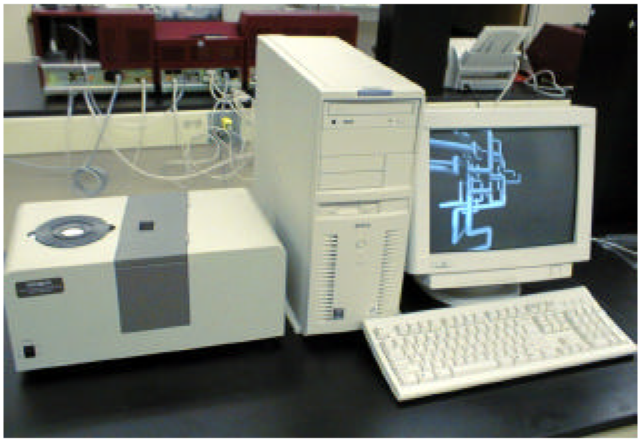
Analysis length: 10-15 minutes.

Benefits of this instrument: It can be used to identify individual varieties. It also can predict end-use quality for hard winter wheats. It is very safe to operate using non-toxic chemicals in very small amounts.

Negatives or limitations of this instrument: Certain chemicals can poison the capillaries and become plugged. As a result, they must be replaced every couple of weeks at a cost of $10 each. The new capillaries must then be calibrated with known mixtures.

Repeatability: Excellent.

COLORIMETER



Instrument function: The Minolta Chroma Meter is a colorimeter that measures the color of flour by measuring the amount of reflected light by the sample from a constant light source. Each sample absorbs and reflects light from different portions of the spectrum and in different amounts. The values are reported as L*a* b* color space which is presently one of the most popular forms for measuring color. Results are given as L*, indicating lightness (the higher the value, the lighter the color), and a* and b* are the chromaticity coordinates. A +a* indicates the red direction (the higher the value, the more red color), and -a* a green direction. A +b* or -b* are the yellow and blue directions, respectively.

Cost of the instrument, each analysis: Portable colorimeters: $5,000-8,000. Labor is the primary analysis cost.

Manufacturer: Minolta Corporation

Level of expertise required: One-hour training.

Analysis length: Less than one minute for flour color determination, but wheat kernels need milling into flour first.

Benefits of this instrument: Objective and reproducible color measurements.

Repeatability: Excellent.

CONSISTOGRAPH (AACC Method 54-50)

Instrument function: The Consistograph measures water absorption of flour and the behavior of dough during kneading. A 250-gram flour sample is used for the analysis. It can be applied to product quality and ingredient control as well as in process control to determine the following rheological characteristics of flour:

1. The water absorption capacity of a flour to reach a desired consistency.

2. The behavior of a dough during mixing (the time it takes the dough to be formed, its tolerance, and the time to breakdown).

3. An estimation of dough consistency in real time and the evolution over time of a dough taken directly from an industrial mixer.

Cost of the instrument, each analysis: $25,100 for the instrument. Time and labor for the analysis.

Manufacturer: Chopin.

Level of expertise required: One-day training.

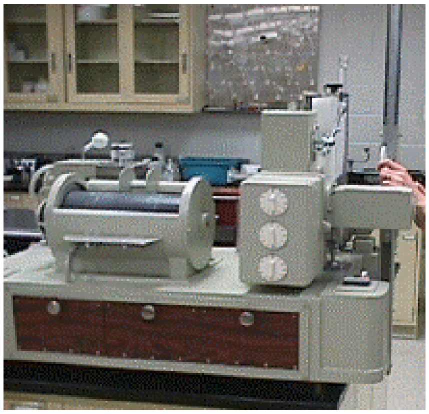
Analysis length: Determine of the absorption capacity of flour takes about four minutes and an additional eight minutes to determine the behavior of dough during kneading.

Benefits of this instrument: Rapid and very easy to use.

Negatives or limitations of this instrument: Information similar to the Farinograph.

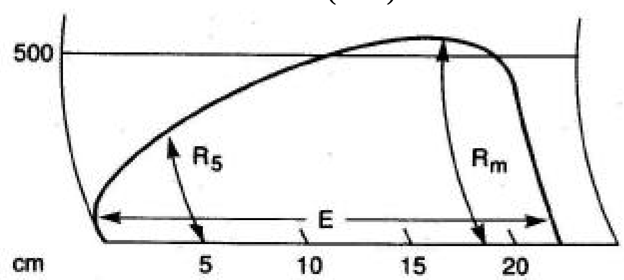
Repeatability: Good.

EXTENSIGRAPH (AACC Method 54-10)

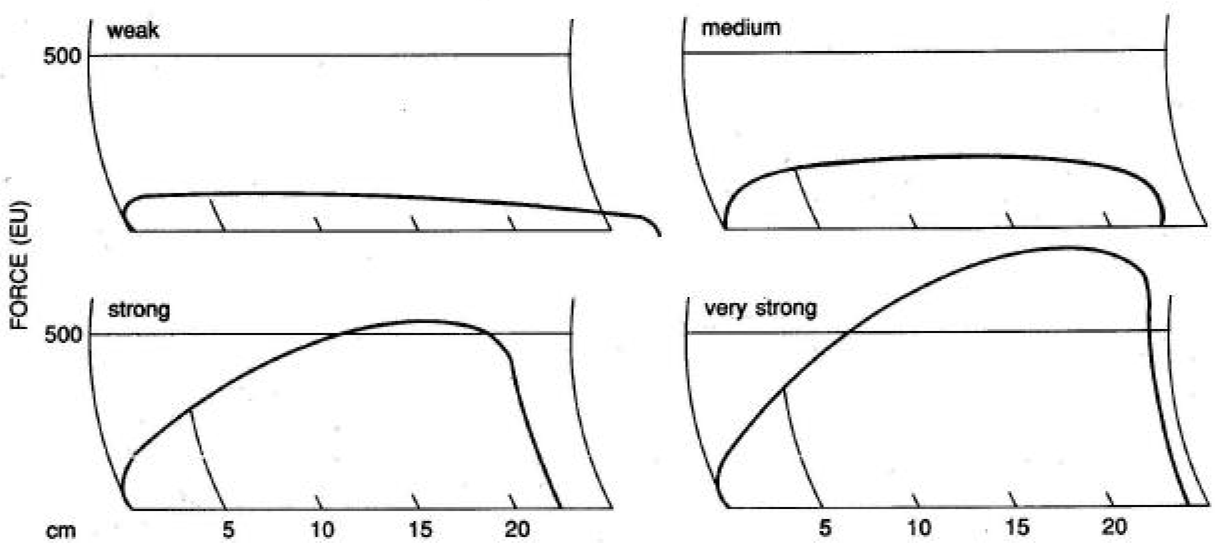


Instrument function: The Extensigraph determines the extensibility of wheat flour dough. The instrument measures dough resistance to extension and extensibility by recording a load-extension curve for a test piece of dough, stretched until it breaks. In essence, the tensile strength of the dough is measured as it is being stretched or "pulled apart." It requires a 300-gram flour sample for analysis. When the Extensigraph is used in compliance with the Farinograph (AACC standard method), information concerning a product's baking quality is attained. Dough is mixed in a Farinograph for 15 minutes, rested for 45 minutes in a fermentation cabinet, stretched, then reshaped and rested for 45 minutes, stretched, reshaped, rested 45 minutes, and then stretched again. The Extensigraph is said to be ideal as an in-house quality control tool for the evaluation of dough on the production line.

The following is a typical extensigram illustrating extensibility (E), resistance at constant extension of 5-cm (R5), and maximum resistance (Rm):



Further, the following illustrate extensigrams of flours having weak, medium, strong, and very strong dough properties:



Cost of the instrument, each analysis: $23,695 per instrument. There are no consumables. Time and labor are the primary analysis cost.

Manufacturer: Brabender.

Level of expertise required: Experience in interpreting the results.

Analysis length: At least 2.5 hours per sample.

Benefits of this instrument: Provides information on the resistance of dough to extension.

Negatives or limitations of this instrument: Sample analysis time is long and you need a farinograph to run this test. Cleanup can be quite messy.

Repeatability: Good, but operator dependent.

FALLING NUMBER (AACC Method 56-81B)

Instrument function: The Falling Number test determines alpha-amylase activity in wheat and rye flour. This is a measure of the amount of sprouted grain and thus of yeast enzyme activity. In bread, too much amylase activity will cause wet, sticky breadcrumbs with large voids in the loaf, and too little causes dry, crumbly breadcrumbs and high loaf density. Results of this test are used to predict the optimal mix of different wheats and to determine the amount of malt additions required to optimize yeast activity during baking.

FN 1800

FN 1500

Two models are available:

- FN 1800 - Dual station system for two simultaneous tests.
- FN 1500 - One sample analyzed at a time.

Both models include improved mixing design, printer, auto-water level and altitude correction.

Cost of the instrument, each analysis: FN 1800: approximately $10,000, FN 1500: approximately $15,000; Consumables include tubes and stoppers to be replaced periodically. Time and labor are the primary analysis costs.

Manufacturer: Perten Instruments, North America.

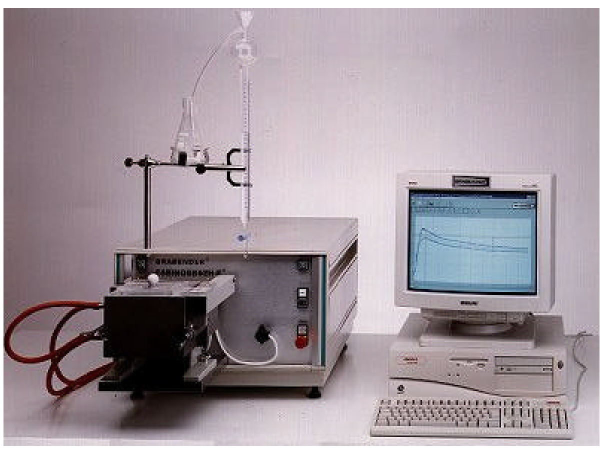
Level of expertise required: One-day training.

Analysis length: 15 minutes, but need to grind grains and determine moisture content of ground material.

Benefits of this instrument: Relatively fast analysis to assist millers in determining grain soundness or if sprouting occurred at harvest.

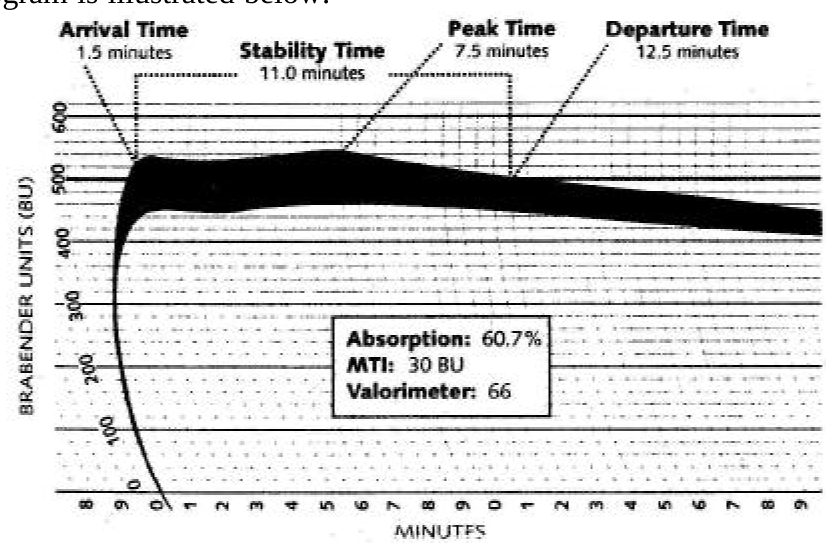
Repeatability: Good.

FARINOGRAPH (AACC Method 54-21)



Instrument function: A critical instrument for quality control, the Farinograph provides checks for uniformity and allows for predictions of baking functionality. It is used to determine the water absorption capacity of flour, dough development time (in minutes), dough stability (in minutes), and the degree of softening during mixing (mixing tolerance index). 50-grams of flour are mixed with water (approximately 60 ml) and the torque of mixing against stationary pins in a bowl is measured. It is similar in action to the mixograph.

A typical farinogram is illustrated below:



- **Arrival Time:** The time required for the curve to reach the 500 Brabender Unit (BU) line. It gives the rate of hydration of the flour.

- **Peak Tine:** The time required for the flour to reach full development. It gives an indication of optimum mixing time in the bakery.

- **Departure Time:** The time at which the curve leaves the 500 BU line.

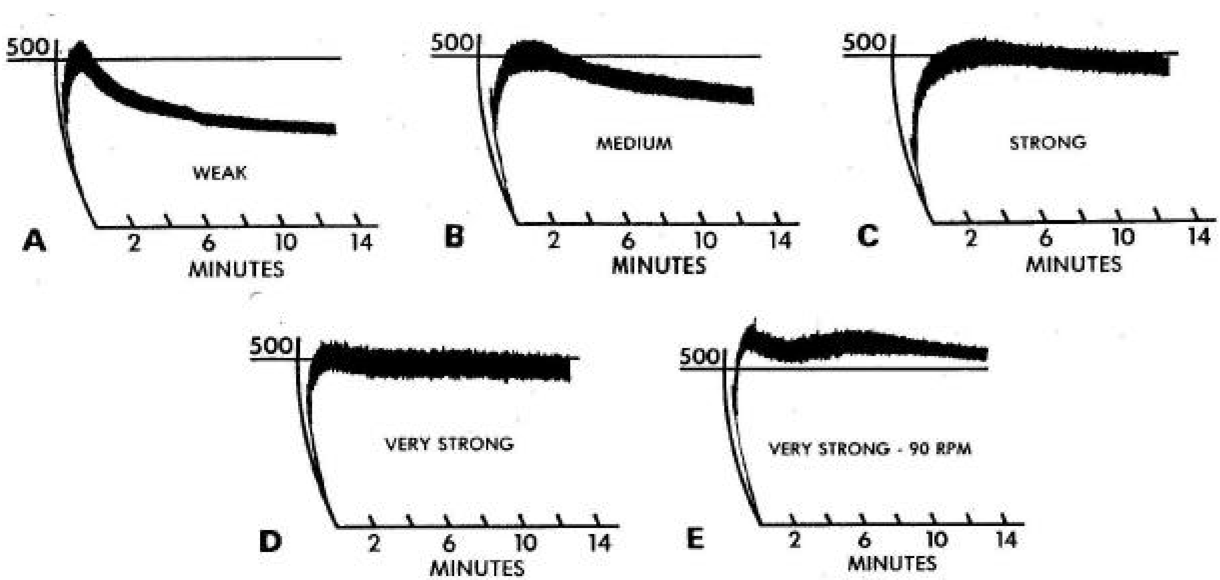
- **Stability Time:** The interval between the arrival time and the departure time. It is also referred to as "tolerance" of the flour to over and under mixing. A higher value means the flour is more tolerant.

- **Absorption:** The percentage of water required to center the curve on the 500 BU line at the maximum consistency of the dough (peak). Due to formula and processing differences, this may not be the true absorption in the bakery.

- **Mixing Tolerance Index (MTI):** The difference in BUs from the top of the curve at peak time to the top of the curve five minutes after the peak is reached. A higher value means the flour breaks down faster after reaching full development.

- **Valorimeter value:** Derived by means of a special template, it is an empirical quality score. Higher values indicate stronger flour.

The following illustrate farinograms of various flour strengths:



Cost of the instrument, each analysis: Approximately $31,000 for the Farinograph, but only time and labor for each analysis.

Manufacturer: Brabender.

Level of expertise required: One-day training to operate the instrument, but more experience is required to interpret the results.

Analysis length: 20 to 30 minutes.

Benefits of this instrument: Highly accepted by industry as a quick, quality assay to check water absorption and dough development time. This test is currently recognized and used worldwide in mills and bakeries. It can also be computerized.

Negatives or limitations of this instrument: Large sample and long test time.
Repeatability: Excellent.

NOTE: This is one of the tests discussed at the Summer 1999, U.S. Wheat Associates meetings for which there was consensus that it could potentially be used in the national inspection program for differentiating protein quality. In fact, discussion participants agreed that the farinograph would be the most likely candidate to use as the basis or reference method for research leading to the development of calibrations for the Near Infrared Transmission Equipment, or NIRT.

GLUTOMATIC (AACC Method 38-12)

Instrument function: The Glutomatic measures gluten quantity and quality, providing the percentage of wet or dry gluten. 10-grams of ground material are used per bowl and two bowls are run per sample. A salt solution is used to dissolve everything except the gluten protein complex. Wet gluten is washed from whole-grain wheat meal or flour by an automatic washing apparatus (the Glutomatic). It is then centrifuged on a specially constructed sieve under standardized conditions, collected, washed, patted dry, and weighed wet. The weight of wet gluten forced through the sieve and total wet gluten are measured. The total wet gluten is expressed as a percent of the sample and the gluten index is expressed as a percentage of wet gluten remaining on the sieve after centrifuging. The gluten index is an indicator of gluten quality.

Cost of the instrument, each analysis: About $15,150 for the instrument, but very cheap for each analysis (time plus a small bit of salt).

Manufacturer: Perten Instruments, North America.

Level of expertise required: This is more of an art form, therefore requires experience to obtain reproducibility.

Analysis length: 15 to 20 minutes.

Benefits of this instrument: It gives an indication of protein quality, i.e., the more gluten, the stronger the protein. Can analyze whole meal or flour. Cleanup is easy.

Negatives or limitations of this instrument: It is very operator sensitive.

Repeatability: High level of variability with poor quality protein flours. However, it is okay with stronger protein flour.

HIGH PERFORMANCE (OR PRESSURE) LIQUID CHROMATOGRAPHY (HPLC)

Instrument function: Chromatographic processes can be defined as separation techniques involving mass-transfer between stationary and mobile phases. HPLC utilizes a liquid mobile phase to separate components of a mixture. The process uses approximately 250 mg. of ground sample, which is extracted in a 5-minute procedure to produce a solution of proteins. A specific volume (a few microliters) of this solution of proteins is then automatically loaded onto a column by the instrument and is washed through the column with solvents. Usually, the column temperature is increased in a programmed fashion to speed the analysis. As the proteins wash through the column, they are separated from each other. As solution exits the column, it is analyzed for the presence of proteins. A graph is produced by plotting protein content versus time and shows peaks every time a protein leaves the column. The area under the peak is proportional to the amount of protein present. The end result is a pattern of protein peaks versus time. This pattern differs from one wheat variety to another.

Cost of the instrument, each analysis: $40,000 and $10 respectively.

Manufacturer: Multiple.

Level of expertise required: A highly trained technician.

Analysis length: Depends on the type of HPLC used (there are two different types): 20 minutes for “reverse phase” where proteins are separated on the basis of their chemical properties, and 50 minutes for “size exclusion” where proteins are separated based on their size.

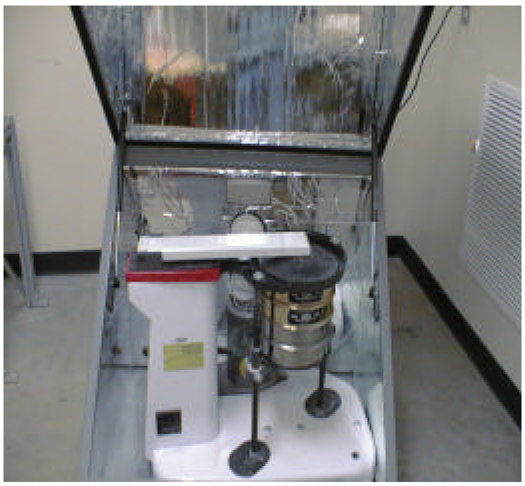
Benefits of this instrument: HPLC can quantify the amounts of various proteins present (true quantification requires a minimum of two extractions in the beginning). Further, it can predict the quality of the wheat flour sample using the ratio of insoluble polymeric proteins to soluble polymeric proteins obtained from the size exclusion data.

Negatives or limitations of this instrument: A large amount of solvent to dispose of which is not "environmentally friendly." Columns are expensive ($100-400). Equipment requires much upkeep.

Repeatability: Excellent. HPLC is a good reference method.

KERNEL SIZE DISTRIBUTION

Based on Cereal Foods World (Cereal Science Today) 5(3): 71 (1960)



Instrument function: The kernel size distribution gives an estimation of the percentage of large, medium and small kernels. It is determined in a sample of 200-grams, processed for one minute in a Ro-Tap Sieve Shaker using Tyler screens No. 7, 9, and 14. Kernels retained on the No. 7 screen are considered "large," on the No. 9 screen, "medium" and on No. 14 screen "small."

Cost of the instrument, each analysis: The Ro-Tap: $1,695, Sound Enclosure Cabinet (recommended): $412. A top load balance (at least to 0.1 g) is also needed.

Manufacturer: W. S. Tyler.

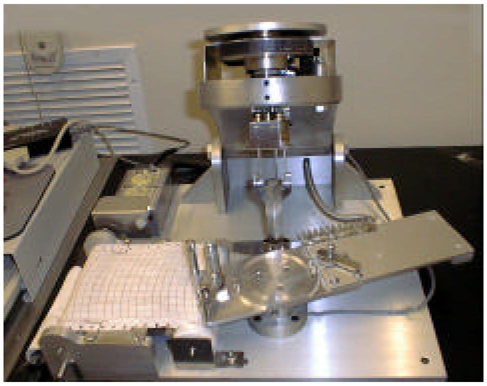
Level of expertise required: 5 minutes of training.

Analysis length: 3 minutes.

Benefits of this instrument: A relatively inexpensive set up and fast testing.

Repeatability: Very good.

MIXOGRAPH (AACC Method 54-40A)



Instrument function: Like the Farinograph, the Mixograph provides a check for uniformity and allows for prediction of baking functionality. It predicts mixing time and measures and records resistance of dough to mixing. The mixing curve (mixogram) indicates optimum development time (the point of minimum mobility), tolerance to over-mixing and other dough characteristics, and estimates bake absorption. 10-grams of ground sample or flour are placed into a bowl along with a specific amount of water (determined from a formula). The bowl contains pins and the mixer shaft also contains pins, which are added to the bowl from the top. The instrument measures the torque generated as the pins mounted on the shaft mix the dough around the pins located in the bowl. Torque is graphed on a page and peak height and shape are indicative of quality.

Cost of the instrument, each analysis: About $11,500 with analysis cost limited to salary and time.

Manufacturer: National Manufacturing Co.

Level of expertise required: One-day training to operate instrument, but much more experience is needed to interpret the information obtained.

Analysis length: 10 to 15 minutes, or less.

Benefits of this instrument: It can measure water absorption (the amount of water that can be added to flour to obtain optimum dough performance), dough tolerance (how long a dough can last before it is not usable), gluten strength (high strength is good for bread), and mixing time (how long does it take the dough to form). It uses a small sample, is easy to clean up, and can be computerized.

Negatives or limitations of this instrument: Interpretation of the results is tricky. Therefore, experience is required to obtain accurate results.

Repeatability: Excellent.

This is the most important indicator of hard winter flour quality used in the ARS-GMRL laboratories. Further, like the farinograph, this is one of the tests discussed at the Summer 1999, U.S. Wheat Associates meetings that participants felt could potentially be used in the national inspection program for differentiating protein quality.

RAPID VISCO ANALYZER

Instrument function: The Rapid Visco Analyzer (RVA) is a rapid automated method for starch characterization & quality assessment. It replaces older outdated methods that are time consuming and expensive. Profiles may be ran and stored in the computer for later processing or overlaid on other samples for comparison purposes. Many of the nations leading processors are profitably applying this versatile unit. Peak viscosity from the test provides a rapid index of flour quality suitable for use in flourmills, bakeries, breeding programs and for research applications. The RVA can be used to assess the gluten quality in soft wheat flour. Gluten proteins increase suspension viscosity when dispersed in dilute lactic acid. This viscosity can be measured using the RVA. The method is most useful for assessing soft wheats used in pastry and biscuit manufacturing. This method has limited screening value for bread making wheats where dough rheological properties are important. During the test, the viscosity reaches a plateau, then when heated to 50°C, the viscosity decreases. The viscosity at 3 minutes and the breakdown (percentage reduction in viscosity between 3 and 10 minutes) are useful indicators of product quality. 3.5-grams of ground sample is placed into a disposable aluminum vessel along with 25 ml of water. A disposable paddle is inserted and the entire sample holder is placed into a heating block. The temperature is raised according to a set program and the resistance to stirring the paddle through the flour/water mixture. Measurements taken during first three minutes are indicative of sprout damage. Measurements from 3 to 13 minutes mimic mixograph results.

Cost of the instrument, each analysis: About $28,000 for the instrument. Disposable canisters cost $.70 for each analysis.

Manufacturer: Newport Scientific, possibly others.

Level of expertise is required: Simple to run, with only about one-day of training required.

Analysis length: 3 to 13 minutes.

Benefits of this instrument: Temperature controlled analysis is fast and simple to perform.

Negatives or limitations of this instrument: Operation is tricky because of potential rubbing of paddle on edges of vessel.

Repeatability: Good.

RHEOFERMENTOMETER

Instrument function: Predicts the fermentation qualities of yeast-raised dough batches by monitoring the effect of various additives on the protein network and measuring gas production retention. The data collected in real time on the dough volume and gaseous release yields information critical to balancing formulas properly. Wheat flour, dough conditioners, additives and yeast types can be optimized based on these evaluations, allowing intelligent selection of the lowest cost formulation for each product.

Cost of the instrument, each analysis: $19,750 (plus printer); time and labor for analysis cost.

Manufacturer: Chopin.

Level of expertise required: One-day training.

Analysis length: 6 hours.

Benefits of this instrument: Optimizes yeast-raised formulas for the best bread properties.

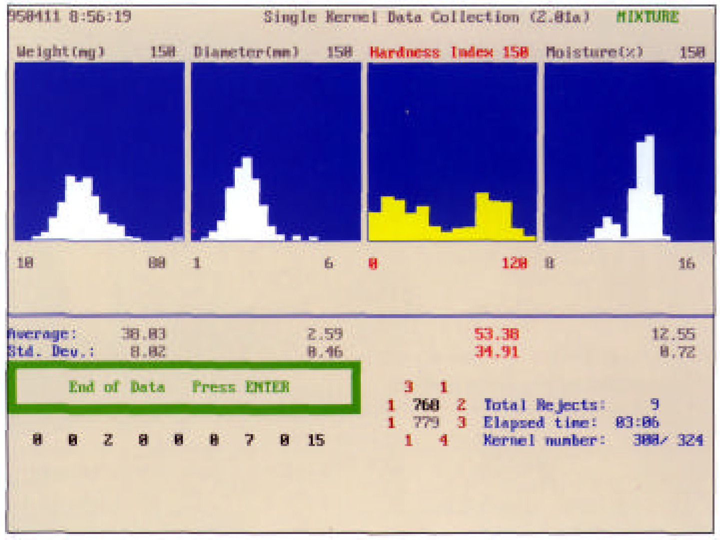
Negatives or limitations of this instrument: One sample per analysis and time consuming.

Repeatability: Good.

SINGLE KERNEL CHARACTERIZATION SYSTEM (SKCS)

Instrument function: The Single Kernel Characterization System analyzes 300 kernels from a 15 to 20-gram portion of wheat. This portion should be free from dockage, shrunken and broken kernels, and foreign material. The instrument measures individual kernel size, weight, crushing profile (hardness), and moisture content. The results are then generated in a histogram of values obtained, including the range average and standard deviation of each of the four factors. This data is used to determine single kernel hardness and establish distribution ranges.

The following is a typical SKCS print out illustrating the distributions of weight, diameter, hardness and moisture content.



Monitor screen: Mixture of soft and hard wheats

Cost of the instrument, each analysis: Instrument: $25,000. There are no consumables. Labor is the primary cost per analysis.

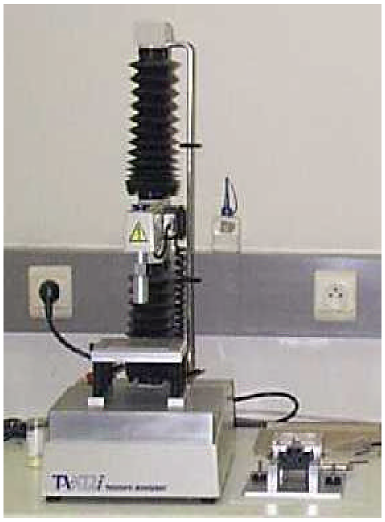
Manufacturer: Perten Instruments, North America.

Level of expertise required: One-day training.

Analysis length: 3 minutes.
Benefits of this instrument: A fast and objective measure of hardness, classification and grain uniformity.

Repeatability: Good.

TEXTURE ANALYZER



Instrument function: The texture analyzer measures a number of texture parameters objectively by using different attachments or probes in the instrument. The equipment measures the resistance the test item presents to the displacement of a probe. Some research laboratories use the texture analyzer to measure firmness (probably the most commonly measured texture attribute) of bread or cooked noodles. This equipment is a research tool that can potentially give information on several textural parameters of end-quality products such as cookies, biscuits and tortillas made with wheat. The analyzer can quantify breaking points, chewiness, cohesiveness, extensibility, fracturability, hardness, resilience, rupture strength, springiness, swelling/absorption, tackiness, tensile strength and many other physical parameters.

Cost of the instrument, each analysis: The texture analyzer: $18,000, attachments: $500-2,000.

Manufacturer: Texture Technologies Corp.

Level of expertise required: One-day training.

Analysis length: 1-2 minutes .

Benefits of this instrument: Permits a direct correlation of flour and analysis with its baking and noodle performance.

Repeatability: The manufacturer claims to be very good, but in practice there is large variation among observations from replicates of the same sample preparation. It is not unusual to analyze a large (more than five, often ten) number of replicate analysis per sample to account for the variation.

ZELENY SEDIMENTATION (SDS - AACC Method 56-70)

Instrument function: Zeleny is used to determine the amount of insoluble protein in a sample based on solubility at a pH in the presence of alcohol. This method does not use an instrument. About 2-grams of flour (14% moisture) are loaded into a 100 ml graduated cylinder. 20 ml of colored water, 20 ml of SDS (sodium dodecylsulfate - a detergent) and 10 ml of lactic acid solution are then added. The cylinder is rocked back and forth several times and then allowed to set. The volume of the protein sediment is then recorded.
Cost of the instrument, each analysis: Very cheap, using common lab equipment. Analysis cost is low.

Manufacturer: N/A.

Level of expertise required: The test is simple to perform and operator dependent.

Analysis length: Approximately 45 minutes for 8 samples.

Benefits of this instrument: Simple and easy, can analyze multiple samples simultaneously.

Negatives or limitations of this instrument: Operator dependent.

Repeatability: Good with same operator.

While this test is used extensively in European mills and bakeries as a predictor of bread making potential, the general consensus is that Zeleny Sedimentation is not a very useful test for U.S. wheat because of our stronger proteins.

Sample Preparation Criteria

Except for the discussion on capillary electrophoresis, analysis time does not include sample preparation. Costs and time for preparing samples will vary depending on whether or not the test is applicable to ground wheat or must first be ground into flour. For grinding, a simple coffee grinder or similar grinder can be used to prepare the sample. However, when the sample must consist of flour, preparation time will increase as will the cost of preparing the sample. (Devices such as Brabender's Quadramat Junior or Senior would be necessary).

The Quadrumat Junior is a precision laboratory mill that yields flour and bran from grain samples. The minimum sample requirement is 20 grams ; however the instrument can mill 500 grams in approximately five minutes with a flour yield of 65-70%. The Quadrumat Junior is said to be ideal for wheat breeders and when operated in conjunction with the Farinograph, Extensigraph, and Amylograph, it is invaluable in the laboratory for the evaluation of extracted flour. The Quadrumat Senior is a pilot mill for rapid milling of production equivalent test flour. It comes equipped with a flour roll system, which includes a break head and reduction head. A total of 13 frames (six sieve frames, six collecting frames, and one transfer frame) are stacked to yield break flour, reduction flour, and bran for a yield of 60-70%. It must be noted, however, that the cost of these "mini mills" is prohibitive!

Two Final Items of Note

One of the stated goals for developing a quick assay for protein or gluten quality is to differentiate between varieties of a given class that are utilized for different products, such as bread-type and noodle-type HDWH. According to NDSU research personnel, the "noodle vs. bread" issue involves a measure of starch viscosity and not protein or gluten strength. Along those lines, a separate set of calibrations would likely have to be established for the NIR based on an instrument such as the Rapid Visco Analyzer (RVA) in order to achieve this goal. While this certainly shouldn't detract from the projects primary objective, establishing a quick assay for protein or gluten quality, at some point, research may have to be expanded.

Lastly, past studies conducted by ARS have not met with great success for correlating protein quality data to NIR or any other simple test. (r5 values in the .65 to .70 range at best have been mentioned). Values this low suggest a lot of room for error. Historically, the industry (and

GIPSA) has preferred to see r5 values in the .90 and above range. Based on past results, it seems unlikely that correlation values of .90 or greater are achievable and therefore, establishing a quantifiable test is doubtful. In light of this, perhaps the goal should be a basic qualitative analysis that could group wheats into weak, medium, or strong gluten strength categories. For example, a 1 to 10 scale where 1 to 3 would indicate weak gluten strength, 4 to 6 medium gluten strength, and 7 to 10 strong gluten strength. A scale such as this would allow room for any correlation error while providing a rudimentary means for segregating wheat by protein or gluten quality at the first point-of-sale. (The r5 of the test we currently use is “zero,” i.e., we don’t have any means of determining protein or gluten quality quickly at the first point-of sale.) Time and research will tell.

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