Rheological Behavior of Flour by Farinograph: Constant Flour Weight Procedure

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Objective

The Farinograph measures and records the resistance of dough to mixing. It is used to evaluate the absorption of flours and to determine stability and other characteristics of doughs during mixing. Two different procedures are in common use: the constant flour weight procedure, described herein, and the constant dough weight procedure (Method **54-22.01**). *Since the two procedures may not yield identical results, the method employed must be specified when absorption and other farinogram values are reported*.

Apparatus

Brabender Farinograph, with large (300 g flour) and/or small (50 g flour) mixing bowls.

Procedure

Adjustments of Farinograph

1. Adjust the Farinograph thermostat to maintain a temperature of 30 ± 0.2°C at the entrance to the mixing bowl (Fig. 1). Check the temperature of the cir-

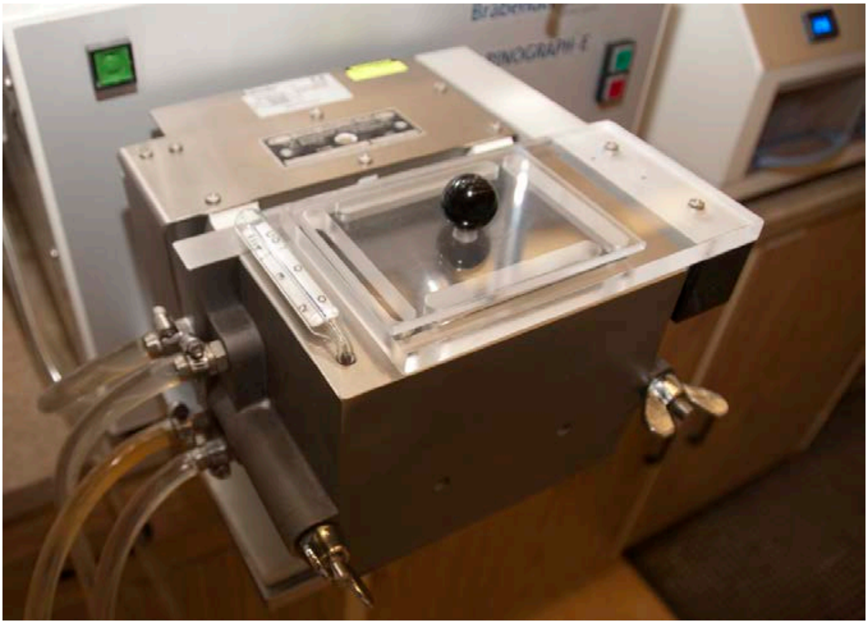

Fig. 1. Farinograph with a thermometer inserted into the entrance to the mixing bowl. The hole may be on the right side in other models.

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culating water with a high-grade thermometer. Make sure that the water is circulating freely through the hose and bowl jackets. Confirm that the flow pattern is the same as shown in the equipment manual.

2. With the help of a spirit level mounted on the base plate, adjust the position of the base plate to horizontal by means of four footscrews. Then fix the footscrews by means of their locknuts (see equipment manual).

3. Make certain that the chart paper runs exactly horizontally. Two small plates on spring-loaded hinges, at the front of recording device, operate as guides for the paper and may be swung open to make this adjustment. This step does not apply to electronic models.

Use of Large and Small Mixing Bowls

In changing from one bowl to another, the following adjustments are involved:

1. *Sensitivity.* Four sensitivities are provided. There are two choices of position linkage between balance levers (rear and front) and two choices of additional weights (400 and 1000). Normal settings are for the large bowl (300 g), linkage toward the rear of the Farinograph, switch on 1000; for the small bowl (50 g), linkage toward the front of the Farinograph, switch on 400. This step does not apply to electronic models.

2. *Zero position of the scalehead pointer.* Adjust the scalehead pointer to the zero position of the dial by changing the position of the threaded balance weights when the instrument is running at 63 ± 2 rpm with the mixer empty. The smaller of two weights should be removed entirely when the small bowl is used on older models (from 1978). Make the final writing arm adjustment with the knurled screw on the left side of the scalehead shaft so that the scalehead pointer and writing pen give identical readings. This step does not apply to electronic models.

3. *Adjustment of bandwidth.* The damping device should be adjusted only after the oil in the damping chamber has been at operating temperature for at least 1 h and after the damping piston has been moved up and down several times. To make the adjustment, raise the dynamometer lever arm until the scalehead pointer indicates 1,000 Brabender units (BU). Release the lever arm and measure with a stopwatch the time required for the pointer to go from 1,000 to 100 BU on the scalehead (should be 1 ± 0.2 s). The damping adjustment controls the bandwidth of a farinogram. To obtain a wider damper opening and quicker movement of the scalehead pointer, and thus, a wider curve, turn the adjustment screw counterclockwise. Opposite adjustment produces a narrower band. A bandwidth at the peak of the curve of 70–80 BU is recommended. It may be advantageous to mark the damper adjustment screw at the correct setting. This step does not apply to electronic models.

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4. *Cleaning.* At the completion of each test and while the machine is running, add dry flour to the bowl to make a stiff dough with a consistency of 800–900 BU within 1 min of mixing with the test dough. Then stop the machine, unscrew the bowl wing nuts, take off the front section of the mixing bowl, and discard the dough. Remove any adhering particles quickly before they dry, using a small plastic spatula to scrape the blades and sidewalls of bowl. (The spatula should be of softer material than the mixing bowl in order not to damage the bowl.) Finally, clean the bowl with a dampened cloth and wipe all parts dry, including the space behind the paddles. (*Caution:* Never use chemical agents such as borax or any dough stiffeners other than flour, since traces of chemicals can affect subsequent curves and may even react with the metal surfaces of the bowl.)

For bronze bowls, put cleaning dough through the mixing bowl every morning, or after the machine has stood idle for several hours, to rub off the thin film of oxidation on the surface. If the preliminary titration of the flour sample is conducted (as explained below), this may be regarded as a cleaning dough. A stainless-steel bowl does not require cleaning dough. Also, after the machine has been standing, small particles of dough may harden between the shafts and blades at the back of the mixing bowl and cause resistance to turning. Correct this by placing a few drops of water on the inside back wall of the bowl directly over the shafts, with blades turning, to soften the dough particles. Then use a strong jet of water or blast of air or CO_2 to remove the dough. Return of the scalehead pointer to zero position indicates that these dough particles have been softened and removed.

Clean the titrating burette periodically with a solution made of 10 parts concentrated H_2SO_4 to 1 part saturated potassium dichromate solution. Fill the burette with this solution and let it stand overnight. *This solution is extremely corrosive and should be handled with caution.* After draining the burette, rinse repeatedly with tap water and finally with distilled water. After recording each titration, and when not in use, keep the burette, including the tip, filled with water at all times.

Procedure for the Large Bowl

1. Turn on the thermostat and circulating pump at least 1 h prior to using the instrument.

2. Determine the moisture content of the flour as directed in any oven method for flour (Method **44-15.02** and following). (Keep the flour samples in moisture-proof containers. Accurate moisture values are very important.)

3. In the bowl, place 300 ± 0.1 g flour (14% moisture basis). (See Notes 1 and 2 and Table **82-23.01**).

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4. Fill the large burette with water at room temperature, making sure that the tip is full and the automatic zero adjustment of the burette is functioning properly.

5. Set the pen point at the 9 min mark on the chart. Turn on the machine to the "63 rpm" setting, and run for 1 min until the zero minute line is reached. This step does not apply to electronic models.

At this instant, begin adding water to the right front corner of the bowl from the large burette to a volume nearly that of the expected absorption of flour. When the dough begins to form, scrape down the sides of the bowl with a plastic scraper, starting on the right front side and working counterclockwise. Cover the bowl with a Plexiglas cover to prevent evaporation. If it appears that the mixing curve will level off at a value larger than 500 BU, cautiously add more water. This will be used to estimate absorption for the next attempt. After the water is added, again cover the bowl with a Plexiglas cover to prevent evaporation.

6. The first titration attempt rarely produces a curve that has maximum resistance centered on the 500 BU line; therefore, in the subsequent titration, adjust absorption either up or down until this is achieved to within 20 BU. Titrations producing wider variation affect the scoring of the curve. As a guide to correcting preliminary titration values, it can be understood that differences between each horizontal line (20 BU) correspond to approximately 0.6–0.8% absorption (1.8–2.4 mL water), depending on the flour. When the correct absorption is achieved, the curve, at the maximum dough development, will be centered on the 500 ± 20 BU line.

7. For the final titration, add all the water within 25 s after opening the burette stopcock. Allow the instrument to run until an adequate curve is available for evaluation as desired (*see Interpretation*), i.e., absorption, slightly beyond the peak; stability, until the top of the curve recrosses the 500 BU line after the peak; valorimeter, 12 min beyond the peak. At this point, lift the pen from the paper (does not apply to electronic models) by means of the small locking knob on the pen arm, add dry flour to the bowl, and proceed with cleaning the bowl.

8. Report absorption values to the nearest 0.1%. Calculate the absorption on a 14% moisture basis determined with the large bowl using the following equation:

$$\text{Absorption \%} = \frac{(x + y - 300)}{3}$$

where x = mL of water needed to produce a curve with maximum consistency centered on the 500 BU line, and y = g of flour used, equivalent to 300 g, 14% moisture basis.

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Procedure for the Small Bowl

The principle is the same as for the large bowl, except that 50 ± 0.1 g flour (14% moisture basis) is used (See Note 2 and Table **82-23.01)**. Titration is conducted with the *small* burette. In this case, each interval between horizontal lines of the chart (20 BU) corresponds to about 0.4 mL water.

Calculate absorption on a 14% moisture basis, determined with the small bowl, using the equation

$$\text{Absorption \%} = 2(x + y - 50)$$

where x = mL of water needed to produce a curve with maximum consistency centered on the 500 BU line, and y = g of flour used, equivalent to 50 g, 14% moisture basis.

Interpretation

Typical farinograms from flours of different strengths are shown in Figure 2. Values other than absorption are frequently derived from Farinograph curves (Fig. 3). Among those that have been proposed are the following:

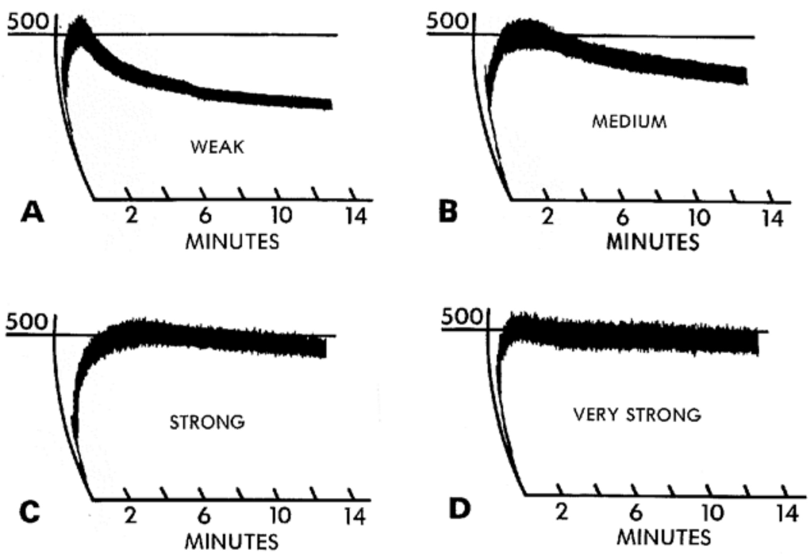

Fig. 2. Farinograms from flours of different strengths. **A,** weak flour: absorption, 54%; dough development time (DDT), 1.25 min; mixing tolerance index (MTI) value, 180. **B,** medium strength flour: absorption, 57%; DDT, 2.75 min; MTI value, 80. **C,** strong flour: absorption, 64.5%; DDT, 5 min; MTI value, 30. and **D,** very strong flour: absorption, 62.7%; apparent DDT, 1.75 min; MTI value, 20. (Reproduced from D'Appolonia and Kunerth, 1984)

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1. *Dough development time.* This is the interval, to the nearest 0.5 min, from the first addition of water to that point in the maximum consistency range immediately before the first indication of weakening. This value has also been referred to as the "peak" or "peak time." For flours having a curve that is nearly flat for several minutes, the peak time may be determined by taking the mean between the midpoint of the flat portion of the top of the curve and the highest point of the arc of the bottom of the curve. Occasionally, two peaks may be observed; the second should be taken for the determination of the dough development time.

2. *Stability.* This is defined as the time difference, to the closest 0.5 min, between the point where the top of the curve first intersects the 500 BU line (arrival time) and the point where the top of the curve leaves the 500 BU line (departure time). If the curve is not centered exactly on the 500 BU line at the maximum resistance, but rather is, for example, at the 490 or 510 BU level, the line must be drawn at the 490 or 510 BU level parallel to the 500 BU line. This new line is then used in place of the 500 BU line to determine the arrival time, departure time, and stability.

3. *Mixing tolerance index.* This value is the difference in BU from the top of the curve at the peak to the top of the curve measured at 5 min after the peak is reached. The related measurement, called "drop-off," refers to the difference in

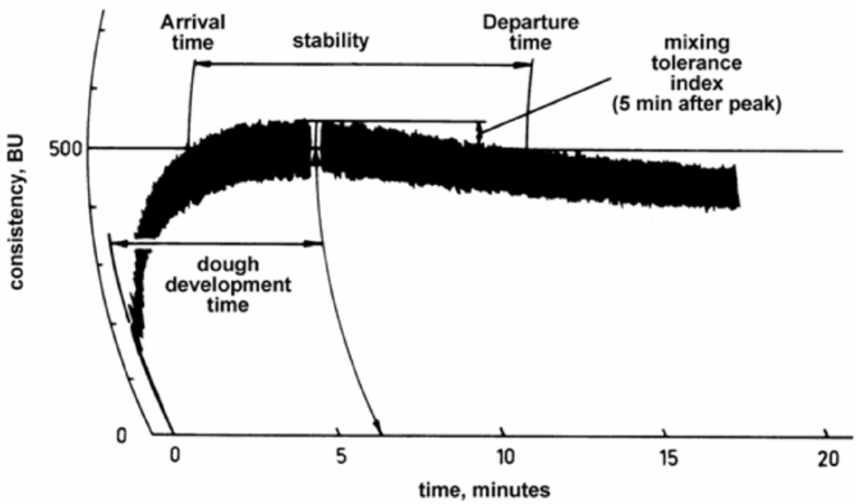

Fig. 3. Representative farinogram showing some commonly measured indices. (Reproduced from Pomeranz, Y., ed. 1971. Wheat: Chemistry and Technology, 2nd ed. Am. Assoc. Cereal Chem., St. Paul, MN)

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BU from the 500 BU line to the center of the curve measured at 20 min from the addition of water.

4. *Time to breakdown*. This is the time from the start of mixing until there has been a decrease of 30 BU from the peak point. It is determined by drawing a horizontal line through the center of the curve at its highest point and then drawing another parallel line at the 30 BU lower level. The time from the start of the mixing until the center of the descending curve crosses this lower line is the "time to breakdown."

5. *Valorimeter value.* This is an empirical single-figure quality score based on the dough development time and the tolerance to mixing that is derived from the farinogram by means of a special template supplied by the manufacturers of the Farinograph equipment. To read the valorimeter value, the farinogram is first placed in the valorimeter so that the zero time and the line (normally the 500 BU line) through the center of the farinogram correspond to zero time and the 500 BU line of the dummy Farinograph charts in the valorimeter. After the farinogram is placed in position, the left-hand edge of the movable slide is placed on the peak, or dough development time, of the farinogram; if the curve is flat, it is placed on the first indication of weakening. The valorimeter value is then read at the right-hand edge of the slide, 12 minutes past the peak, and is the value corresponding to the line of the stationary template that intersects the center of the farinogram at this point.

Notes

1. Farinograms of various flours are affected differently by the addition of a malt supplement. In general, an addition of malt shortens dough development time and lowers absorption. Practical evaluation of flour may require an addition of malt in amounts required for proper diastatic activity.

2. Example: If a flour sample contains 12.5% moisture, the amount of flour required for a 300 g test is (86.0/87.5) × 300 = 294.9 g. For the 50 g test, it is (86.0/87.5) × 50 = 49.1 g.

3. Farinograph software provided by the manufacturer employs the constant flour weight procedure.

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