Method for Evaluation of Rheological Behaviour of Flour by Extensograph: Using Pin Mixer for Dough Preparation

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<th>Method Owner(s)</th>
<th>Approval date</th>
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<tr>
<td>Program Manager of Bread and Durum Wheat Research</td>
<td>2016-08-26</td>
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1.0 Scope and Field of Application
The standard extensigraph method (AACC Method 54-10.01, ICC 114/1, ISO 5530-2) has been traditionally used to evaluate rheological properties of wheat dough by providing information on dough strength (resistance to extension) and extensibility. The method described here, which uses a pin mixer rather than the farinograph for dough preparation, is on a constant flour weight basis. The extensigraph provides information about the dough strength, extensibility and processing quality of the dough in general.

2.0 Principle
The standard extensigraph method (AACC Method 54-10.01, ICC 114/1, ISO 5530-2) uses the farinograph for the preparation of dough in the presence of 2% salt at reduced water absorption (farinograph absorption minus 2-3%). However, the dough so prepared is usually under-developed and drier than typically seen in common baking processes. In addition, the standard extensigraph test is time consuming and requires large sample size.

In this modified method, dough is fully developed in a National pin mixer until peak dough consistency. Salt is reduced from 2% to 1% and water absorption is increased by 6-7% (farinograph absorption plus 4%). Two uniform dough pieces are subjected to dough rounding, molding, resting and stretching using the Brabender Extensograph®-E according to AACC International method 54-10.01.

Strong correlations for Rmax (r = 0.90) and area (r = 0.92) were found between the modified and standard dough preparation methods (Suchy et al, 2016). This protocol requires much less flour sample (reduced from 300g to 200g), is faster to prepare for subsequent extensigraph testing, and significantly increases overall sample throughput (>50%).

3.0 References


4.0 Materials
4.1 Equipment

4.1.1 200 g pin mixer (National Mfg. Co.) equipped with 200 g water-jacketed mixing bowl and cooling/heating water circulating bath. For instrument operation and testing refer to manufacturer’s manual.


4.1.3 Balance with accuracy of 0.01 g.

4.1.4 Mixer power box and P2M software (RAR Software Systems, Winnipeg, MB).

4.2 Chemicals

4.2.1 Sodium Chloride, NaCl, should be the non-ionized, high purity salt, also used for baking.

4.2.2 Prepare 1% (flour basis) sodium chloride solution by dissolving 2g of NaCl in a required volume of distilled water. The volume of water is determined from water absorption (farinograph absorption plus 4%) and corrections to 14% moisture basis (e.g. flour of moisture content = 13.1% and a farinograph absorption = 65% plus 4% requires 140.1 mL water and 197.9 g flour, based on a 200g flour sample). If the solution is mixed in advance, protect the solution from unnecessary evaporation.

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<tbody>
<tr>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td>Sample Number</td>
<td>Example</td>
</tr>
<tr>
<td>Flour Moisture (%)</td>
<td>13.1</td>
</tr>
<tr>
<td>FAB</td>
<td>65</td>
</tr>
<tr>
<td>FAB + 4</td>
<td>=B5+4</td>
</tr>
<tr>
<td>Flour Weight (g)</td>
<td>=(100-14)/(100-B4)*200</td>
</tr>
<tr>
<td>Water (mL) to add</td>
<td>=(200*B6/100)-B11</td>
</tr>
<tr>
<td>Water from Flour</td>
<td></td>
</tr>
<tr>
<td>Above or below 14% mb</td>
<td>=(B7<em>B4/100)-(200</em>14/100)</td>
</tr>
<tr>
<td>(Moisture in actual flour) - (Moisture in 14% moisture flour)</td>
<td></td>
</tr>
<tr>
<td>Explanation of the above calculation:</td>
<td></td>
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<tr>
<td>Solids in flour = Flour Wt - (Flour Wt x Moisture Content)</td>
<td>=B7-(B7*B4/100)</td>
</tr>
<tr>
<td>Moisture in flour = Flour Wt x Moisture Content</td>
<td>=B7*B4/100</td>
</tr>
<tr>
<td>Total flour weight</td>
<td>=B15+B16</td>
</tr>
<tr>
<td>Water to add for FAB + 4 (Where FAB is 14% mb)</td>
<td>=B6*200/100</td>
</tr>
<tr>
<td>Moisture in the flour that is over or under 14%mb</td>
<td>=B11</td>
</tr>
<tr>
<td>Adjusted Water to add</td>
<td>=B18-B19</td>
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5.0 Procedure

5.1 Equipment Preparation

5.1.1 Water Bath

5.1.1.1 Ensure an adequate water level in the water bath tank (between minimum and maximum lines).
5.1.1.2 Set and operate the water bath at 30 ± 0.2 °C.

5.1.2 National 200g Pin Mixer

5.1.2.1 Turn on the water bath set at 30 °C to circulate through the mixing bowl jacket.
5.1.2.2 Turn on the RAR control box. Then turn on the mixer and allow it to run at 116 rpm for 30 min. Note: The instrument can be operated at different rpm, therefore check the rpm display before starting the mixer. Verify that the mixer is operating at the required rpm by using a hand held tachometer. Note that the mixer-displayed rpm may differ from the tachometer rpm and needs to be adjusted accordingly.
5.1.2.3 Ensure that personnel and other objects are kept away from the moving pins.
5.1.2.4 After 30 min, turn on the computer and start the P2M mixer software (RAR software). Ensure that plot properties and data acquisition is set properly. While the mixer is running, press the <G> green go icon in the P2M program. Monitor the signal. If the mixer is warmed-up and clean, the value on level (Watts) should be just above zero (<5). If that level value is below zero (not moving) or well above the zero, you have to go to data acquisition and reset the calibration B value. The general rule is that you reduce the B calibration value when level value is above zero, and increase it when the level value is below zero. Once the baseline is stable, mixing of dough can begin.

5.1.3 Extensograph

5.1.3.1 Ensure that dough incubation chambers contain distilled water and have reached the 30 ± 0.2 °C operational temperature. Check the ball rolling and molding chambers, dough cradles, and the extension hook for traces of dry dough. If necessary, clean the area with warm water and wipe dry with towels.
5.1.4 Balance

5.1.4.1 Ensure that a suitable balance is leveled and calibrated. Balance must be able to weigh 200 g of flour plus sample holder weight with accuracy ± 0.01 g. Shield the balance from excessive air drafts and static.

5.2 Mixing Protocol

5.2.1 The mixer should be ready for use (5.1.2.4) and should be running between tests to keep it warm. Good practice is to put in the date, sample name, and other comments into the software before mixing. This information stays there and needs to be changed before the next test.

5.2.2 Prepare the required amount of 1% (flour basis) sodium chloride solution required (section 4.2) and weigh 200g flour on a 14% moisture basis. Place the flour in the bowl and create a well so that the flour and the solution will mix reproducibly (cover the bowl if not mixing immediately).

5.2.3 Add saline solution to the flour and immediately start the mixer <FWD>, followed by starting the software by clicking <G> in the P2M software.

5.2.4 Monitor the dough development curve closely. When the dough starts to break down, the red marker line will indicate latest peak development and you need to stop the test by pressing <Stop> switch on the controller and clicking <S> in the P2M software. Sometimes the red marker line is prematurely placed on the curve and stopping the test at that moment would produce underdeveloped dough. In most cases nearly developed dough has a characteristic “slapping” sound and is then most likely ready for stopping.

5.2.5 With hands lightly greased, gently remove the dough (avoid unnecessary stretching or pulling). Fold the dough in half two times and scale off two 150 g dough pieces. Note: process the first dough piece while preparing the second piece. Fold each dough piece twice. Place the dough in the dough rounder and start the rounder. Once the ball is completed, you may require a small amount of dusting flour to prevent stickiness. Gently dip the bottom of the ball in dusting flour, if necessary, and remove excess flour. Carefully center the dough ball on the dough molder and shape it into a cylindrical dough piece. Place the dough into a non-greased and “warm” dough holder (cradle) with the “rough” side up and store it in a humidified chamber. Immediately start the timer counting down to 45 min.

5.3 Dough Testing

5.3.1 Open the Brabender Extensograph®-E software and create a sample list using <Test> and then <New>. Click on the add test <Add>. Fill in the blanks with
required information: operator, number of duplicates, number and time of tests (45 and 90 min), sample name, water absorption (14% mb) and any other remarks (such as dough handling properties, etc.). The system will prompt you to save the test. If time is limited, the sample list can be generated before mixing dough and absorption can be added once the dough is mixed.

5.3.2 After 45 min rest, firmly place the cradle with the dough piece on the holding tray of the stretcher. Click the <Start Measurement> icon to initialize the test and as soon as the yellow sign “initializing” disappears, press the <Start> switch. As the hook descends, put your right hand below the hook (in case you need to catch broken dough piece), and the left hand on the stop switch. When the dough piece ruptures, immediately press the <Stop> switch to terminate the test. The results are automatically saved to the previously created test file (45 min test).

5.3.3 Remove the dough pieces from the cradle, combine into one piece, fold gently two times and reshape as before in 5.2.5. Incubate the dough in the humidified chamber for another 45 min. After 45 min the dough is taken out from storage and tested again (90 min test). The results are automatically saved to the previously created test file (90 min test).

5.4 Cleaning

5.4.1 Pin Mixer: Clean the pin mixer immediately after the test dough is placed in the extensigraph dough chamber. Clean the mixing bowl and mixing pins with water using a small toothbrush, wet- and dry- towels. At the end of the test day, unscrew the cover in the mixing head and clean thoroughly with a wet towel. Ensure that the cover is firmly reattached with the two numbers (engraved on the cover and mixing head) on the same side.

5.4.2 Extensigraph: Clean the rounder and molder after each use if the samples are very sticky. Otherwise cleaning at the end of a test day is acceptable. Clean the cradles immediately after the final dough stretch so they are ready for the next sample. If the instrument is not used the next day, turn off the water bath, remove the water from the dough chamber and leave the door open to prevent microbial growth.

5.4.3 Water Bath: Drain and clean the water tank, and refill with distilled water, at least twice a year or more frequently if visible discoloration appears.

6.0 Evaluation and Interpretation of the results

The Brabender software will automatically plot force (resistance) against the length (extensibility) and derives quality parameters such as resistance to extension ($R_{max}$), extensibility, area under the curve and the ratio between resistance and extensibility.
6.1 Resistance to extension, $R_{\text{max}}$ or $R_5$, is the height of the curve in BU, either at maximum or at 5 cm after the start of the test.

6.2 Extensibility is the total length of the curve in cm. The noise in the “curve” after the dough breaks should be ignored.

6.3 Area is the area under the curve ($R_{\text{max}}$ vs extensibility) in cm$^2$. 