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Wheat flour — Physical characteristics of doughs —

Part 1: Determination of water absorption and rheological properties using a farinograph

Farines de blé tendre — Caractéristiques physiques des pâtes —

Partie 1: Détermination de l'absorption d'eau et des caractéristiques rhéologiques au moyen du farinographe

ISO/CEN PARALLEL PROCESSING

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Foreword

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This document was prepared by Technical Committee ISO/TC 34, *Food products*, Subcommittee SC 4, *Cereals and pulses*, in collaboration with the European Committee for Standardization (CEN) Technical Committee CEN/TC 338, *Cereal and cereal products*, in accordance with the Agreement on technical cooperation between ISO and CEN (Vienna Agreement).

This fourth edition cancels and replaces the third edition (ISO 5530-1:2013), which has been technically revised. The main changes compared with the previous edition are as follows:

— a wheat flour interlaboratory test was performed in 2015 to evaluate the repeatability and reproducibility of the test method specified in this document, and the results have been added as Annex C;

— more detailed procedure for electronic devices has been added.

A list of all parts in the ISO 5530 series can be found on the ISO website.

Any feedback or questions on this document should be directed to the user's national standards body. A complete listing of these bodies can be found at www.iso.org/members.html.

Wheat flour — Physical characteristics of doughs —

Part 1: Determination of water absorption and rheological properties using a farinograph

1 Scope

This document specifies a method using a farinograph for the determination of the water absorption of flours and the mixing behaviour of doughs made from them by a constant flour mass procedure or by a constant dough mass procedure.

The method is applicable to experimental and commercial flours from wheat (*Triticum aestivum* L.).

NOTE This document is related to ICC 115/1[5] and AACCI Method 54-21.02[6].

2 Normative references

The following documents are referred to in the text in such a way that some or all of their content constitutes requirements of this document. For dated references, only the edition cited applies. For undated references, the latest edition of the referenced document (including any amendments) applies.

ISO 712, *Cereals and cereal products — Determination of moisture content — Reference method*

ISO 3696, *Water for analytical laboratory use — Specification and test methods*

3 Terms and definitions

For the purposes of this document, the following terms and definitions apply.

ISO and IEC maintain terminological databases for use in standardization at the following addresses:

— ISO Online browsing platform: available at https://www.iso.org/obp

— IEC Electropedia: available at https://www.electropedia.org/

3.1
consistency
resistance of a dough to being mixed in specific conditions

Note 1 to entry: For the purposes of this document, consistency refers to the resistance of dough being mixed in a farinograph under the conditions specified in the methodology.

Note 2 to entry: It is expressed in *farinograph unit (FU)* (3.2).

Note 3 to entry: Specific conditions include mixing conditions, temperature, hydration, etc.

3.2
farinograph unit
FU
arbitrary unit used for *consistency* (3.1) on the farinogram

Note 1 to entry: For the mathematical expression of FU, see 6.1.

Note 2 to entry: It is also possible to define an FU as a torque expressed in Nm, measured in the axis of the mixer.

3.3
maximum consistency
consistency (3.1) measured at the end of the *dough development time* (3.5)

Note 1 to entry: For the mathematical expression of maximum consistency, see 9.3.

Note 2 to entry: It is expressed in *farinograph unit (FU)* (3.2).

Note 3 to entry: See 3.7.

3.4
water absorption of flour
W_a
volume of water required to produce a dough with a *maximum consistency* (3.3) of 500 *farinograph unit (FU)* (3.2) under the specified operating conditions

Note 1 to entry: Water absorption is expressed in millilitres per 100 g of flour at 14 % (mass fraction) moisture content to an accuracy of 0,1 ml.

Note 2 to entry: Water absorption can also be expressed in % (ml per 100 g).

3.5
dough development time
DDT
DEPRECATED: peak time

time from the beginning of the addition of water to the point on the curve immediately before the first sign of the decrease of *maximum consistency* (3.3)

Note 1 to entry: In cases where two peaks are observed, use the second maximum to measure the DDT.

Note 2 to entry: See Figure 1 and 9.3.

Note 3 to entry: It is expressed in minutes to the nearest 0,1 min.

3.6
stability
difference in time between the point where the top part of the curve intercepts, for the first time, the line of 500 *farinograph unit (FU)* (3.2) and the last point where leaves this line

Note 1 to entry: This value measures the tolerance of the flour to mixing.

Note 2 to entry: When the *maximum consistency* (3.3) of a peak curve deviates from the (500 ± 20) FU line, the line of this consistency should be used to read the interceptions (see also B.4.2).

Note 3 to entry: The stability is expressed in minutes, to an accuracy of 0,5 min.

3.7
degree of softening
difference between the height of the centre of the curve at the point where it begins to decline (*dough development time* (3.5)) and the height of the centre of the curve 12 min after that point

Note 1 to entry: It is expressed in *farinograph unit (FU)* (3.2).

Note 2 to entry: In cases where two peaks appear, the second peak is considered to determine the degree of softening.

Note 3 to entry: The degree of softening should be expressed to the nearest 5 *farinograph unit (FU)* (3.2).

Note 4 to entry: This definition is equivalent to ICC 155/1[5].

3.8
farinograph quality number
FQN
length along the time axis between the point of the addition of water and the point where the height of the centre of the curve has decreased by 30 *farinograph unit (FU)* (3.2) compared to the height of the centre of the curve at the *dough development time* (3.5)

Note 1 to entry: It is expressed in millimetres to an accuracy of 1 mm.

4 Principle

Measuring and recording, by means of a farinograph, the consistency of a dough as it is formed from flour and water, as it is developed and as it changes with time.

NOTE The maximum consistency of the dough is adjusted to a fixed value by adapting the quantity of water added. The correct water addition, which is called the “water absorption”, is used to obtain a complete mixing curve, the various features of which are a guide to the rheological properties (strength) of the dough.

5 Reagent

Use only distilled or demineralized water or water conforming to grade 3 in accordance with ISO 3696.

6 Apparatus

The usual laboratory apparatus and, in particular, the following shall be used.

6.1 Farinograph[1)] (see Annex A), with the following operating characteristics:

— slow blade rotational frequency: (63 ± 2) min^{-1}; the ratio of the rotational frequencies of the mixing blades shall be 1,50 ± 0,01;

— torque per FU:

  — for a 300 g mixer: (9,8 ± 0,2) mN·m/FU [(100 ± 2) gf·cm/FU];

  — for a 50 g mixer: (1,96 ± 0,04) mN·m/FU [(20 ± 0,4) gf·cm/FU];

  — for chart recording devices: chart speed: (1,00 ± 0,03) cm/min;

  — for electronic devices: chart speed is not applicable but time is measured.

6.2 Water dosing system, comprising:

a) for a 300 g mixer: a burette graduated from 135 ml to 225 ml in 0,2 ml divisions;

b) for a 50 g mixer: a burette graduated from 22,5 ml to 37,5 ml in 0,1 ml divisions;

c) an electronically driven water dosage system.

6.3 Thermostat, with circulating water for a constant temperature of (30 ± 0,2) °C.

6.4 Balance, capable of weighing to the nearest ±0,1 g.

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1) This document has been drawn up on the basis of the Brabender Farinograph. which is an example of a suitable product available commercially. This information is given for the convenience of users of this document and does not constitute an endorsement by ISO of this product. Equivalent products may be used if they can be shown to lead to the same results.

6.5 **Spatula**, thin, made of a non-metallic material.

7 Sampling

Sampling is not part of the method specified in this document. A recommended sampling method is given in ISO 24333[4].

It is important that the laboratory receives a sample that is truly representative and that has not been damaged or changed during transport and storage.

8 Procedure

8.1 Determination of the moisture content of the flour

Determine the water content of the flour using the method specified in ISO 712 or by near infrared spectroscopy. The performance of the NIR should be demonstrated in accordance with ISO 12099 and reach at least one standard error of prediction (SEP) ≤ 0,15 % determined over the entire scope of this document.

NOTE In comparison with ISO 712, the error prediction for ISO 12099 is higher.

8.2 Preparation of the farinograph

NOTE Details of the electronic farinograph characteristics and procedure are given in A.4.

8.2.1 Turn on the thermostat (6.3) of the farinograph and circulate the water until the required temperature is reached prior to using the instrument. Before and during use, check the temperatures of:

— the thermostat;

— the mixing bowl of the farinograph in the hole provided for this purpose.

The temperature of the mixing bowl shall be (30 ± 0,2) °C.

The laboratory temperature should be between 20 °C and 30 °C.

8.2.2 For mechanical devices, uncouple the mixer from the driving shaft and adjust the position of the counterweight(s) so as to obtain zero deflection of the pointer with the motor running at the specified rotational frequency (see 6.1). Switch off the motor and then couple the mixer. For electronic devices, the zero adjustment is programmed to be done automatically at the start of each measurement.

8.2.3 For mechanical devices, lubricate the mixer with a drop of water between the back-plate and each of the blades. Check that the deflection of the pointer is within the range (0 ± 5) FU with the mixing blades rotating at the specified rotational frequency in the empty, clean bowl. If the deflection exceeds 5 FU, clean the mixer more thoroughly or eliminate other causes of friction. For electronic controlled devices, the lubrication of the blades is done with silicon fat.

8.2.4 For mechanical devices, adjust the arm of the pen so as to obtain identical readings from the pointer and the recording pen.

8.2.5 For mechanical devices, adjust the damper so that, with the motor running, the time required for the pointer to go from 1 000 FU to 100 FU is (1,0 ± 0,2) s. This should result in a bandwidth of approximately 60 FU to 90 FU.

8.2.6 Fill the burette (6.2) with water at 30 °C. The time to flow from 0 ml to 225 ml (for a 300 g mixer) or from 0 ml to 37,5 ml (for a 50 g mixer) shall be not more than 20 s. For electronic farinographs, the time for the water flow by means of the dosing system is the same.

8.3 Test portion

8.3.1 General

If necessary, bring the flour to a temperature of between 25 °C and 30 °C.

8.3.2 Constant flour mass procedure

Weigh (6.4), to the nearest 0,1 g, the equivalent of 300 g (for a 300 g mixer) or 50 g (for a 50 g mixer) of flour having a moisture content of 14 % mass fraction. Let this mass, in grams, be *m*. See Table 1 for *m* as a function of moisture content.

Place the test portion in the mixer. Cover the mixer and keep it covered until the end of mixing, except for the shortest possible time when water has to be added and the dough scraped down. The temperature of the measurement is defined in 8.2.1.

Table 1 — Mass of flour, in grams, equivalent to 300 g and 50 g at a moisture content of 14 % mass fraction

Moisture content	**Mass, *m*, of flour (in g) equivalent to**	
% mass fraction	300 g	50 g
9,0	283,5	47,3
9,1	283,8	47,3
9,2	284,1	47,4
9,3	284,5	47,4
9,4	284,8	47,5
9,5	285,1	47,5
9,6	285,4	47,6
9,7	285,7	47,6
9,8	286,0	47,7
9,9	286,3	47,7
10,0	286,7	47,8
10,1	287,0	47,8
10,2	287,3	47,9
10,3	287,6	47,9
10,4	287,9	48,0
10,5	288,3	48,0
10,6	288,6	48,1
10,7	288,9	48,2
10,8	289,2	48,2
10,9	289,6	48,3
11,0	289,9	48,3
11,1	290,2	48,4
11,2	290,5	48,4
11,3	290,9	48,5
11,4	291,2	48,5
11,5	291,5	48,6

Table 1 *(continued)*

Moisture content	Mass, *m*, of flour (in g) equivalent to	
% mass fraction	300 g	50 g
11,6	291,9	48,6
11,7	292,2	48,7
11,8	292,5	48,8
11,9	292,8	48,8
12,0	293,2	48,9
12,1	293,5	48,9
12,2	293,8	49,0
12,3	294,2	49,0
12,4	294,5	49,1
12,5	294,9	49,1
12,6	295,2	49,2
12,7	295,5	49,3
12,8	295,9	49,3
12,9	296,2	49,4
13,0	296,6	49,4
13,1	296,9	49,5
13,2	297,2	49,5
13,3	297,6	49,6
13,4	297,9	49,7
13,5	298,3	49,7
13,6	298,6	49,8
13,7	299,0	49,8
13,8	299,3	49,9
13,9	299,7	49,9
14,0	300,0	50,0
14,1	300,3	50,1
14,2	300,7	50,1
14,3	301,1	50,2
14,4	301,4	50,2
14,5	301,8	50,3
14,6	302,1	50,4
14,7	302,5	50,4
14,8	302,8	50,5
14,9	303,2	50,5
15,0	303,5	50,6
15,1	303,9	50,6
15,2	304,2	50,7
15,3	304,6	50,8
15,4	305,0	50,8
15,5	305,3	50,9
15,6	305,7	50,9
15,7	306,0	51,0
15,8	306,4	51,1

Table 1 *(continued)*

Moisture content	**Mass**, *m*, **of flour** (in g) **equivalent to**	
% mass fraction	300 g	50 g
15,9	306,8	51,1
16,0	307,1	51,2
16,1	307,5	51,3
16,2	307,9	51,3
16,3	308,2	51,4
16,4	308,6	51,4
16,5	309,0	51,5
16,6	309,4	51,6
16,7	309,7	51,6
16,8	310,1	51,7
16,9	310,5	51,7
17,0	310,8	51,8
17,1	311,2	51,9
17,2	311,6	51,9
17,3	312,0	52,0
17,4	312,3	52,1
17,5	312,7	52,1
17,6	313,1	52,2
17,7	313,5	52,2
17,8	313,9	52,3
17,9	314,3	52,4
18,0	314,6	52,4

NOTE The values in this table are calculated using the following formulae:

a) for the mass, in grams, equivalent to 300 g at 14 % mass fraction moisture content:

$$m = \frac{25\,800}{100 - H}$$

b) for the mass, in grams, equivalent to 50 g at 14 % mass fraction moisture content:

$$m = \frac{4\,300}{100 - H}$$

where H is the moisture content of the sample, as a percentage by mass.

Calculation example: Mass of flour to be added, e.g. having 13 % moisture:

m (13 %) = 300 g × (100 % – 14 %) / (100 % – 13 %) = 296,55 g

8.3.3 Constant dough mass procedure

Calculate the necessary mass of flour, m, in grams according to Formula (1):

$$m = \frac{C_m}{100 \pm W_a} \quad (1)$$

where

C_m is a constant number, which is 48 000 using a large bowl (for a 300 g mixer) and 8 000 using a small bowl (for a 50 g mixer);

W_a is the water absorption of flour, expressed in millilitres per 100 g of flour at 14 % (mass fraction) moisture content (determined by 9.2).

Calculate the necessary volume of water, V, in millilitres according to Formula (2):

$$V = C_V - m \quad (2)$$

where C_V is a constant number, which is 480 using a large bowl and 80 using a small bowl.

Weigh (6.4), to the nearest 0,1 g the calculated mass, m, of flour and place the test portion in the bowl.

Fill the burette (6.2) with water at 30 °C. Start the mixer and recording mechanism and, 1 min later, add the calculated volume of water to the flour. In this case, the maximum consistency of the dough will be (500 ± 20) FU.

NOTE W_a is indicated in dependency of m, calculated by Formula (1) using the large or small bowl (in the water absorption range from 54 % to 77 %)[5].

8.4 Common rules of determination

8.4.1 For the steps of the operation not specified in this document, follow the manufacturer's instructions.

8.4.2 Mix at the specified rotational frequency for 1 min or slightly longer to allow the flour to reach the temperature of the mixer. Start adding water from the burette into the right-hand front corner of the mixer within 25 s, when a whole-minute line on the recorder paper passes by the pen.

In order to reduce the waiting time, the recorder paper can be moved forward during the mixing of the flour. Do not move it backwards.

Add a volume of water close to that expected to produce a maximum consistency (see 9.2) of 500 FU. When the dough forms, scrape down the sides of the bowl with the spatula (6.5) adding any adhering particles to the dough, without stopping the mixer. If the consistency is too high. Add a little more water to obtain a maximum consistency of approximately 500 FU. Stop mixing and clean the mixer.

When using electronic devices, the measurement also starts after a mixing time of 1 min, but the starting point on the diagram is independent from certain lines on the chart paper.

Depending on the flour quality and evaluations being made, e.g. when using very strong flours with a long stability, it is possible that the measurement time has to be extended in order to record all the evaluation points at least 12 min after the maximum consistency.

See also 8.4.3.

8.4.3 Carry out additional mixings as necessary until two mixings are available:

— in which the water addition has been completed within 25 s;

— the maximum consistencies of which are between 480 FU and 520 FU;

— the recording of which has been continued for sufficient time to calculate all reported terms of the selected method, e.g. when using very strong flours with a long stability; it is possible that the measurement time has to be extended in order to record all the evaluation points;

— based on the evaluation points of two valid curves, the average values have to be calculated.

Stop mixing and clean the mixer.

9 Evaluation of the farinogram and calculation of the derived rheological characteristics

9.1 General

From each sample, two determinations shall be carried out. Read directly or calculate the values of each rheological characteristic to be determined from both farinograms. Express the results as the mean value of the relevant data. Two curves to be averaged shall be within the range of 480 FU to 520 FU at their DDT.

NOTE To facilitate the calculations, a computer can be used. In that case, it would be necessary to modify the farinograph by adding an electrical output for transferring the data to the computer.

9.2 Water absorption of flour

In order to obtain the water absorption of flour, first derive, from each of the mixings with maximum consistencies of between 480 FU and 520 FU, the corrected volume, V_c, in millilitres, of water corresponding to a maximum consistency of 500 FU, by means of Formulae (3) and (4):

a) for a 300 g mixer:

$$V_c = V + 0{,}096(C - 500) \quad (3)$$

b) for a 50 g mixer:

$$V_c = V + 0{,}016(C - 500) \quad (4)$$

where

V is the volume, in millilitres, of water added;

C is the maximum consistency, in FU (see Figure 1), given by:

$$C = \frac{C_1 + C_2}{2}$$

where

C_1 is the maximum height of the upper contour of the curve, in FU;

C_2 is the maximum height of the lower contour of the curve, in FU.

In the relatively infrequent case where two peaks are observed, use the height of the higher maximum.

Use for the calculation, the mean value of duplicate determinations of V_c, provided the difference between them does not exceed 2,5 ml (for a 300 g mixer) or 0,5 ml (for a 50 g mixer) of water.

The water absorption of flour, W_a, expressed in millilitres per 100 g of flour at 14 % (mass fraction) moisture content, is as given in Formulae (5) and (6):

— for a 300 g mixer:

$$W_a = \left(\overline{V_c} + m - 300\right) \times 0{,}333 \quad (5)$$

— for a 50 g mixer:

$$W_a = \left(\overline{V_c} + m - 50\right) \times 2 \quad (6)$$

where