12 Determining the Baking Quality of Wheat and Rye Flour

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A number of methods for determining the baking quality of flours have been developed and standardized throughout the world. In particular they have been elaborated by the scientific bodies of the ICC (Vienna, Austria, www.icc.or.at) and AACC International (St. Paul, MN, USA, www.aaccnet.org). They are regularly checked and optimized in special study groups. So when making comparisons it is important always to use the latest issues of the collections of methods.

The following chapter describes the methods for analyzing kernels and the products ground from wheat or rye. Before the procedure is described (usually the ICC method) the standards and principles of the ICC and AACC International are compared in the form of a table. For a discussion of the results it is important always to state the method by which the analysis was carried out.

12.1 Determining the Moisture Content of Flours

Method No.	Description
ICC Standard No. 110/1	Temperature: 130-133 °C Time: 90 min
ICC Recommendation No. 202	Determination by NIR spectroscopy
AACC Method 44-19	Temperature: 135 °C Time: 90 min

The water content or moisture of the flours is very important not only for their shelf life but also for determining the solids content. For many tests it is necessary to know the dry weight of the material in order to determine the amount of the substances it contains. The weight of the flour sample therefore has to be adjusted to the moisture content of the flour. There are tables to show that at a moisture content of 15.5%, 305.3 g of flour have to be weighed into the Farinograph instead of 300 g, since the solids content decreases as the moisture content increases. Most analytical methods are designed for flour with a moisture content of 14%, so at 12.5% only 294.9 g of flour are needed. Bakers have to think on the same lines, since they need flours with a high solids content.

With the exception of maize and brewer's barley it is possible to determine the water content of all cereals and cereal products by drying them at 130 °C for 90 min (ICC Standard 110/1). Fig 37 shows a device permitting virtually continuous determination of the moisture content of several samples at the same time.

By using NIR spectroscopy (ICC Recommendation 202) it is possible to obtain the result within seconds (Fig. 38). This method makes use of the fact that the light rays in the near-infrared (NIR) range are absorbed or reflected by the sample at different wavelengths (see Spectrometry). The calibration of the equipment enables the computer to determine the values for moisture and protein very quickly. The moisture content of whole kernels can be determined as well as that of flour. The near-

Fig. 37: Device for determining the moisture content (source: Brabender OHG)

Fig. 38: Determining the moisture content of whole kernels (left) and flour (right) using near-infrared transmission technology (NIT) or near-infrared reflection spectroscopy (NIR) (sources: Brabender OHG / Mühlenchemie GmbH)

infrared transmission technology (NIT; Fig. 38) necessary for this is the more convenient method for mills, since the kernels do not have to be crushed.
The water content of flour depends to a large extent on climatic conditions during harvesting and ambient moisture during storage. Moisture values well over 15% restrict the shelf life. Both storage time and storage temperature have to be monitored to ensure that the cereal products do not become inedible through enzyme or microbiological degradation and that their processing properties do not suffer. In wholemeal products, especially, a stale, mouldy taste can develop very quickly.

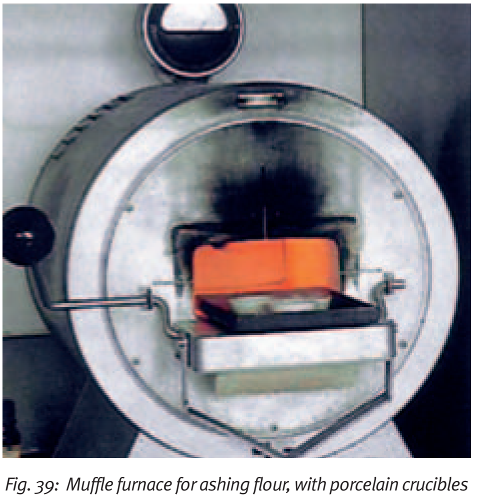

Fig. 39: Muffle furnace for ashing flour, with porcelain crucibles (source: University of Hanover)

12.2 Determining the Mineral Content of Flours

Method No.	Description
ICC Standard No. 104/1	Temperature: 900 °C Time: 2 h
ICC Recommendation No. 202	Determination by NIR spectroscopy
AACC Method 08-03	Temperature: 600 °C Time: 2 h
AACC Method 08-21	Determination by NIR spectroscopy

In most regions, flours are traded according to their mineral content (which also used to be called the ash content). Since the baking properties of the flours change with the degree of extraction, the mineral content should be stated in concrete terms.

The mineral content is determined by ashing a flour sample in a muffle furnace (Fig. 39) at 900 °C. The organic material initially burns quite fiercely; after this it is necessary to continue heating the sample for up to 120 minutes. Only pure white ash is then to be seen in the porcelain crucible. After cooling, the crucible is weighed and the quantity of ash stated as a percentage of the dry matter. In Germany the type designation is obtained by multiplying this value by 1,000.
The mineral content of flours may fluctuate between a minimum and a maximum, depending on the regulations in individual countries.

29 In some cases the variability is very wide, and
33 this may result in differences in baking properties. Especially in the production of baked goods with a high volume yield, e.g. bread rolls, it makes a difference whether the flour used has a mineral content of 0.51 or 0.63%. If the level of extraction includes little more than the endosperm of the grain, the protein content increases considerably in addition to the mineral content (Fig. 40), but at the same time there is likely to be a sharp fall in the volume yield.

In the case of the rye flour types, full use of the outer layers also changes the colour of the flour. This may result in bread with a noticeably darker crumb in spite of using the same flour type. The dough yield will also fluctuate if the flour has a mineral content of 1.11 g on one occasion and 1.30 g per 100 g of dry matter on the next.

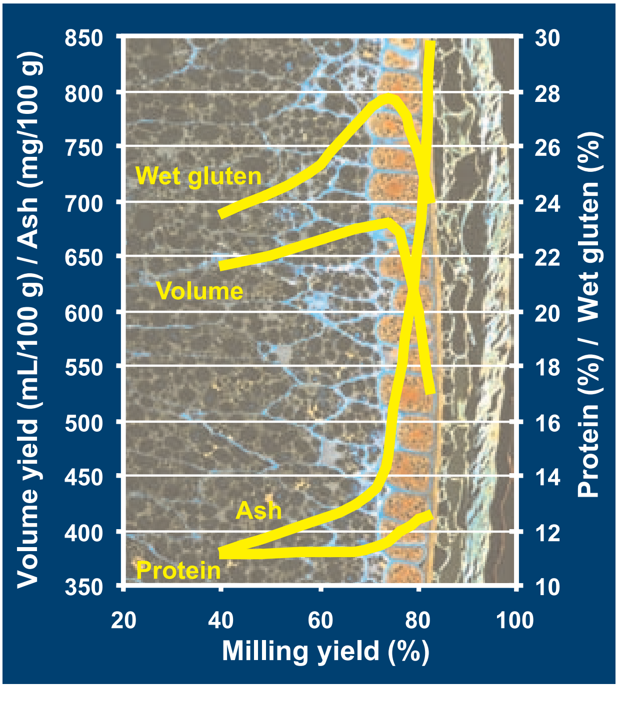

Fig. 40: Changes in the flour values when the flour yield is increased beyond the endosperm. red brown: aleuron cells; blue: cell walls; dark brown: starch granules (modified from Bolling, 1986 by L. Popper; wheat micrograph courtesy of VTT, Helsinki, Finland)

The ash content is determined according to ICC Standard 104/1. A quick test is also possible using NIR.

12.3 Determining Acidity in Flours

Method No.	Description
ICC Standard No. 145	Determination of acidity (according to Schulerud)
AACC Method 02-31	Titratable acidity

The acidity of a flour is an important indicator of its freshness. The fats and phosphatides (lecithin) are broken down enzymatically during storage of the flour. This breakdown is accelerated by a high water content, high temperatures and a high degree of extraction. The lipases and phosphatases naturally present in the cereal cause an increase in the percentage of free fatty acids and phosphate. To a certain extent this breakdown is desirable as a maturing of the flour, but once the tolerances are exceeded the flours become inedible. By determining the acidity of the flour, taking the degree of extraction into account, it is possible to monitor the progress of maturing and the possible start of deterioration.
Since the changes in the flour during storage consist mainly in an increase in the free fatty acids, the sample is suspended in ethanol (67% alcohol) before filtration. The filtrate is then titrated with sodium hydroxide solution to a pH of 8.5. The amount of 0.1 N (mol/L) of sodium hydroxide solution required (multiplied by two) is a measure of the degree of acidity. Titration is sometimes carried out using the indicator dye phenolphthalein, but the point at which the colour changes from yellow to pink is difficult to determine precisely. It has therefore become established practice to use a pH meter.

12.4 Determining the Falling Number as a Measure of α-Amylase Activity

Method No.	Description
ICC Standard No. 107/1	Measurement of the degree of α-amylase activity in grain and flour (according to Hagberg-Perten)
AACC Method 56-81B	Identical

188 The gelatinization properties of the starch in wheat or rye dough depend greatly on the α-amylase activity. Since rye starch gelatinizes at low temperatures, it is more easily broken down by this enzyme. It is therefore especially important to establish the gelatinization properties of rye flours. Determination of the Falling Number and the Amylogram have established themselves as standard methods. The Amylogram is used mainly for testing rye, whereas the Falling Number serves as a measure for both cereals.

To determine the Falling Number, 7 g of flour are heated with 25 mL of distilled water in a water bath for one minute to approximately 95 °C (modified Falling Number: approx. 80 - 95 °C). The viscosity of the starch gel thus obtained is then determined by measuring the time the stirring rod takes to sink through the gel to the bottom of the measuring cylinder. The Falling Number is the sum of the stirring and sinking time. It is stated in seconds. The minimum Falling Number is 60 s. When the flour is weighed, its moisture content is assumed to be 15%. If the water content differs from this value, the amount weighed in must be corrected by calculation or according to a special table.

Nowadays the test is performed with a Falling Number device (Fig. 41) that carries out the stirring and measuring procedure automatically. If the enzymatic activity is high, the starch is broken down very rapidly during gelatinization. The stirring rod falls through the relatively liquid paste in a short time. The Falling Number is low. If the activity of the amylases is low it takes much longer for the rod to cover the distance and trigger the signal for the end of the process.

This equipment can also be used to adjust the amylase activity of flour mixtures or determine the amount of malt to be added. With the aid of a diagram it is easy to read off the mixing ratios. Conversely, it is possible to make a precise adjustment to the desired Falling Number. But blending with other flours is preferable, since enzyme-active malt flours contain the whole spectrum of cereal enzymes as well as the starch-degrading enzymes. In other words, they are able to break down the other constituents to an undesirable extent.

Determination of the Falling Number is an internationally recognized method that has long been used as ICC Standard No. 107.

Fig. 41: Equipment for determining the Falling Number (source: Mühlenchemie GmbH & Co. KG)

12.5 Determining the Gelatinization Properties of Starch with the Amylograph

Method No.	Description
ICC Standard No. 126/1	Measurement of the gelatinization properties of rye and wheat (Brabender OHG). - Gelatinization maximum (AU) - Gelatinization temperature (°C) Determination of enzyme activity.
AACC Method 22-10	Identical

The Amylograph (Fig. 42) enables continuous measurement of the changes of viscosity in a flour-and-water suspension during heating. For heating, a temperature gradient is selected that corresponds to the rise in temperature during the baking process; this means that the Amylograph can be used to make important predictions about the baking properties of the flour. Besides the gelatinization characteristics of the starch it also shows the effect of the amylases.

To obtain an Amylogram, flour (14% moisture) and water are transferred to the stirring bowl, ensuring that there are no lumps. The bowl contains rods that project upwards with the suspension between them. When the bowl has been placed in the appropriate opening in the device, the sensor is inserted into it from the top. The sensor is fitted with similar rods, projecting vertically downwards. During heating, the liquid has to flow between the rods projecting into it from above and below, since the bowl is rotated continuously. The shear forces that occur between the rods as gelatinization progresses are recorded on a diagram as changes in viscosity; this results in the typical curve of an Amylogram.

When gelatinization starts, the suspension reaches the optimum temperature for α-amylase activity. The rise in viscosity to be seen on the evaluation diagram is the product of the increase caused by gelatinization and liquefaction by the amylases. Besides the maximum viscosity, the curve also shows the temperature at the start of gelatinization and at its maximum. A viscosity of at least 200 AU (Amylogram units) alone is not enough for rye to be classified as bread rye; a temperature of at least 63 °C in the suspension must also have been reached at this time.

Testing of wheat and rye flours with the Amylograph conforms to ICC Standard 126/1. It is especially important for assessing rye flour products. This method is also suitable for investigating the effects of enzyme-active ingredients.

A further measure of the breakdown of starch is the maltose content of the flour. Being a degradation product of starch, maltose – also called malt sugar – may indicate increased sprouting of the grain. The method is based on the enzyme activity of the flours and measures

Fig. 42: Amylograph (source: Brabender OHG)

the fermentable sugar formed within an hour at 27 °C. The amount of maltose measured is influenced chiefly by ß-amylase activity, but the starch damaged during milling may also contribute to a high "maltose number". If a value of 2.3% for rye or 1.8% for wheat is exceeded, it must be assumed that there is too much activity of starch-degrading enzymes or too much damage to the starch.

12.6 Quantitative Methods of Protein Determination

43 Quantitative methods are those tests in which the amount of a constituent is determined. The total amount of protein has a very important influence on the baking properties of wheat flour. Fig. 40 shows that the protein content increases with the degree of extraction, but there is no increase in the gluten content that enhances the properties of the dough and also the baking properties. The increase results from the protein contained in the aleuron layer, which is especially protein-rich.
This effect indicates that it is not just the protein content in absolute terms that matters. In wheat flour there are several protein fractions that differ in respect of their solubility. It is the gluten-forming protein fractions of the endosperm that determine the baking properties of wheat flours. The amount of these present can only be established by testing for the wet gluten content. The proteins from the outer layers and the germ have quite different properties. Although they are included in the determination of the protein content, they are soluble in water or brine and therefore have no influence on the properties of a wheat dough.

12.6.1 Determining Total Protein

The total protein content of the wheat is determined by the Kjeldahl method. The organic constituents are oxidized in the presence of a catalyst. The ammonia formed after another step is distilled and titrated. The amount of nitrogen ascertained by titration is multiplied by a factor specified for each food. For wheat and rye and the products for human nutrition made from these cereals the factor for converting the nitrogen values found from the protein is 5.7 (see also chapter 5.7.2 and 5.8.2).

Method No.	Description
ICC Standard No. 105/2	Kjeldahl method
ICC Standard No. 159	NIR spectroscopy
ICC Standard No. 167	Dumas combustion principle
AACC Method 46-10	Improved Kjeldahl method
AACC Method 46-11A	Improved Kjeldahl method, copper catalyst modification
AACC Method 46-12	Kjeldahl method, boric acid modification
AACC Method 46-13	Micro-Kjeldahl Method
AACC Method 46-15	5-minute Biuret method for wheat and other grains
AACC Method 46-16	Improved Kjeldahl method, copper-titanium dioxide catalyst modification

A more modern way of determining the nitrogen content is the practically automatic "Dumas combustion method" (Fig. 43) in which the sample is incinerated under oxygen, the resulting nitric oxide converted into nitrogen and the heat conductivity of helium and nitrogen subsequently measured against pure helium. This procedure is faster and less complicated than the Kjeldahl method usual in the past.

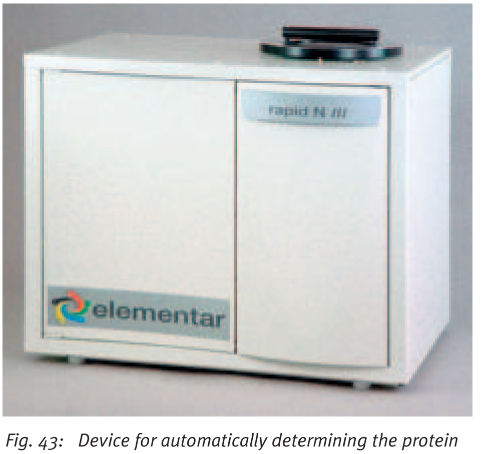

Fig. 43: Device for automatically determining the protein content by the Dumas combustion method (source: Elementar Analysensysteme GmbH)

The method for determining the crude protein content of cereals and cereal products for human nutrition is specified in ICC Standard 105/2. ICC Recommendation 202 favours determining the protein content by near-infrared spectroscopy (NIR); see also the section on determining the moisture content.

12.6.2 Determining the Wet Gluten Content

Method No.	Description
ICC Standard No. 106/2	Method for the determination of wet gluten in wheat flour
ICC Standard No. 137/1	Mechanical determination of the wet gluten content of wheat flour (Perten Glutomatic)
AACC Method 38-10	Gluten - hand washing method
AACC Method 38-12A	Wet gluten, dry gluten, water-binding capacity and gluten index

The wet gluten content is a measure of the amount of swollen gluten in the wheat flour that can be determined by forming a paste from a flour sample and washing it out. The principle of the method is that a dough is made with a buffered solution of common salt (for adjustment to a pH of 5.95) and then washed out to remove the starch and the water-soluble constituents of the gluten.
The gluten is then dried and subsequently weighed. The amount of gluten thus determined is the wet gluten content in percent by weight. The methods for washing the sample differ greatly. The gluten content can be determined under running water or in a gluten washer. But reproducibility (repeatability of the results) can only be achieved with these methods if the test is carried out by very experienced persons. ICC Standard 106/2 uses a gluten washer with an eccentric plate and a gluten press. Mechanical determination of the wet gluten content of wheat flour (ICC Standard 137) is carried out with the Glutomatic equipment.
In this method the paste is prepared and washed automatically in the machine (Fig. 44). The washing vessel and the sieve on which the paste is processed are specified. At the end of the washing procedure the gluten is placed in the centrifuge with tweezers and the adhering water removed.

Evaluation is carried out by weighing the pieces of gluten after centrifuging. The result has to be converted to correspond to a flour moisture content of 14%. If a special sieve is used for certrifugation it is possible to determine the Gluten Index. The centrifugal force presses some of the gluten through the sieve. The higher the proportion of gluten that has not passed through the sieve, the higher is the index and the better the gluten.

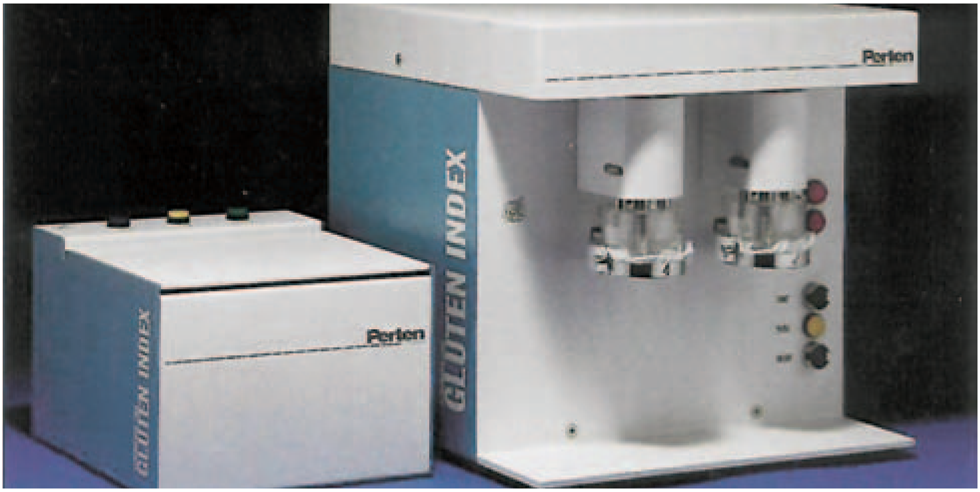

Fig. 44: Perten gluten washer, with the Gluten Index centrifuge (source: Perten Instruments AB)

12.6.3 Determining the Sedimentation Value

Method No.	Description
ICC Standard No. 116/1	Determination of the sedimentation value (according to Zeleny) as an approximate measure of baking quality
AACC Method 56-60	Identical (for flour)
AACC Method 56-61A	Identical (for wheat)

The swelling properties of wheat flours are tested by determining the sedimentation value (sedimentation means the sinking of a solid in a liquid). Since gluten is insoluble in water and comes from the floury kernel of the grain, the method measures the volume of the swollen gluten proteins. On the one hand this volume of sediment (settled solids in a liquid) shows the amount of gluten, and on the other it reflects the swelling properties of the gluten. Since the gluten-forming proteins of the wheat differ in their ability to bind water, the sedimentation volume is not solely a function of the quantity of protein. The sedimentation value combines qualitative and quantitative elements of the measurement of the wheat gluten.

To carry out the test, small quantities of wheat flour (3.2 g, with 14% moisture content) are placed in a sedimentation cylinder with 50 mL of bromophenol blue solution (sedimentation solution I) and shaken first by hand for 5 s and then with the mechanical shaker for 5 minutes. After this, 25 mL of sedimentation solution II (lactic acid and isopropyl alcohol with distilled water) are added and the constituents mixed intensively for a further five minutes in the shaking device. The sedimentation cylinder is left to stand without moving on a level tabletop for another five minutes, then the amount of sediment is read off exactly at the end of the time.
The sedimentation value is stated in millilitres. It has proved possible to predict the resting time of the dough, its gas retention capacity and the volume yield of the baked products by the sedimentation value. The more millilitres of sediment that can be read off the measuring cylinder, the more suitable is the flour for making bakery products that require strong-protein flours.

German Wheat Quality Groups:
In the descriptive lists of varieties of the Bundessortenamt (the German agency responsible for the protection of new plant varieties) the wheat varieties are assigned to baking quality groups. Besides the volume yield, which is the most important attribute, the Falling Number, sedimentation value, dough properties and milling properties are rated. Wheat with the highest volume yield (for buns and toast) is classified as "elite" ("E" wheat). The baked volume of "A" wheat is only slightly less. "B" wheat is quite suitable for ordinary breads, and "K" wheat with a low protein content is used for making biscuits. "C" wheat should not be used for baking or for pasta production, since it is very difficult to process mechanically.

Determination of the sedimentation value is carried out according to ICC Standard 116. The result may lie between 8 mL for an extremely low protein content and 78 mL for a flour with very strong gluten.

12.7 Methods for Testing the Quality of Wheat Gluten

As we already mentioned in connection with the sedimentation value, the quality of the wheat gluten is extremely important. Since it is a genetic attribute, it is given great attention in the breeding of new varieties. The quality of the gluten is the basis for assigning the wheat varieties to quality groups.
For investigating the dough properties dependent on the gluten it has become usual to employ methods that show water absorption and mixing stability and also record the extensibility of the dough. The changes to the dough during fermentation and baking can also be detected with special instruments. Suitable devices for this purpose are the Maturograph and the Oven Rise Recorder.

12.7.1 Determining Water Absorption and the Mixing Behaviour of Wheat Doughs with the Farinograph

Method No.	Description
ICC Standard No. 115/1	Measurement of quality and processing characteristics of wheat flour (Brabender OHG). Measurement of the water absorption of the flour. Determination of the mixing behaviour of the dough - Dough development time (min) - Stability (min) - Dough softening (FU[14])
AACC Method 54-21	Identical

In the Farinograph (Fig. 45) a dough is prepared under standardized conditions from 50 or 300 g of flour, depending on the size of the mixer. While the dough is being made up, its resistance to the mixing paddles is measured and recorded continuously. In order to achieve uniform dough properties it is first necessary to measure the water absorption of the dough. To do this, water is added to the flour, which has a moisture content of 14%, from a burette until the dough reaches a consistency of 500 FU. This amount of water is a measure of the water absorption of the flour, since a consistency of 500 FU corresponds to the average firmness of a dough. It is often necessary to make several attempts to determine the amount of water needed, as it is rarely possible to add the liquid to the mixer so quickly the first time that no dough softening occurs.

Once the amount of water has been determined, another dough is made from the same flour by adding all the necessary water at once. This dough is then mixed for 12 min. On the graph paper or the VDU[15] there appears a mixing curve from which it is possible to read off the development time, the stability and the softening of the dough.

These Farinograph data can be used for preparing the dough. The water absorption – largely dependent on the quality of the gluten – indicates the dough yield; the dough development time permits conclusions on the speed of swelling; the fall in consistency (degree of softening) shows whether the flour is strong (slight fall) or weak. The Farinogram curves are characteristic of the gluten properties of a flour.

Fig. 45: Farinograph - E (source: Brabender OHG)

Farinogram curves with a broad band (bandwidth) and only a slight fall over the mixing time indicate elastic doughs that do not become weaker even when exposed to intensive mechanical stress. These flours are most suitable for bread rolls and toast slices. In flours with very strong gluten the consistency may even be found to increase during mixing. Subsequent swelling of the gluten causes the dough to become firmer. Narrow curves with very obvious dough softening result from weak flours (flours with weak gluten), which should preferably be used for making biscuits.

Testing of wheat flours with the Farinograph conforms to ICC Standard No. 115/1. Since there are other methods of evaluating the curves (e.g. according to Brabender), the method used should be stated. Simple adaptation of the equipment and connection to a personal computer with the appropriate software makes it possible to evaluate and store the

[14] FU = *Farinograph Units; also referred to as Brabender Units (BU)*

[15] VDU = *Visual display unit*

measurements electronically. With the addition of a printer, the software can produce a complete report on the results if required.
The water absorption for certain standard baking tests is also determined in the Farinograph. For the baking test for white pan bread the measurement used should be 350 FU, for the Rapid Mix Test and the wholemeal wheat baking test it should be 500 FU. The Farinograph can also be used for standardizing rye doughs. The dough consistency for the sour dough baking test with rye flours should be 300 FU. The dough for measuring stretching properties with the Extensograph is also prepared in the Farinograph.

12.7.2 Determining the Stretching Properties of Wheat Doughs with the Extensograph

Method No.	Description
ICC Standard No. 114/1	Measurement of quality and processing characteristics of wheat flour (Brabender OHG). Determination of the stretching properties of the dough. - Area (energy, cm^2) - Resistance to extension (EU[16]) - Extensibility (cm)
AACC Method 54-10	Identical

The Extensograph (Fig. 46) has proved to be a useful instrument for determining the stretching properties of wheat flour doughs. To do this a dough is made up of flour, water and salt under standard conditions in the Farinograph and rolled out in the rounder and shaping unit. After 45, 90 and 135 min the piece of dough held by clips is pulled by the stretching hook until it ruptures.
The force exerted during stretching and the length of the extension are recorded on graph paper. Both resistance to extension, measured as the force required for stretching, and extensibility (stretching length to rupture) are important variables for assessing wheat flour doughs. The curves of an Extensogram give a

[16] *EU = Extensograph Units; also referred to as Brabender Units (BU)*

Fig. 46: Extensograph (source: Brabender OHG)

clear indication of the results to be expected when the flour tested is baked. If the resistance to extension is low, i.e. the curve is rather flat, the dough has weak characteristics and the baked volume will be small. If the curve of the Extensogram rises steeply and is quite pointed at the top, the dough may be assumed to have short characteristics; such doughs are also said to be "bucky". In this case it is difficult to influence the structure of the dough; the gas formed by the yeast is not sufficient to achieve the necessary leavening. The best Extensograms for making bread and rolls are those with a well-balanced curve. The following curve (Fig. 47) shows an example of a flour that is well suited for the mechanical production of bread.

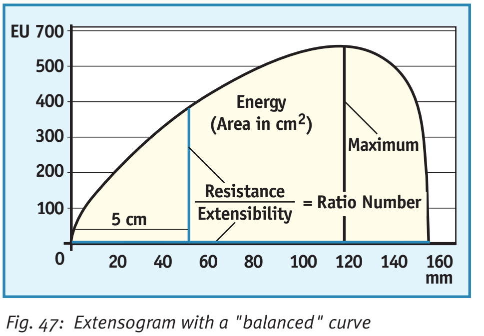

Fig. 47: Extensogram with a "balanced" curve (source: Brabender OHG)

The Extensograph offers a simple method of testing the effect of additives on the properties of the gluten. For example, the amounts of ascorbic acid to be added to improve wheat flour should first be determined in the Extensograph. Too much ascorbic acid results in Extensogram curves characterized by high resistance to extension and rapid rupture of the dough. All substances acting on the gluten (cysteine, cystine, proteinases etc.) can be tested in this way for their effects on the dough made from a flour.

Evaluation of the curve drawn on the graph paper by the plotting device yields a number of measurements. First, the resistance of the dough to extension and its extensibility should be established. Then the area below the curve can be determined as an indicator of fermentation tolerance. The area is stated in cm^2 and referred to as energy. ICC Standard 114 does not provide either for information on the energy or for calculation of the Ratio Number, but this data should always be used for rating flours. The Ratio Number is calculated by dividing resistance by extensibility. The different measuring units are disregarded. High Ratio Numbers indicate a gluten with short dough properties and baked products with a low volume. Flours with Ratio Numbers below 2 are not suitable for making bread rolls.

12.7.3 Determining the Extensibility of Wheat Doughs with the Alveograph

The Alveograph (Fig. 48) is used chiefly in the Mediterranean countries, parts of South America and the former French colonies in Africa for testing the extensibility of dough. The principle is based on an extension test in which a disc of dough in a holder is blown up into a bubble (*alveolus*). The aim is to investigate the stretching properties of the dough up to the point where the bubble bursts. The process of extension and the volume achieved are recorded as a curve from which it is possible to read off the baking properties of the wheat flour. Testing of flour with the Alveograph is described in ICC Standard No. 121.

Method No.	Description
ICC Standard No. 121	Measurement of resistance of the dough to extension and extent to which it can be stretched under the conditions of the method (Chopin Alveograph). - Tenacity (max. pressure reached when blowing the dough piece to rupture) - Extensibility (length of the curve) - Strength of the flour (area of the curve) - Configuration ratio of the curve - P200/P Elasticity (P200 = pressure after 200 mL blowing or 4 cm from origin of the curve)
AACC Method 54-30A	Identical

Fig. 48: Alveograph and Consistograph (source: Mühlenchemie GmbH, Ahrensburg)

12.7.4 Mixograph for Determining the Water Absorption and Mixing Times of Wheat Doughs

Method No.	Description
AACC Method 54-40A	The Mixograph provides a check for uniformity and allows for prediction of baking functionality (National Manufacturing Co.). - Water absorption - Dough tolerance - Gluten strength - Mixing time

In the USA the Mixograph (Fig. 49) is often used for testing the baking properties of wheat flours. In the newly developed computerized Mixograph it is possible to determine the water absorption of flours with as little as 10 g of flour.

The Mixograph curve also reveals the mixing tolerance (MT) of the dough. The dough development time and a fall in the viscosity of the dough can be read off the curve with certainty. As with the Farinograph, the extent of the "tail" of the curve indicates the quality of the flour.

12.7.5 Method for Testing the Aggregation Behaviour of Wheat Gluten for the Production of Wafer Batters

Method No.	Description
	Determination with gluten aggregation test (Brabender OHG)

In the gluten aggregation test (Fig. 50) a slurry of wheat flour is tested for its suitability for making flat wafers. The instrument measures the electric current consumed by the mixer.

For the test a thin wheat flour/water suspension is beaten at high speed. The gluten thus formed increases the shear forces, and this in turn alters the power consumption of the mixer. The aggregation time, recognizable by the time of greatest power consumption, and the aggregation area described by the curve are used in the evaluation, as are the maximum, mean power consumption and the rise in temperature.

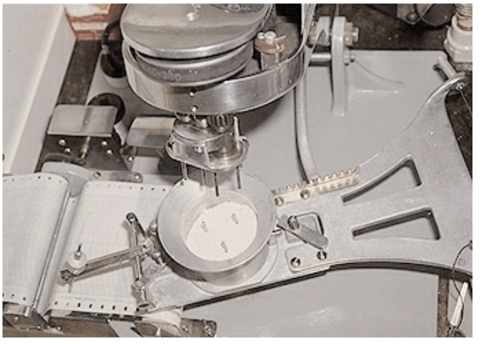

Fig. 49 Mixograph with mechanical plotting of the measurements (source: Oregon State University)

Aggregation times up to 80 s indicate soft gluten structures that go hand in hand with high water absorption and average baking potential. Samples with a higher protein content and corresponding gluten structure formation have aggregation times of about 100 - 250 s. In this case very good baking properties can generally be expected. The flour quality is less suitable if the aggregation times are longer than 300 s.

Fig. 50: Equipment for performing the gluten aggregation test (source: Brabender OHG)

12.8 Equipment for Testing the Fermentation of Doughs (Maturograph) and the Increase in Volume During the Baking Process (Oven Rise Recorder)

The Maturograph (Fig. 51) has shown itself to be a useful instrument for testing doughs in the fermentation phase. The device measures the increase in volume of a piece of dough during proving. The dough ferments in an air-conditioned chamber. An automatic sensor draws the "Maturogram" in the form of a curve throughout the proving time. This makes it possible to read off optimum proving or the final proving time, proving stability, elasticity and the dough level. The proving time for the piece of dough, which is normally determined manually by the baker, can be made more objective by this equipment. The advantage of the device is that a piece of the actual dough with all its ingredients is tested. So the Maturogram can be regarded as a very practical measurement.

The Oven Rise Recorder (Fig. 52) is a very useful instrument for documenting the increase in volume during baking. The dough is heated in an oil bath from approximately 30 °C to 100 °C at the core. The resulting curve shows the rise of the dough during heating. The diagram yields information on the development of dough volume, the baked volume, the increase during heating and the times at which gas escapes.

Fig. 51: Maturograph for measuring dough stability during proving (source: Brabender OHG)

Fig. 52: Oven Rise Recorder for measuring the increase in the volume of dough pieces during the baking process (source: Brabender OHG)

12.9 Baking Tests to Determine Baking Properties

All the procedures described so far are termed indirect methods of testing flours made from bread cereals. But only baking tests that show the complex interaction of all the ingredients give real information on baking characteristics. Carefully conducted baking tests are the only reliable way to predict the properties of the dough and the baked products. Like the indirect methods, the baking tests should be standardized, i.e. human influence on the results should be excluded as far as possible. But standardization also means that the conditions under which the tests are carried out must be reproducible, so that the result is the same if the same flour sample is used again.
As long as these requirements are met it does not matter whether a baking test for flour is carried out as suggested in the standard methods or whether a special baking procedure is used to reflect the conditions at a particular plant. The main criterion is that it must be possible to describe the properties of the flour.
The structure of the baking test must be suitable for the raw material and reflect the usual production process. In the case of wheat flours the mixing system used in production must also be taken into account. For rye flours the company's own sour dough should be used. Only then is it possible to assess the quality of the flour accurately and make any changes to the process to compensate for changes in the raw materials.

12.9.1 Baking Tests to Determine the Quality of Wheat Flours

A method permitting comparability throughout the world is the baking test with wheat flour described in ICC Standard 131. For the European region the baking tests for pan bread and rolls and the test using wholemeal flours for pan bread have proved very satisfactory. The following section describes examples from Germany that can be modified for specific applications in other countries.

12.9.2 Standard Baking Test for Pan Bread Made with Wheat Flours of the German Classified Types

This baking test is suitable for all wheat flours of the types classified according to their ash content. The method reveals the baking properties of the flours from the point of view of bread-making. The results yield information on the baked volume that can be achieved, the texture, and the characteristics of the crumb. To permit comparability the score can be calculated.

Even more than with the indirect methods, it is important to check the raw materials and mechanical equipment before the baking test is performed to ensure that it takes place under standardized conditions.

Before the dough is prepared, the moisture content of the flour must be determined, the weight corrected to a level of 14% and the water absorption determined in the

Farinograph at 350 FU. The amount of water determined in this way, 3% fresh yeast and 1.2% salt are made up into a dough with 500 g of flour in a laboratory mixer (arm mixer), taking the dough development time shown in the Farinogram into account. After a resting time of 30 min and 60 min the dough is worked with 15 strokes of the mixer in each case. When the fermentation gases have been expelled for the second time, the dough is divided into two pieces of equal weight. This results in dough pieces that contain 250 g of flour each.

After being made into a round shape in the ball homogenizer the dough pieces are put in a special container to prove. The proving time is determined on the basis of the baker's experience. The first piece of dough is placed in the oven with the container when the normal level of proving has been reached. The second piece of dough is used to ascertain the effects of over-proving, so the fermentation time is extended by 20%. After baking for 30 min at 240 °C, the loaves are brushed with water and stored in such a way that they cannot dry out. The evaluation is made after 15 to 24 hours (Association of Cereal Research, 1994).

12.9.3 Standard Baking Test for Bread Rolls Made with Wheat Flour Type 550 – Rapid Mix Test

Bread rolls are made almost exclusively from wheat flour of the type 550. The Rapid Mix Test (RMT) was developed to establish the suitability of flours of this type for making bread rolls. The name is derived from the quick method of mixing and making the baked product. The principle of the method is to have as many activities as possible performed by machines in order to limit human influence on the results.
Using a portion of wheat flour of the type 550 corrected in weight to a moisture content of 14% a Farinogram is made in which the water absorption is determined at a consistency of 500 FU. The flour must previously have been adjusted to a Falling Number of 250 ±25 s by adding malt flour. No malt flour is added to flours with high enzyme activity (Falling Numbers below 200 s).

The dough is prepared from 1,000 g of flour with 5% yeast, 1.5% salt, 1% each of sugar and peanut fat and 0.002% ascorbic acid (only if the flour is untreated). The temperature of the dough should be between 26 and 27 °C. The calculation of the water temperature should be based on the sum of the flour and room temperature. The water temperature is the difference between this sum and key figures stated in the comprehensive instructions for the test. The temperature of the mixing bowl should be adjusted before the dough is prepared. The doughs are made up in a rapid mixer with a special mixing paddle. The mixing time is only 1 min; after 20 s the sides of the bowl should be scraped.

When performing the test it must be ensured that the dough pieces are placed in the oven no more than one hour after mixing is finished, so the dough has to be kneaded and shaped within the resting times. The dough pieces are divided and rolled into balls in the divider. The elongated shape is produced by a moulder after brief intermediate proving. The machine settings are prescribed.

The rolled dough portions are placed on tilting trays with the open side downwards and set in a precisely adjusted fermentation cabinet for 25 min to prove. Before baking, the dough portions should be left to stiffen for 2 min at room temperature, exposed to a fan. They are then baked at 250 °C in a deck oven with the open side upwards. The baking time is 20 min.

12.9.4 Standard Baking Test for Pan Bread Made with Wholemeal Wheat Flour

To test wholemeal flours a baking test can be used in which the consistency of the dough is set at 500 FU (14% moisture content). The doughs are made from 600 g of flour in a laboratory mixer. 10% of the flour is soured in a one-stage sour-dough process. To prepare the dough, ascorbic acid (60 mL of a 0.1% solution) is added besides sugar, fat, salt and yeast (1.5% each).

The mixing time is based on the dough development time determined in the Farinograph.

After a resting time of 30 min the whole of the dough is put in a rectangular loaf tin, then placed in the oven after the appropriate proving time. The oven temperature should be 210 °C. Evaluation is carried out 15 to 20 hours after baking. The rating criteria are much the same as those for the pan-loaf baking test with classified white flours.

12.10 Baking Tests to Determine the Quality Attributes of Rye Flours

The following baking tests are not as widely used as those for wheat flours, since the indirect methods yield more information on the baking properties of rye than is the case with wheat. Nevertheless, baking tests are performed with and without acid, using classified rye flour and wholemeal rye flour.

12.10.1 Baking Tests for Hearth Bread Made from Classified Rye Flours

This standard baking test can be carried out with yeast, lactic acid or sour dough. In all three cases the rye loaves are made as hearth bread. The yeast baking test can provide information on the baking properties of the rye flours without the effect of acidification. If lactic acid is added, the rating is carried out at slight acidification. Product quality at optimum acidification can be ascertained in the baking test with sour dough.

For both doughs, 1,000 g of rye flour, 1% yeast and 1.5% salt are placed in the laboratory mixer (arm mixer). In these tests, too, the amount of flour naturally has to be adjusted in accordance with the moisture content. In the lactic acid baking test, lactic acid is added too. The temperature of the dough should be adjusted to 29 °C; the prescribed mixing time is a total of 3 min. This is followed by a resting time of 30 min. The dough weight used is the whole of the dough; proving takes place in fermentation baskets. Readiness for the oven is a matter of experience; baking starts at a temperature of 250 °C, falling to 200 °C. But with these small amounts of dough the temperature of the oven is unlikely to change much, so at the end of the baking time a lower temperature can also be achieved by moving the dough portions into a different part of the oven.

For the test with sour dough the dough yield is determined with the Farinograph at 300 FU. The sour used is a "Berlin short sour dough" with 20% starter, a dough yield of 190, a temperature of 35 °C and a maturing time of 3.5 hours. If these parameters are adhered to, this one-stage sour dough process is just as reproducible as the Detmold one-stage process. 45% of the flour should be soured. The remaining procedure is no different from that of the yeast or lactic acid baking test, but the pH and degree of acidity of the sour dough, the bread dough and the bread crumb should be ascertained (Association of Cereal Research, 1994).

12.10.2 Baking Test for a Pan Loaf Made from Wholemeal Rye Flour

For this test the wholemeal rye flour is baked into a pan loaf as in the sour dough baking test. The dough yield is set at 180. The oven temperature should be adjusted to a constant 210 °C. The evaluation criteria are the same again.

12.11 References

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