Wheat and flour testing

nabim

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Introduction

Millers produce flour from wheat. In the United Kingdom millers classify wheat into four groups that broadly describe the purposes for which it can be used. Groups 1 & 2 contain wheats that are suitable for bread making, group 3 contains those that are suitable for biscuit and cake making as well as other none yeasted products and group 4 contains those that are mainly used for animal feed. However, some in this latter group have characteristics that allow them to be blended into mixes suitable for general milling use. These listings of the wheat groups are described in the **nabim** 'Wheat Guide' (http://www.nabim.co.uk) that is revised annually.

The flour milling industry works closely with plant breeders, agronomists, farmers and bakers to ensure that wheat breeding and agronomy continue to produce crops that are suitable for milling and baking. Each year, members of the **nabim** Varieties Working Group test the candidate varieties of wheat that are being assessed as part of the National and Recommended List process.

In order to understand the characteristics of individual wheat varieties, flours or doughs, millers carry out a range of tests. These are used throughout the industry and act as comparative performance standards. Most millers now use near infrared (NIR) spectrometers for many of the tests that they perform. These instruments are then calibrated to the appropriate reference method. A number of 'ring checks' take place between mills and reference laboratories to ensure that similar measurements are being made across the sector.

This leaflet explains the tests that are used and how the results are interpreted. It has been written for plant breeders, farmers, merchants, users of flour and anyone who wishes to understand the testing of wheat and flour.

Grain sampling

The first step in any testing regime is to obtain a representative sample. A recognised sampling system should be used to produce samples that are as representative as possible. Sampling on-farm may be difficult unless samples are taken and aggregated from each trailer as grain is discharged into the store or dryer. The AHDB Grain Sampling Guide provides more details of optimum sampling procedures. The ISO method (24333:2009) is the reference but may not be applicable to all situations.

A spear sampling probe at intake

Grain is sampled at mill intakes by the use of pneumatic probes that collect a minimum of 8 samples per 29 tonne bulk or 3 samples for vehicles of 15 tonnes or less. The probe collects grain as it withdraws from the bulk in order to sample the entire depth of the load. Each probe sample is aggregated and sometimes sub-sampled before testing.

Wheat testing

Flour millers test grain arriving at the mill intake and they may also undertake 'due diligence' testing later in the milling process. At intake, testing is mainly used to determine whether the wheat is the specified variety or Group, levels of screenings, admixture or other physical or biological contaminants, moisture, specific weight, protein quantity, protein quality and alpha-amylase content. In some seasons, all intake wheat will be examined for mycotoxins.

All **nabim** member companies operate intake procedures that conform to the **nabim** recommended code of practice for flour mill intake.

Visual assessment

Wheat samples are visually examined to determine the soundness of the grain, the presence of broken, diseased, shrivelled grains and the presence of insects or ergot sclerotia. First, the wheat is inspected on a white inspection tray. If the load is contaminated, affected by disease, ergot or contains live pests it will be rejected by the mill. A second test is conducted to quantify the level of impurities or screenings in the sample. This assessment is made by using slotted sieves, a mechanical sifter and visual appraisal of the sieved fractions. The level of admixture is assessed and expressed as a percentage of the unclean wheat. The usual maximum acceptable level of impurities in home-grown wheat is 2.0%, but levels of other contaminants and infestations are more tightly controlled.

Variety identification

It is important for millers to be certain of the wheat variety that they have bought. At intake, wheat variety is checked by visual techniques. But the definitive reference method is an electrophoresis technique where an electrical charge is applied to a gel or chip to which wheat proteins have been applied, causing the proteins to separate. The proteins appear as peaks on a spectrum, or as bands on a gel, and each variety gives a different pattern. This technique can be used to identify the constituent wheat varieties in grists or where millers suspect that a parcel of grain actually contains several different varieties. Mills usually reject grain where there are more than 1 in 50 grains that are not the specified variety.

Specific weight

This is a measurement of the weight of a known volume of wheat and can be used as an indication of wheat quality. A low specific weight can indicate grains that are poorly filled, shrivelled, very large, slightly curved or where a large quantity of dust / chaff is present. It may also indicate high moisture content. Wheat with a low specific weight generally results in a low flour extraction rate and unsatisfactory flour colour. A high specific weight can suggest that the grain is well filled, or of a low moisture content.

To determine the specific weight, a fixed volume of wheat is weighed and the specific weight (in kilograms per hectolitre) is automatically displayed on the balance. The specific weight for UK wheat is usually in the range 74 – 85kg/hl. European bread wheat is usually 75 – 83kg/hl and the North American types are between 80 – 85kg/hl.

A chondrometer for measuring specific weight

Protein

The amount of protein in wheat determines how flour performs. It is also used for a trading specification. The wheat protein is quoted at 100% dry matter and most laboratories will test it using a near infrared (NIR) spectrometer calibrated against the reference method. In the reference method, a ground sample of wheat is burnt in oxygen at 950°C and the gases produced are analysed for their nitrogen content. The protein is the percentage of that nitrogen gas multiplied by 5.7. Millers typically look for a 13.0% minimum protein for bread wheat, whereas for biscuit wheat, a typical level is 11.0 - 11.5%. In the UK, France and Germany protein levels in wheat are normally between 10 - 15% whereas levels in North America are usually 15.5 - 17.5%.

Infratec Nova NIR wholegrain analyser © Foss

Gluten Washing: Protein quality is determined by washing out the gluten. Protein quality also determines the suitability of wheat for use in bread making, biscuit making, or to show whether the wheat has been heat-damaged. A sample of sieved flour from ground wheat is mixed with water and made into a dough ball, which is then kneaded for 15 minutes under a steady stream of water. The starch is washed out and the colour and texture of the gluten (protein) ball are assessed. Some millers use a Glutomatic machine which mixes the flour with a saline solution.

Glutomatic Gluten Washing Machine
© Calibre Control International Ltd

Gluten from biscuit wheat is very extensible and has little elasticity, while bread making wheat is elastic and extensible with a creamy colour and smooth appearance. The protein ball from wheat that is too 'strong' is tough and irregular in appearance. That from partially heat-damaged wheat is incohesive with a dark colour, whereas if the grain is totally heat damaged the gluten would all wash away

Hagberg Falling Number (HFN)

The Hagberg Falling Number (HFN) gives an indication of the cereal alpha-amylase activity in ground wheat and flour.

High natural alpha-amylase activity, can lead to problems of sticky dough and, in bread processing, gumming up of the mechanical slicers. A low HFN indicates high alpha-

amylase activity. Very low HFNs are often associated with significant rainfall during harvest where the grains have started to germinate in the ear.

To assess HFN, a slurry of ground wheat is heated in a boiling water bath whilst being stirred. The time taken for stirring and for the stirrer to fall a certain distance through the gelatinised slurry is then measured and is called the Hagberg Falling Number. This is expressed in seconds. The specification of a bread making wheat is a minimum HFN of 250 seconds.

In flour, a low reading of 62 seconds suggests excessive alpha-amylase activity and is normally found with sprouted grain. Most white and wholemeal flours have HFNs in the range 200 - 350 seconds. HFN may also be predicted using some types of NIR equipment but wheat would never be rejected on an NIR prediction.

Grain hardness

The SKCS (Single Kernel Characterisation System) differentiates between hard and soft wheats and gives an indication of their likely milling characteristics. An SKCS of less than 10 indicates very soft milling wheat. Results of 40 - 46 would be intermediate between soft and hard milling types and values above 46 are termed hard. Most laboratories use a NIR instrument, calibrated to an SKCS system. Biscuit wheat needs to be soft milling (SKCS typically 10 - 45), whereas bread wheat should be hard milling (SKCS typically 50 - 80).

In the SKCS technique a rotating pick-up wheel takes wheat kernels through the instrument. The weight, diameter, moisture and force required to crush each grain is measured. The hardness of the sample is calculated from the readings taken from 300 individual grains and the result is quoted in arbitrary hardness units.

Moisture

The moisture content of wheat can affect its suitability for storage and influence the milling properties when processed. At intake, moisture is measured by NIR but in the reference method a sample of wheat is ground and heated for two hours at a temperature between 130 and 133°C and the weight loss is calculated into a percentage as moisture. Typical acceptable grain moisture content for North American wheat is 11 - 14 %, while UK, French and German wheats are normally 13 - 15%.

Mycotoxin testing

Mycotoxins are toxic chemicals produced by several species of fungi that grow on wheat in the field or during storage. Mycotoxins can damage human health in a variety of ways and statutory limits have been set for levels of several mycotoxins in wheat and the products made from it, including flour, for deoxynivalenol (DON), zearalenone (ZEA) and ochratoxin A (OTA). All wheat being offered into the human food chain must have levels of the important mycotoxins that are below the statutory limits.

A Charm mycotoxin tester
© Calibre Control International Ltd

There is significant annual variation in the levels of DON and ZON and there can also be variation in levels within a bulk of grain. It is for these reasons that millers require DON (and sometimes ZON) counts from every load of grain being delivered. Testing is carried out by the supply chain using rapid diagnostic kits often based on ELISA (Enzyme-linked immuno-absorbent assay) technology. Sometimes follow-up testing is carried out using accredited confirmatory methods. Millers also test their flours and bran for the presence of mycotoxins as part of their 'due diligence' procedures to ensure food safety.

Flour testing

Flour millers undertake routine testing of the flours which they produce to monitor physical and chemical qualities but most importantly the functionality for the relevant application.

Flour types

By blending together different flour streams, a miller can tailor performance characteristics of the finished flour and features such as colour.

White flour: Also known as 'straight run' flour incorporating all the flour streams. Bran and germ are removed and the semolina (coarse flour particles) is ground to a fine particle size.

Grain milled into flour © Allied Technical Centre

Divide/Patent flour: Only brighter flour streams are included in the final product, to make very bright white flour. It is sold at a premium because it is more expensive to produce.

Brown flour: Includes most streams and contains about 85% of the original grain (some bran and germ is removed).

Wholemeal flour: Nothing is removed. All streams, bran, germ and flours are blended back together.

Flour colour

The brightness of white flour is important to both millers and their customers. UK millers examine the natural pigmentation of the flour and use a variety of techniques to measure this. Bright white flour is a positive attribute. Yellow is not desirable and grey flour is unacceptable.

Since January 2010 the standard UK colour method has been the tristimulus method. Tristimulus colour measurements are based on the use of spectrophotometers and colorimeters and are widely used for colour measurement in a range of other industries. Tristimulus measurements use three values to describe the full range of colours that can be distinguished by eye and most millers express results as L*-b*. Bran specks can also be measured by image analysis machines such as the Fluoroscan.

Water absorption

This measurement is made so the baker or processor knows how much water can be added to the flour at the mixing stage of dough preparation. Higher water absorption values (typically 58-64% water for white flour as a proportion of flour weight) are required for bread making while lower values (typically <55%) are required for biscuit type flours. Most laboratories assess water absorption using NIR techniques, but also have reference instruments. Flour is mixed in a bowl with specially shaped mixing blades and water is added to form dough of a fixed consistency.

Dough stability

Having determined the water absorption, a second dough is prepared using the same quantity of water, and is left mixing for a prolonged period. Measurements are taken from the resulting mixing curve (Farinogram) which characterise the dough development and stability over time. The shape of the curve gives an indication of the suitability of the flour for its end use. Low stability (stable over a short time) suggests weak gluten quality, whereas high stability (stable over a long time) indicates strong gluten.

Extensograph Resistance & Extensibility

The extensibility of the dough is also an important feature for both bread and biscuit making.

In order to test this, dough prepared using a Farinograph is moulded into a cylinder, clamped into a saddle and allowed to relax. A moving hook then stretches the dough and a force versus distance trace is produced. The force is indicative of the resistance (measured in Brabender Units, BU) and the distance moved (measured in centimetres) is a measure of extensibility. The extensograph of a given flour is used to assess the stretching characteristics of the resultant dough and the shape of the curve is affected by wheat quality.

A low resistance indicates a weak gluten (protein) quality, whereas a high resistance suggests tough or strong gluten. Bread wheats will typically have an Extensograph resistance of 250 - 350BU with extensibility above 17cm. For biscuit wheats the resistance would be between 100 - 250BU with extensibility above 16cm.

Brabender Farinograph
© Calibre Control International Ltd

Brabender Extensograph
© Calibre Control International Ltd

Test Baking

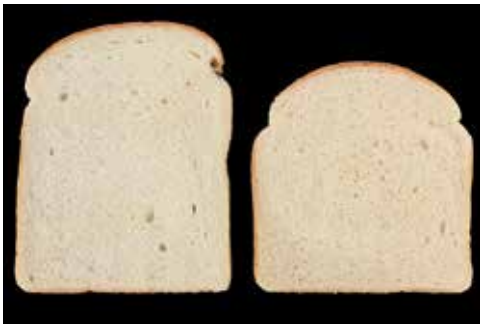
UK millers and bakers use a variety of different test baking procedures to mimic large plant bakeries as well as the small craft bakers. Commonly used tests measure loaf volume, crumb colour, crumb structure and crumb texture.

Loaf volume

Loaf volume is an important feature and can be measured by volume displacement, laser instruments or by ultrasound. The volume of bread is measured when the loaf has cooled down and is at ambient temperature.

Crumb colour

Bakers wish to produce white bread that has a white crumb colour and anything other than white is a negative feature.



Examples of good quality loaf (left), compared with poor quality loaf (right) © Allied Technical Centre

Yellow pigmentation can occur with some wheat varieties, but this is not favoured by either the miller or the baker. Grey crumb colour is unacceptable.

Crumb structure

The structure of the bread needs to be resilient so that when the slice is buttered it does not tear.

Crumb texture

The final bread crumb assessment is the texture. For sliced bread the ideal quality is to have fine, even texture, but more open textures may be desirable for other products.

Reference methods

All testing is undertaken to provide consistent and reliable results. Much testing is undertaken using suitable NIR equipment but these are regularly calibrated and for each test there is a documented reference system. Those commonly used are:

	Reference method
Moisture	Equipment referenced to BS EN ISO 712:2009
Specific weight	BS EN ISO 7971-3:2009 CCAT method 20
Protein	DD CEN ISO/TS 16634-2:2009 CCAT method 19
Hagberg Falling Number	BS EN ISO 3093:2009 CCAT method 06
Detection of ergot sclerotia	CCAT method 30
Gluten	BS EN ISO 21415:2008 CCAT method 13 and CCAT procedure 04p
Grain hardness	NIR calibrated to a SKCS system CCAT method 22
Mycotoxins	No reference method but confirmatory testing using HPLC equipment. Guidelines for rapid tests should be followed.
Screenings & admixture	CCAT method 26

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Cover picture: A Carter-Day dockage tester being used to assess screening levels. © Allied Technical Centre

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