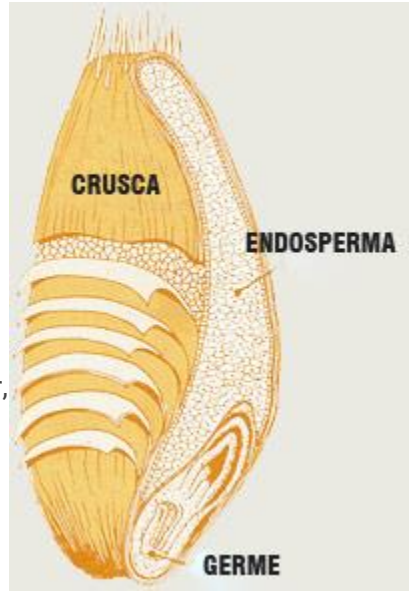
FLOUR & SCIENCE IN THE KITCHEN

The strength of flour

Wheat, or common wheat, (*Triticum aestivum*) is native to the Middle East. Its flour is the basis of many preparations: bread, pizzas, focaccia, cakes, croissants, biscuits, leavened cakes and so on.
The largest producers of soft wheat (source: FAOstat) are China, India, USA and Russia. Italy in 2007 was in 19th place and not being self-sufficient we import 70% of the wheat we consume. We are in second place behind Canada as producers of durum wheat, which we mainly use to produce pasta, but even in this case we are forced to import 40%. The area cultivated with wheat, both hard and soft, in Italy has decreased in the last 20 years

Classification of flours



Here you can see a graphic representation of a grain of wheat or, more precisely, of a *caryopsis*. The outer skin, the *integuments*, constitutes the bran. Then we have the *germ or* embryo and finally the *endosperm*, that is, the part that, containing starch and proteins that form gluten, most interests us. In the production of flour the grain is deprived of the germ and the outer casing. The endosperm is then broken and ground in successive stages to produce a flour of the desired type. Since bran is richer in minerals while endosperm, rich in starch, contains much less, in Italy, the flours on the market are classified according to the mineral content. Or rather, they are classified according to ashes, that is, what remains after burning the flour (minerals and their oxides do not burn). The lower the ash content, the more flour was produced with endosperm alone, and the whiter it is. The "wholemeal" flour will instead have the maximum ash content because the whole grain has been used and will be darker. In the milling industry we talk about *sifting*, that is the percentage of flour extracted from a grain. The "surrender" in short. The analysis of the ashes of a flour is therefore a measure of the sifting obtained. Italian law classifies soft wheat flours into types 00, 0, 1, 2 and whole meal.
Wheat flour is composed mostly of starch (64%-74%) and protein (9%-15%), mainly glutenin and gliadin. These, in contact with water and by mechanical action, bind together and form a protein complex called gluten, creating a kind of elastic mesh. Gluten absorbs one and a half times its

weight in water, and during leavening retains the carbon dioxide developed by the yeast. The relative percentage of gliadins and glutenins determines the properties of the dough: glutenins make it tenacious and elastic while gliadins make it extensible.

Type of Flour	Max humidity	Ashes min	Max ash	Min protein	*Sieving
00	14.50%	–	0.55%	9.00%	50%
0	14.50%	–	0.65%	11.00%	72%
1	14.50%	–	0.80%	12.00%	80%
2	14.50%	–	0.95%	12.50%	85%
Integral	14.50%	1.30%	1.70%	13.00%	100%

* Sieving is the yield of the product of the milling, i.e., the quantity of flour obtained from 100 kg of wheat. The higher the extraction rate, the more fiber the flour contains.

Checking the quality of the flour and its properties during kneading, leavening and baking is not a simple thing. For this purpose, a whole series of chemical and physical measurements are now carried out in the mills to better classify the flours produced.

Look for example at this data of a flour:

Minimum protein: 13%

The determination of the protein content is necessary to distinguish the differences between the various flours and the intended use. The protein content of the flour derives from the quality of the wheat ground to produce it and from the mixtures made. There are low protein values in biscuit flours and high values in flours for leavened products.
Gluten is a protein cross-link that forms during the kneading phase, when liquid ingredients (water, milk, other liquids) are combined with the flour and a force is applied. The thicker and more resistant the grid is, the more it manages to maintain the structure of the dough during the processing phases, expanding under the pressure of the fermentation gases.
The behavior of the dough at all stages of production depends on the quantity and quality of the gluten.

Chopin alveograph: W from 270 to 300

W is an indicator used to classify flours according to their strength. It is obtained thanks to the

analysis made with Chopin's Alveograph instrument on a sample of flour mixed with salt water for a fairly short time.
The greater the W, the stronger the flours. The values vary from 130-150 for weak flours (for biscuits) to 500 for very strong flours, for long-fermentation doughs such as leavened products for special occasions.
Like all the parameters that are obtained from the consistency analysis of the bodies, for a complete judgment, the value of W must be related to the parameters of the other analysis tools: Farinograph, Amylograph and Brabender Extensograph.

P/L from 0.45 to 0.55

The P/L ratio measures the rheological properties of the flour, highlighting its degree of balance, resistance and extensibility.
The P/L index is measured through the analysis made with the Chopin Alveograph instrument on a sample of flour mixed with salt water for a fairly short time.
A P/L ratio = 0.6÷0.7 corresponds to a balanced flour, a P/L ratio > 0.9 corresponds to a resistant flour and a P/L ratio < 0.5 to an extensible one.
For a complete evaluation, this index must be evaluated in relation to data from farinographic, extensographic, gluten and Hagberg index analyses.

Brabender Farinograph: Absorption (A) from 55% to 57% - Stability (CD) from 8-15 minutes

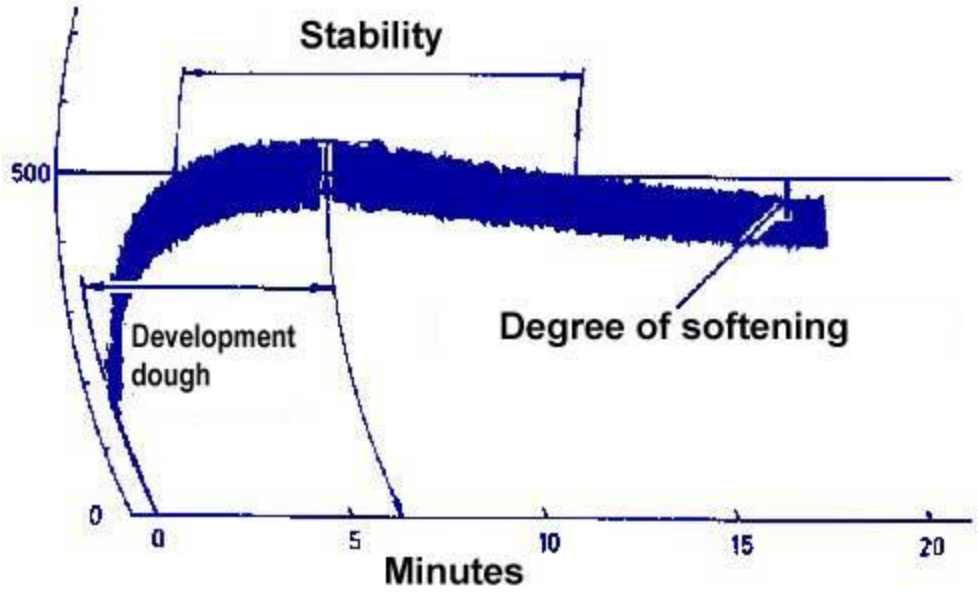
Stability is a parameter that is measured with the Brabender Farinograph instrument and indicates how long the dough can be subjected to mechanical stress without getting damaged. The stronger a flour is, the longer this period is. A short interval (< 10 minutes) indicates the flour is weak, an intermediate interval (14 to 16 minutes) indicates the flour is normal, a long interval (> 20 minutes) indicates the flour is strong. A dough with good stability will be able to withstand more intense processing and longer fermentation.
As for the other analyses, also in this case to have complete information on the characteristics of the flour it is necessary to compare these data with those of the alveographic, extensographic and gluten tests.

What is all that data?

Since the hobby of baking at home is becoming more and more popular, I thought I'd go into a little detail to satisfy the curiosity of us household messy.

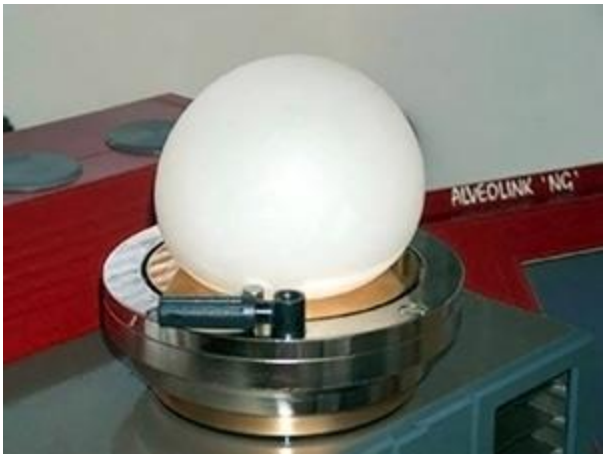
The Farinograph

In the '30s the *Brabender Farinograph* was invented to graphically record, on paper using a mobile nib, the phase of dough flour with water. In the Farinograph the mixture of water and flour is mechanically kneaded and the resistance opposed by the dough is measured as a function of time.



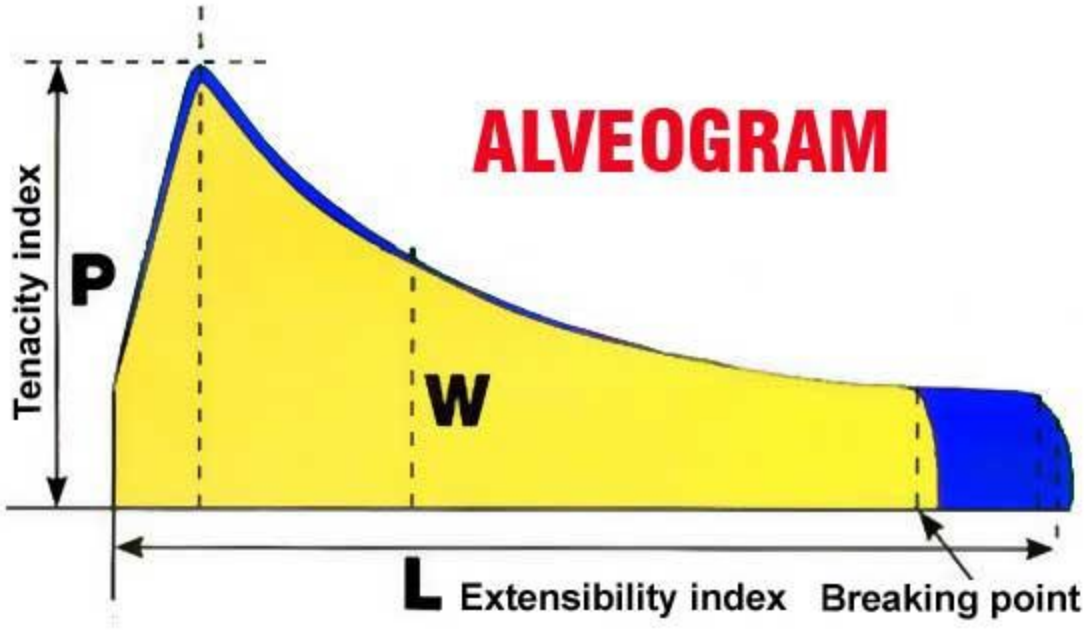
The flour *analysis* obtained is useful for measuring the optimal percentage of water to be added to the flour to have the right consistency, the development time of the dough (let's say the minimum processing time necessary to best develop gluten), its stability (how much processing time it can withstand before starting the softening phase), and the fall index (how long the dough loses its consistency). Low quality flours do not withstand more than 3 minutes of kneading while excellent quality flours can also withstand kneading times of more than 10 minutes. The flour described above in the figure absorbs 55% to 57% of water and has a stability time between 8 and 15 minutes. Longer processing times result in the softening of the dough.

The alveograph



Another device, *Chopin's Alveograph*, invented in 1921 by Marcel Chopin, provides an index that is now commonly used by professional bakers and, lately, also by amateurs: W, often a bit improperly called *flour strength*.
In the alveograph, air is blown into the center of a disc of dough of standard weight and hydration to produce a bubble, in order to simulate the effect of leavening, and measure the ability of the dough to retain the gas. Under the effect of the pressure of the blown air the bubble expands until it breaks.

The result of this test is an *Alveogram*, which shows a graph of the pressure (P) as a function of the extension (L) of the dough bubble.
From the area below the curve you can calculate the total energy spent to break the dough. This energy is indicated with W (it is the symbol of work, so I said that it is a bit improper to call it "force") and represents a global index of flour behavior. Below you see, in yellow and blue, two typical alveograms.



The maximum of the curve identifies P, which represents the toughness of gluten, while L represents extensibility: the higher it is, the more extensible the dough is.

For practical purposes, these two parameters are combined, dividing them together, to calculate the P/L index. The reference value is 0.5. A biscuit flour will have a low W and P/L value (e.g. W=100 and P/L = 0.4) while a flour for leavened products will have high W and P/L (e.g. W=350 and P/L=0.6). A P/L value that is too high indicates a flour that is too resistant and not very extensible, difficult to process. On the contrary, a P/L that is too low indicates a flour that is not very resistant and too extensible.

The strength of the flour

Flours with W between 90 and 160 are called 'weak/medium flours'. They have a low protein content, usually 9-10%, and are used to make dry biscuits or biscuits. Flours with W between 160 and 250 have an average strength. They are used, for example, for Apulian bread or French bread, for direct dough or short leavening, for pizzas and focaccias.
In general, the more a product requires long leavening, the more a flour with a high W is needed, in order to better retain the carbon dioxide produced in fermentation. Gluten is able to absorb water for

one and a half times its weight, so the stronger the flour, the higher its hydration. It goes from a hydration of less than 50% for biscuit flours up to values above 70% for strong flours.

Flours with a high W are called "Extra strong flours" because they oppose a great resistance to the deformation of gluten. With W between 250 and 310 you get processed breads such as biove or baguettes. W values between 330 and 400 are used for particular breads or long-rising products such as panettone, brioches and croissants. There are also flours with W values above 400, called *Manitoba* because they originate from that region of Canada. They are called *Manitoba* even though the corresponding wheat is now also cultivated in Europe. They have a high protein content and are often used in mixture with weaker flours to increase their strength.

Unfortunately, the W values of a flour, available on bags for professional use and on the websites of the mills, are not reported in the packages for home use, and we must be satisfied with the protein content: roughly the more proteins are present the stronger the flour, with the same type of flour (00, 0 etc. ...). Whole wheat flour contains more protein, coming from the germ and bran, however they are not all proteins that produce gluten. This is why baking with whole meal flour is more complicated.

Wanting to prepare biscuits we must prevent gluten from forming, so we must use weak flours, low protein and very extensible. Some preparations have very low percentages of protein, around 7%, and that is why the flour (whose protein content is at least 9% by law) is mixed with starch and the product sold as a "preparation for cakes and desserts".

For leavened products instead we need strong flours. The stronger a flour, the longer the leavening, and remember that the final volume of the product is related to the protein content of the flour.

Below you can see a rough summary table:

FLOUR TYPE	FLOUR STRENGTH W	PROTEIN PER 100g.	P/L*	FLOUR HYDRATION %	USE
Weak	90/130	9/10	0.4/0.5	50%	Direct dough biscuits.
Medium	130/170	10/10.5	0.4/0.5	52/55%	Grissini, Crackers

Medium / Strong	180/220	11/11.5	0.45	55/65%	Common bread, ciabatta, direct dough, sandwich bread, pizzas, focaccias, rusks.
Strong	230/260	12/12.5	0.45/0.5	65/75%	Baguette bread. common with direct dough, Maggiolini, ciabatta with direct dough and biga of 5/6 hours.
Extra Strong	270/320	13/13.5	0.55	65/75%	Processed bread, leavened pastry with 15-hour biga and direct dough.
Special	330/400	13.5/16	0.55/0.6	Up to 90%	Puffed bread, pandoro, panettone, long-fermented leavened products, pastries leavened with biga over 15 hours, bread for hamburgers.

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For a complete evaluation, this index must be evaluated in relation to data from farinographic, extensographic, gluten and Hagberg index analyses.

There are other parameters to consider when talking about soft wheat flour, and we have not even started talking about yeasts, starch, enzymes and the cooking phase, but I think that for now it can be enough.

Good baking