# Agitation and Mixing

## Special case of kneading bread dough

The first phase of the bread production process is the dough mixing. These are the rheological characteristics of the dough, obtained during this phase, which largely determine the structure of the crump in terms of form and dimensions of gas bubbles in the dough.
Dough mixing has the objective of mixing water, flour and other ingredients by providing a certain amount of energy.
During mixing, a portion of the amount of water binds to flour starch and its proteins, while the remaining quantity of water is used to dissolve other ingredients such as salt and sugar.

Mixing guarantees three important functions:

- Mixing of different ingredients into a homogeneous dough
  - Water plays a predominant role; that of achieving the enzymatic reactions allowing the transformation of flour starch into compound sugar (maltose) and simple sugar (glucose). It also helps to dissolve the salt and dilute the yeast by creating the favorable environment to the dough proofing changes...
- Development of the glutinous network
  - Water is also involved in the agglomeration, softening and extension of certain proteins contained in the flour and insoluble in water. It is these gliadins and glutenins which form a more or less soft and elastic substance: the gluten. Enough hydrated, the gluten gives the dough its impermeability and its rheological properties.
- The air imprisonment in the dough
  - The stretching of the gluten network creates a fiber which will become stronger through the incorporation and the imprisonment of air bubbles. The dough becomes smooth, elastic and uniform and its bleaching is proportional to the duration and intensity of the mixing.

These functions are performed by two successive phases:

1. Mixing: which promotes the absorption of starch and gluten by casting water
2. The stretching and blowing: which promote the structuring of the dough through the reinforcement of its glutinous network

These 2 phases may be interrupted by a stage called of autolysis, a phenomenon of relaxation of the glutinous network under the natural action of enzymes contained in the dough.

The basic characteristics of the flour used, the recommended method of bread-making, the amount of mixed dough and its desired consistency affect the mode and duration of its mixing. Hence, we talk (1) of low speed mixing, (2) of improved mixing and (3) of intensified mixing and all of this is for dough that can be (i) firm (hydration < 60%), (ii) hybrid (hydration from 60 to 64%), (iii) soft (hydration > 64%), or (iv) liquid (hydration close to 100%).

### The Dough Temperature

The dough temperature control is of great importance for the bread-making process and must be undertaken since the phase of mixing. In fact, in order for the fermentation to develop in a satisfactory manner and for being able to manage the development, it is required to have a dough temperature after mixing that is in general comprised between 20° and 26°C.

The final temperature of the dough is based on the temperature of raw materials, of room temperature, of the mixing method and of the type of mixer used (more particularly of the heat generated by the mechanical frictions caused by the mixing movements).
We often play on the casting water temperature, the easiest temperature to adjust among the influential factors, in order to monitor to the maximum the final temperature of the dough. This temperature is often calculated empirically by simple formulas such as:

$$3 \times T_{dough}^{\circ C} - T_{flour}^{\circ C} - T_{room}^{\circ C} = 3 \times T_{water}^{\circ C} \text{ or:}$$

$$T_{room}^{\circ C} + T_{flour}^{\circ C} + T_{water}^{\circ C} = T_{base}^{\circ C}$$

### Characterization of the dough

1. Sensory Methods :

The baker uses sensory methods for gauge the dough quality after mixing, preferring his own tactile and visual experience for judging:

- the smoothing,
- the extensibility,
- the elasticity,
- the consistence,
- the slackening,
- the stickiness,
- the color of his dough.

They are indeed such sensory criteria which were selected by AFNOR to classify different types of flour at the discretion of their baking value.

2. Experimental Methods:

Another classification, called indirect, consists of estimating the same baking value depending on biochemical and rheological experimental measurements:

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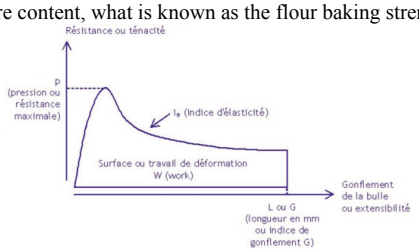
- Rates of proteins in the flour and gluten dosing
  A minimal threshold of proteins is required in the flour to ensure the formation and stability of a good glutinous network. If it is possible to set a minimal threshold, below which we cannot obtain satisfactory results, it is difficult to determine an optimal value of protein levels, the latter depending on the intensity and the speed of mixing as well as the style of bread-making.
  The mix of proteins is obtained quantitatively by the chemical method of Kjeldhal.

- Water absorption by the gluten
  A method, based on the absorption of water by the gluten and its swelling in the presence of lactic acid, allows judging the quality of glutinous proteins. This measurement is done by settling a given quantity of flour in a diluted solution of lactic acid (Index of Zeleny)

- Amylase Activity
  This activity corresponds to the capacity of an enzyme, the amylase, to degrade the starch into simple elements or compound sugar. Such a strong activity is often linked to poor climatic conditions before and during the harvest of wheat and its conservation conditions after harvest. At an advanced stage of such deterioration, the flour is no more suitable for bread making or gives rise to defects such as sticky dough or excessive reddening of the crust of bread. By contrast a defect of the amylase activity leads to a lack of fermentative activity. This activity is assessed by two methods: the Hagberg falling number and Brabender amylograph.

- Rheological characteristics
  Devices like the alveograph have been developed to measure the extensibility of dough. These measures allow obtaining, for a mixing time and a given moisture content, what is known as the flour baking strength (or index W)




  The W is fairly well correlated with the amount of gluten, and should be neither too strong nor too weak (typically between 180 and 220) for flour destined to the bakery.
  The power opposed by the mixer dough when mixing is also a value allowing the classification of flour. The Brabender farinograph is a recording mixer that can measure the mechanical torque generated by the dough on the mixing tool that allows assessing its evolution and more particularly its period of stability and the intensity of its weakening over time.
  Other recent studies have been conducted by different laboratories (including the INRA Biopolymer Unit) to better define the rheological properties of flour during their mixing, especially in performing tests on major distortions to measure the viscosity of wheat flour dough. These tests have shown the rheofluidifying character of non-yeasted bread dough.

***To Learn More:***

*Literature*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- *Le Goût du Pain – Professeur Raymond Calvel (Editions Jerome Villette)*
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- *Le Compagnon Boulanger – Jean-Marie Viard (Editions Jerome Villette)*
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*Web*


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