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Essential Steps of Bread making Process Due to Relevant Rheological Parameters of the Raw Material

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ABSTRACT

The objective of this work was to establish a relationship between the raw material rheological properties and the key steps of the bread making process. Glucose oxidase was added to the biological material in order to improve its rheological properties. The main steps such as mixing, kneading, fermentation and baking of bread making process and the raw material rheological properties are reviewed. The most commonly used rheological variables and their relationship with the final product quality are reviewed. It is shown that the most commonly used steps of bread making are generally mixing, kneading, fermentation and baking processes. The mixing process generated the choice of key ingredients qualityfor the dough formulation and constitution. The kneading steps depend on time, temperature, pressure and the process intensity. The dynamic shear properties (G', G''and tan α) are source of dough viscoelasticity properties. The consistency and resistance of dough for deformation and compression are shown as indicators of final dough quality. The "consistency index" (K), "flow behaviour index" (n) and strain hardening property (m) are thus performed as quality variables. The gas bubbles development and retention during fermentation process, permits to expect and understand the consistency, resistance, strength, extensibility of dough to deformation and their impact on final products. The reliability properties of bread such as rising volume, density, strength, flavor and extensibility to deformation were determined as indicator of firmness and freshness properties. However, these properties depend largely on the dough consistency, flow and strain hardening behaviors.

Key words*: Rheological Properties, Raw Material, Essential Steps, Bread making Process.*

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INTRODUCTION

Rheology is the study of the flow and deformation of materials. Rheology, as a branch of physics, studies the deformation and flow of matter in response to an applied stress or strain[1]. Rheological principles and theory can be used as an aid in process control and design. They are as a tool in the simulation and prediction of the material response to the complex flows and deformation conditions. They are often found in practical processing situations which can be inaccessible to normal rheological measurement[2]. The Raw material's Rheological study can give an indication of material parameters such as stiffness, modulus, viscosity, hardness, freshness, firmness, strength or toughness of the material. The general aims of rheological measurements areto obtain a quantitative description of the materials mechanical properties, to obtain information related to the molecular structure and composition of the material, to characterize and simulate the material performance during processing and for quality control[3].

Bread making is the process of the manufacture of the bread. Bread is a leavened food produced via fermentation of flour starch involving chemical and physical interactions of various food ingredients. All of the processes which have evolved for the manufacture of bread have a single, common aim, namely to convert wheat flour into an aerated and palatable food[1,2]. In achieving this conversion there are a number of largely common steps which are used: (i) the mixing ingredients in appropriate ratios, (ii) the development of a gluten structure (hydrated proteins) in the dough, (iii) the incorporation of air bubbles within the dough during mixing, (iv) the continued "development" of the gluten structure created as the result of kneading, (v) the creation or modification of particular flavor compounds in the dough, (vi) the subdivision of the dough mass into unit pieces, (vii) a preliminary modification of the shape of the divided dough pieces, (viii) a short delay in processing to modify further the physical and rheological properties of the dough pieces, (ix) the shaping of the dough pieces to achieve their required configurations, (x) the fermentation and expansion of the shaped dough pieces during proof and (xi) further expansion of the dough pieces and fixation of the final bread structure during baking[3]. However, for the study of the raw material rheological properties, the main differences between individual or groups of bread making processes can be regrouped in mixing, kneading, fermentation and baking as key steps of the process.

Wheat flour dough rheological properties assessment is essential for bread making technology. It gives valuable information regarding the quality of the wheat flour and the finished bakery products. Dough rheological properties describe its behavior during bread making technological process[1,2]. During the formation and processing of dough and its transformation to bread, large physical, chemical and biochemical changes, take place on its micro structural level[4,5]. These changes can have significant effects on the mach inability of the dough and the quality of the final product.

The microstructure of flour is continuously modifying during bread making process until, in the final bread, the structure was fixed. Rheological properties of wheat bread dough are largely governed by gluten. Gluten, the protein phase of wheat flour, also has the ability to form a continuous macromolecular network. This dependence source of bread dough on gluten and its possible interaction to other proteins, lead to its rheological properties difficult for interpretation[6]. The bread dough proteins oxidation induces the formation of proteins network and improves the bread structural properties. Enzymes are used in bread making to optimize bread dough properties and improve bread quality. The use of enzymes instead of chemical oxidants is a very interesting option to improve bread making performance, because they are perceived as natural and non-toxic food components. Enzymes are specific biological catalysts able to react under mild conditions of temperature (T°C) and potential of hydrogen (pH). They contribute to the formation of covalent bonds between polypeptide chains within proteins (intramolecular crosslinks) or between proteins (intermolecular crosslinks)[7].

Glucose Oxidase (GOX) (EC 1.1.3.4) from *Aspergillus niger* catalyzes the oxidation of β-D glucose to gluconic acid and hydrogen peroxide. GOX is an enzyme with oxidizing effect due to the hydrogen peroxide released from its catalytic reaction. This reaction is the mechanism by which GOX improves bread quality. Wikström and Eliasson[8] indicate that hydrogen peroxide produced during GOX reaction causes the oxidation of the free sulfhydryl units. It gives disulfide linkages and the gelation of water soluble pentosanes. These proteins reactions change wheat bread dough rheological properties. They observed an increase in bread tenacity and extensibility upon GOX addition.

Knowledge of flour dough rheology and its evolution during various stages of bread making can help to improve its performance processes and thus final bread quality. The objective of this study was to establish an accurate relationship between different steps of bread making process at some keys steps for the study of the raw material rheological properties. Whatever the type of methods used the raw material rheological properties obtained at each main step of bread making process were then reviewed. It is believed that from this approach further insight into the rheological properties of the raw material at the key steps of bread making process will be gained. It would lead to a better understanding of the performance of bread making under the raw material rheology study during the various processes encountered in the modern commercial bakery to ensure the quality of end products.

MATERIALS AND METHODS

Ingredients for bread dough

All-purpose wheat flour (type 55) variety “Apache” obtained from Group Soufflet was used without any chemical or proteins supplementation. It contained 12.3 wt % water, 11.6 wt % protein and 0.58 wt % ash (moist basis). It was particularly intended for baking products. It was stored in a freezer at −20°C for 7 days and then at 4°C for 1 to 3 days before using. Basic dough formula (flour basis) consisted of 2.0 wt % salt, 1.62 wt % glucose, 51.96 wt % added water, 5 nkatal/g of GOX (only for dough with GOX. It could be used 48 hours after preparation) and 3 wt % yeast (it was used up to 96 hours after preparation and only for dough fermentation). The ingredients were weighed and placed in sealed boxes in a refrigerator at 4°C during the night before the test.

Kneading Products

Mixing ingredients, kneading dough and manufacture

The Brabender Farinograph (Brabender-USA) was used to mix ingredients and to knead the dough. It has a capacity of 300 g flour (450-500 g dough).

For the kneading process, we have used a quantity of 200g flour, the maximum water absorption capacity indicated by the Brabender device and 85% of humidity (ambient conditions). The water temperature was 4±0.2°C in order to have correlation with the water recirculated temperature in the Farinograph system.

The kneading time was 5.8 minutes necessary to obtain bread dough with a high quality[9]. A dough at 41.3 wt % water (total water moist basis) was obtained at the end of the kneading process. It was then left to rest for 5 min at 25°C tightly closed in the storage system of Chopin Alveograph to allow the relaxation of induced stresses during kneading process. The manual laminating system of the Chopin Alveograph was used under lubricated conditions to prepare samples of thicknesses L_0= 08± 0.15 mm by manual rolling (8 round trips). A disk was then cut with a circular punch (diameter 32 mm) to obtain samples for rheological tests with an initial aspect ratio $2R_0/L_0$ of 4. Paraffin oil (η = 0.15 Pa.s) was used as a lubricant before mixing ingredients and during dough manufacture. It was satisfied the conditions of Secor *et al.*[10] and Macosko[11] considering wheat flour dough viscous properties.

Dynamic shear properties

Bread dough flowand dynamicshear properties were measured with astress-controlled rheometer Carrimed CSL[2] 100 (TA Instrument, New Castle, United States).

A truncated cone was used to eliminate unwanted phenomena that may occur near the tip of the cone and facilitate its setting. The bread dough was prevented from drying during the test using a solvent trap and a chamber saturated by water vapor of the rheometer system. The equipment control and initial data handling were performed using TA instruments Rheology Solution software version V123u. Sample dough was placed on the lower plate. It was then moved towards to the upper plate in order to obtain a setup of 2 mm gap. The sample dough was then in contact with the upper plate and the excess dough around of both plates was carefully cut. The sample dough was then left 5 min before measurement to allow the relaxation of induced stress during the establishment process.

All oscillatory tests were performed at 25°C, a constant frequency of 1 rad.s^{-1}, and a stress range from 0.5 to100 Pa[12,13].

Lubricated squeezing flow (LSF) experiments

In order to ensure reliable results, two rheometers, MCR301 (Physica-Anton Paar, Austria) and CT3 Texture Analyzer (Brookfield Engineering Laboratories, Inc. USA) have been used to the lubricated squeezing flow experiments[14].

Test performed by rheometer MCR301 (Physica-Anton Paar, Austria)

LSF experiments have been performed with a rheometer MCR301 (Physica-Anton Paar, Austria) using paraffin oil (η = 0.15 Pa.s). A stainless steel upper plate (50 mm diameter) and a Teflon Peltier down plate (100 mm diameter) were used. After resting time (30 min) at 18-20°C in the Chopin Alveograph chamber, the bread dough sample disk was placed on the lubricated Peltier plate of the MCR 301. The lubricated upper plate was then placed in contact with the surface of the disk at a contact force no greater than 0.1 Newton (N) but allowing contact between the upper plate and the entire surface of the lubricated dough disk. This sample was then left to rest for 5 min to allow the relaxation of induced stresses until the normal force was less than 0.01 N.

When starting the LSF experiment, even at very small compression speeds, the normal force increases from the beginning of the experiment without any change of curvature that may indicate a change of contact surface. Thus, it was considered that the sample was totally in contact with both plates. Constant plate speed (CPS) tests were carried out up to 2.4 mm dough final thickness at different speeds, *v*, from 0.005→1.5 mm.s^{-1}, allowing to provide concrete rheological properties such as consistency, hardness, behavior, apparent viscosity, stress, strain and strain rate of the bread dough sample. Constant biaxial extension rates ($\dot{\varepsilon}_b$) from 0.005→1.5 s^{-1} were obtained by varying *L(t)* (the lubricated upper plate displacement)following this equation[15]:

$$L(t) = L_0 \exp(-2\dot{\varepsilon}_b t) \qquad (1)$$

where L_0 is the initial sample thickness.

Under both driving modes, the resulting normal force, *F*, was measured every 0.015 s. The *L(t)–F(t)*files were generated by a data-processing interface (*F(t)* is the normal force). All tests were performed at a temperature of 25°C. After completion of the test, when the upper plate was raised, no dough remained on it, and the thin dough film did not present any holes or discontinuities.

Under various experimental conditions, it was observed that the dough disks retained a circular shape and displayed rapid strain recovery indicating that extension was, at least in part, reversible.

Test Performed by Rheometer CT3 Texture Analyzer (Brookfield Engineering Laboratories, Inc. USA)

Dough freshness and hardness properties were determined by CT3 Texture Analyzer (10 kg load cell). Texture Pro CTV1.5 Software were usingfor equipment control and initial data handling. The maximum force of the first compression cycle was also used. A cylinder probe TA4/1000 of 38.1mm diameter was attached to a moving cross-head. The bread dough samples were subjected to compression under the following conditions: 1 mm.s^{-1} constant cross-head speed, 5g trigger load and 70% maximum deformation in lubricated conditions. Paraffin oil (η = 0.15 Pa.s) was used satisfy the conditions described by Secor *et al.*[10] and Macosko[11].

Data Processing

Lubricated squeezing flow (LSF) experiments on wheat flour dough have been performed in constant plate speed mode. During wheat dough compression, all calculations start with strain and stress values depending of the force applied and the dough sizes. At constant crosshead speed mode, and considering dough as an incompressible material, the biaxial strain could be defined by Chatrei *et al.*[16]:

$\varepsilon_b = 1/2.Ln\ (L_0/L(t))$ (2)

where L_0 and $L(t)$ are the initial sample thickness and its value at time t, respectively. The 1/2 factor is added to take into account the biaxial character of the deformation. The biaxial extension rate is:

$\dot{\varepsilon}_b = -1/2.[dL(t)/L(t).dt]$ (3)

The corresponding biaxial stress is then:

$\sigma_b = F(t)/S(t) = F(t)/\pi.R^2(t)$ (4)

where $F(t)$, $S(t)$ and $R(t)$ are the measured normal force, the dough disk area and its radius, respectively. The initial dough disk radius used during the present study was much smaller than those of the upper and lower plates of the instrument. The values of the deformation (i.e., stress and strain rate) obtained were used versus dough strain to determine its apparent viscosity. Therefore, if the dough was considered as incompressible, Eq. (4) becomes:

$\sigma = F(t).L(t)/\pi.R^2_0.L_0$ (5)

where R_0 is the initial dough disk radius. The apparent biaxial viscosity is given by:

$\eta_{app} = \sigma_b/\dot{\varepsilon}_b$ (6)

An empirical analysis of the data obtained on wheat flour dough and gluten using a mechanical testing machine at a constant crosshead speed and with plate radius equal to the dough disk radius ($R(t) = R_0$) was developed by Van Vliet's group[17,18]. The force, $F(t)$ and displacement, $L(t)$ curves at various crosshead speeds (v) were converted into stress–strain curves using Eq. (2) and Eq. (4). At a given value of v, there was a simultaneous increase in σ_b and $\dot{\varepsilon}_b$. The group of Van Vliet observed that, at any fixed value of ε_b, a power-law could be seen between σ_b (orη_b) and $\dot{\varepsilon}_b$. For a fixed value of $\dot{\varepsilon}_b$, σ_b increases exponentially with ε_b. The following relationship could then be written[13]:

$Ln\ \sigma b = A + nLn\dot{\varepsilon}_b + m\varepsilon_b$ (7)

where A, n and m are constant to be adjusted to experimental data. It should be noted that, under experimental conditions, m only remains constant in a limited strain domain. Then for any given ε_b, Eq. (7) corresponds to a power law, where A is equal to log K, K being the "consistency index". When n <1 is obtained, i.e. η_b decreased and $\dot{\varepsilon}_b$ increased. This case corresponds to a strain rate thinning behavior for a purely viscous extensional flow ("flow behavior index"), and m >0 [19,20]. Factor m in Eq. (7) was interpreted by Van Vliet's group as a "strain hardening" parameter. Van Vliet *et al.*[17] proposed that, in the context of biaxial extension, no necking will occur if these conditions are applied to the results obtained in LSF. In this case, the parameter m became:

$m = dLn\sigma_b/d\varepsilon_b > 2$ (8)

When ensuring LSF at a constant crosshead plate speed, the biaxial strain rate, biaxial strain and resulting stress vary throughout the test[13]. An increase in the biaxial deformation rate during squeezing should induce a continuous increase in stress. However, the "strain hardening" parameter m, continues to be a subject of research, interpretation and discussion. It is also of considerable interest when it is related with dough behavior during proofing and oven-rising. Consequently, the data processing to obtain the dough rheological properties remains long and difficult, being yet of capital interest for scientists.

Fermentation Products

Molding dough

After kneading, 250g of dough were removed. The hands were first cleaned with sample flour in order to minimize stickiness dough on the skin.

The bottom of the mold was covered with greaseproof paper. The edges were lubricated with a thin layer of rapeseed oil (η = 0.16 Pa.s). This oil was used as a lubricant satisfying the conditions of Secor *et al.*[10] and Macosko[11], considering wheat flour dough viscous properties. This lubricant was used in order to restore the entire kneading dough.

Fermentation dough

The molds of the dough were placed in a fermentation oven regulated at 25 °C. Cylindrical tank glass graduated at 1 to 7 cm ensured the bread dough fermentation level control. A cylindrical dough sample of 25 ± 0.5g was placed in the mold tank. The molded dough was fermented for 90 min. This time (90 min) was essential to obtain better fermented dough than those made with a standard 180 min of fermentation[21]. A disc was placed above the sample dough slides during the fermentation. It served as an indicator for the bread dough rising. Measurements data were taken every 10 min. The volume of the rising dough during fermentation was evaluated considering its initial and reached level at the time t (min) by the formula:

$$V_{pi} = \pi R^2 L \quad (9)$$

V_{pi} is the dough volume at the time t (min); R, the radius of the measuring cylindrical tank; L, the dough thickness at the time t (min) and π=3.14, a constant.

Considering that the deformation of the sample dough during the fermentation is uniaxial and its development surface is perfectly horizontal, the deformation is defined by Hencky[22] that:

$$\varepsilon_u = -\ln (L_0/L) \quad (10)$$

ε_u is the uniaxial deformation; L_0 is the initial thickness of the sample dough and L, the thickness at time t.

The sample dough was cylindrical, so the thickness ratio was equal to the ratio of its volumes at time t (min). The deformation of Hencky[22] is then given by:

$$\varepsilon_u = -\ln (V_0/V) \quad (11)$$

V_0 is the initial volume of the sample dough and V, the volume at time t.

In this case, the deformation was followed versus time during the fermentation.

Baking Products

Baking dough

The fermented dough was baked in domestic oven (Henry Simon Limited, Cheshire, UK) during 60 min at 180°C of temperature. The beginning and the end of the process were indicated by a beep sound emitted by the oven temperature regulator system.

Wheat bread and its volume measurement

White loaf bread was obtained at end of the baking process. It was remained 2 hours at 25°C in the storage room 85% of humidity. It was then placed in an airtight plastic bag during 24 hours for its relaxation. Méthodes of colza seeds was used to measure the volume of the bread[23].

The bread rheological properties were performed after this storage period.

Compression bread crumb

Bread freshness and hardness properties were first determined by CT3 Texture Analyzer (10 kg load cell) using Texture Pro CTV1.5 Software (Brookfield Engineering Laboratories, Inc. USA) for equipment control and initial data handling. A cylinder probe TA4/1000 of 38.1mm diameter was attached to a moving cross-head.

A stainless steel knife was used to prepare cylindrical slices bread 25 mm of diameter and 52 mm of thickness. Sample bread was then centered under probe. It was compressed under the following conditions: 1 mm.s^{-1} of constant cross-head speed, 5g of trigger load and 70% of maximum deformation.

A second test was performed by TAXT2i (Stable Microsystems Ltd, Godalming, UK) with a flat stainless steel probe 10 cm of diameter and 25 kg of cell to confirm the CT3 Texture Analyzer results. The Texture Expert Exceed software (version 2.03) was used for the data acquisition and processing.

Cylindrical slices crumb 25 mm of diameter and 52 mm of thicknesses were compressed at 0.33 mm/s of constant cross-head speed to obtain 70% of maximum deformation. The test was taken place immediately after making slices breads in order to avoid samples crumbs drying.

Bread crumb and crust physical properties

The bread crust and crumb were directly observed visually taking into account the color, touch feeling, crust thickness and crumb alveoli width and number.

Samples slices bread were cut in the parallel direction of its lifting into the oven during the baking process in order to preserve and protect their alveolar structure. Samples breads3 mm of thickness were scanned. Picturewastakenwith aflatbed scanner (Epson® Perfection V370 Photo Flatbed Scanner) covered with ablack boxto avoid the influenceof the surrounding light. This device providedgoodcontrast betweenthe black backgroundand the clearbrackets.

The slices breadswerecorrectly positioned in the center of the scanner in order to minimize the variations of resolution during imaging.The images were taken with 4800 x 9600 dpi optical resolution and enlargement up to 13" x 19". These samples were eventually observed visually from (x100) of image scale magnitude. They showed slices crumbs alveolar width and crusts thickness. Slices crumbs and crusts were visualized 24 hours after the baking process in order to have total firmness and freshness concentrations.

Statistical Analysis

All determinations reported in this study were carried out in triplicates. Mean value and standard deviation were calculated. Analysis of variance (ANOVA) and correlations were also performed.

Tukey's Honest Significant Difference (HSD) test at $P < 0.05$ was used for mean values separation. It was made in order to evaluate differences among samples while the relationship between measured parameters was assessed by Pearson's test (significant level at $p \leq 0.05$).

RESULTS AND DISCUSSION

Rheology is the science of flow and deformation of matter and describes the interrelation between force, deformation and time. The rheological property of a food system is dependent on the composition or the ingredients or the type of the material. In order to evaluate the raw material rheological properties as indicators of final product quality, the knowledge of the main steps of bread making process able to provide the essential indicators of quality of the finished product, is indispensable. Figure 1 shows the key steps of bread making process which can perform the raw material main rheological properties essential to predict the quality of the use-end product.

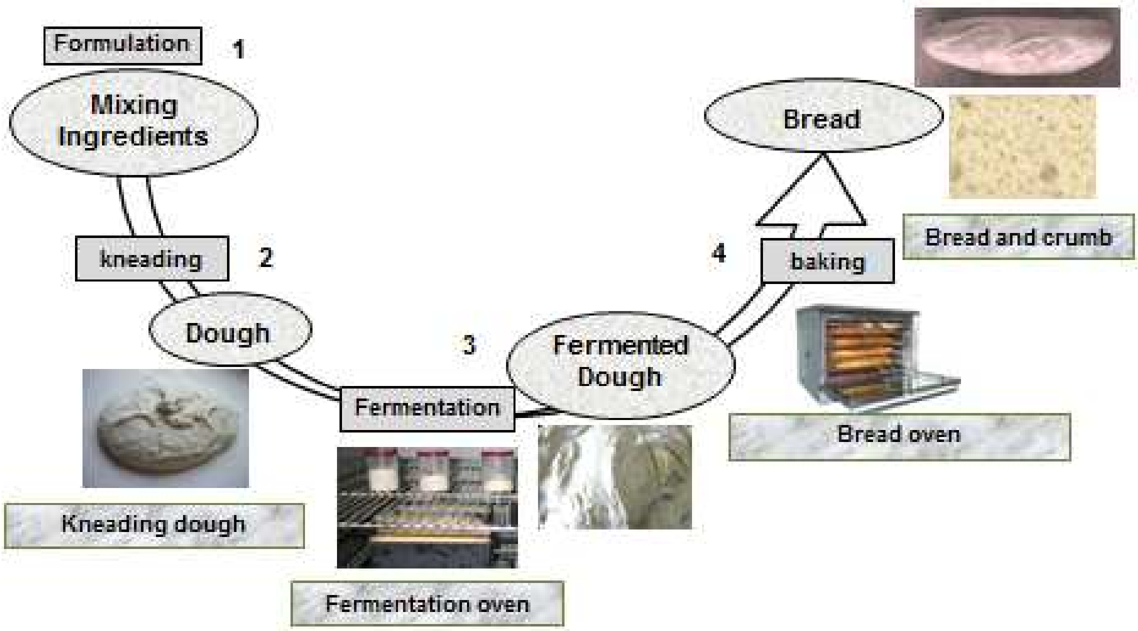

Fig. 1: Essential steps of breadmaking process for the raw material rheological properties study. 1 formulation or mixing ingredients step, 2 kneading step, 3 fermentation step, 4 baking step.

According to Peter et *al.*[24], there are numerous areas where rheological data are needed in the food industry: (i) the process engineering calculations involving a wide range of equipment;(ii) the determining ingredients functionality in product development; (iii) the intermediate or final product quality control; (iv) the characterizing ingredients and final products, as well as for predicting product performance and consumer acceptance; (v) the evaluation of food texture by correlation to sensory data; (vi) the analysis of rheological equations of state or constituent equations and then (vii) the way to predict and control a host of product properties, end use performance and material behavior as well as sensory analysis and quality control of foods. However all those rheological quality control parameters can be found at mixing or formulation, kneading, fermentation and baking processes of bread making technology[9,13,25] (Fig. 1).

Different rheological parameters such as viscosity, plasticity, elasticity, flow behavior, hardening behavior, consistency, resistance, deformation, gas bubble development, gas bubble retention, firmness, freshness, are performed at these four steps of bread making process (Fig. 1). It needs simply the regulation of factors affecting rheological properties such as temperature, shear rate, measuring conditions, time, pressure, previous history, composition and additives.

Mixing or formulation step

Mixing is a critical operation in food processing where, apart from the obvious function of mixing ingredients, the structure of the food is often formed. Figure 2 shows wheat flour's classic bread making mixing of ingredients. This formulation of ingredients in order to obtain bread dough is dependent on the different ingredients in appropriate ratios and their own quality. The mixing step is largely affected by temperature, pressure and time of the process. The mixing process transforms the combination of flour, water, salt, yeast and other ingredients into cohesive viscoelastic dough subjected to fermentation confirmed by Kouassi-Koffi *et al.*[15]. The mixture of flour, water, salt, yeast and other ingredients involves mixing of these ingredients until the flour is converted into a stiff dough. The rheological study will interest to the choice of ingredients, their appropriate ratio and the control of parameters which can affect the quality of the final dough and thus the achievement of the process.

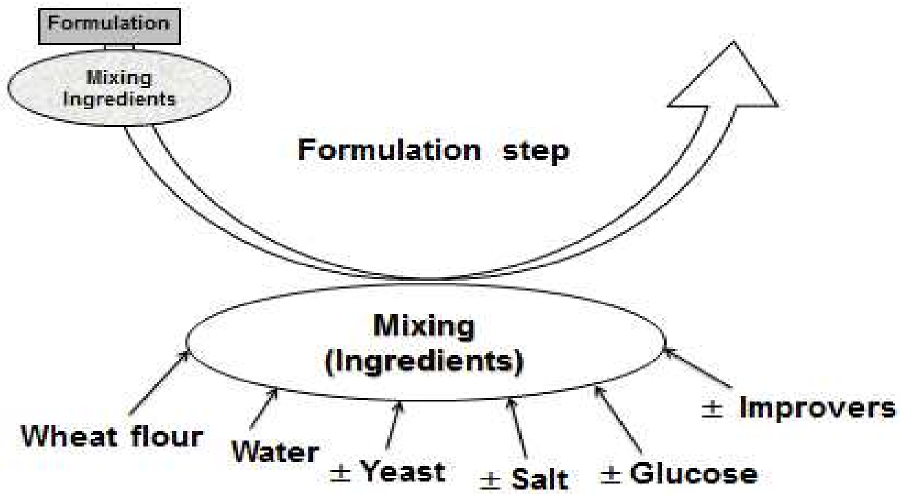

Fig. 2: Mixing step of breadmaking process by formulation of different ingredients

According to Dobraszczyk and Morgenstern[3], the main nature of the mixing action develops the viscoelastic properties of gluten and also incorporates air, which has a major effect on their rheology and texture. However, most of the studies on doughs have been on the relationships between mixing, rheology and bread making performance, because of the rheological changes that occur in the gluten viscoelastic network during mixing and their importance for product quality. Despite the obvious importance of mixing in the development of rheology and texture in doughs, there is very little information in the literature on these changes during the different stages in the mixing process.

Kneading step

Kneading is a process in the making of bread, used to mix the ingredients and add strength to the final product. It develops the gluten by making it stronger and more elastic for better volume and gas retention for a finer grain or texture in breads. However, the kneading dough leads to the development of gluten and helps to uniformly distribute the gases that are produced by the yeast. In this way, the kneading dough is one of the most important products of the bread making process. It is an essential product for fermentation and baking processes accomplishment.

Figure 3 shows the kneading steps of bread making processable to produce relevant results on the rheological properties of the raw material.

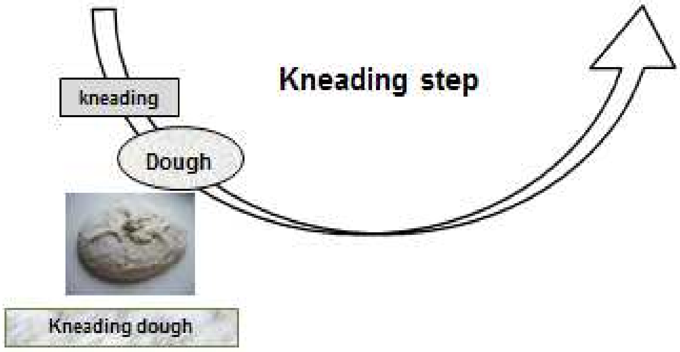

Fig. 3: Kneading step of bread making process

During the kneading process, several phenomena take place such as the continued "development" of the gluten structure created as the result of kneading, in order to modify the rheological properties of the dough and to improve its ability to expand when gas pressures increase because of the generation of carbon dioxide gas in the fermenting dough. They permitted the creation or modification of particular flavor compounds in the dough, the subdivision of the dough mass into unit pieces, a preliminary modification of the shape of the divided dough pieces, a short delay in processing to modify further the physical and rheological properties of the dough pieces and then the shaping of the dough pieces to achieve their required configurations confirmed by Peter *et al.*[24] and Dobraszczyk and Morgenstern[3]. However, from the beginning to the end of the kneading process, several rheological parameters of the dough such as the consistency, viscosity, plasticity, elasticity, flow and hardening behaviors, resistance, deformation are investigated. They are main parameters of dough quality and keys indicators for fermentation and baking processes attainment confirmed by Kouassi-Koffi *et al.*[13,25]. Thus, these relevant rheological parameters of the raw material are dependent on temperature, time and pressure. The kneading process isthat one of the most important steps of bread making process because of its ability to provide dough rheological variables and their impacts on the raw material.

Fermentation step

Fermentation is a metabolic process serving for some microorganisms to get energy through digestion of fermentable sugars, mostly glucose and fructose. Figure 3 shows the step of fermentation of the bread making process.

Fig. 3: Fermentation step of bread making process

The bread dough rheological study interests the bread dough gas retention and development, the time, the pressure and the dough deformation throughout the fermentation process. The rheological study of these parameters on the bread dough during the fermentation process permits to predict the final dough quality for a best quality of the baking product.

In bakery fermentation, the production of carbon dioxide (CO_2) is required as it serves for fluffing up the dough. Thus, the principle of rheological apparatus, used for the evaluation of fermented dough properties during its maturation, is the measurement of gaseous volume or pressure produced confirmed byŠvec and Hrušková[26]. The purpose of fermentation is to bring dough to the optimum condition for baking. The amount of CO_2 depends on yeast and flour properties under standard conditions of the dough preparation. They have thus strong effects on the final product quality confirmed by Bloksma[27]. Thus, at the end of the fermentation, the dough must contain a large volume of gas and sufficient gas retention in reserve for oven rise. They can be occurred in the first period of baking process confirmed by Švec and Hrušková[26].

The expansion and volume of baked products, as a quality attribute to the flour were the result of the gas production and its retention in the dough network film. They depend on dough viscoelastic behavior[28]. In this context, bread dough viscoelasticity or consistency is initially the main characteristic for its mach inability and then its fermentation confirmed by Kouassi-Koffi *et al.*[25]. It regulates the gas retention for making up flour into baking products, the development of a gluten structure (hydrated proteins), the incorporation of air bubbles within the dough and thus the fermentation and expansion of the shaped dough pieces during proof which interest the rheological study.

Baking step

Baking bread is a method of cooking dough using prolonged dry heat in an oven. Bread is a bakery product preferred by some consumers for its flavor, firmness and freshness which are indicators of best quality. In figure 4, the baking step of bread making is presented.

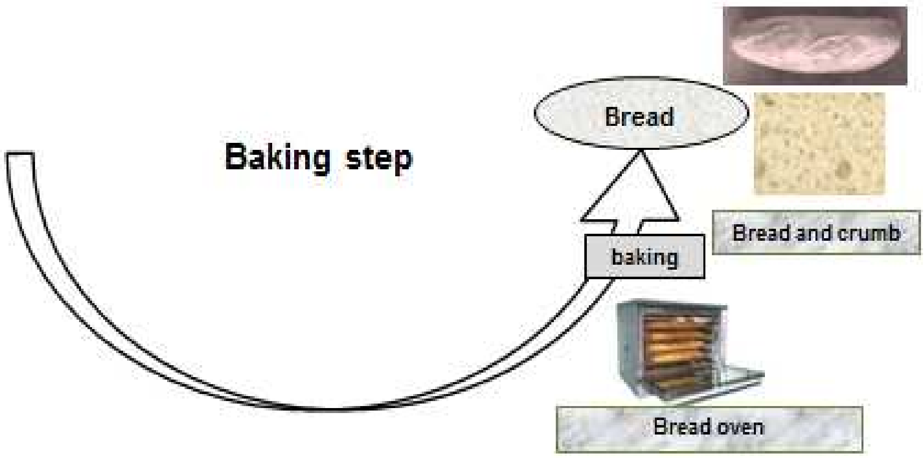

Fig. 4: Baking step of breadmaking process

Indeed, duringthis last step of bread making process, there are formation and expansion of Gases, trapping of gases in air cells, gelatinization of starches, coagulation of proteins, evaporation of some of the water, melting of shortenings and thus crust formation and browning to obtain the final bread. According to Wayne[29], during the formation and processing of wheat bread dough and its transformation to bread, a large number of physical, chemical and biochemical changes on the micro structural level, take place. Those changes can have significant effects on the mach inability of the bread dough and then the quality of the final bread confirmed by Muhammad *et al.*[2]. Bread rheological properties depend essentially on flour, water, temperature and time during baking process. These physical properties are essential for bread making technology and give valuable information such as strength, consistency, resistance, texture and extensibility of the bread[30,1].

The baking process represents a highly complex interaction of physical, chemical and biological processes to obtain bread. Létang *et al.*[31] confirmed that these interactions can be adjusted to create desirable products, once the underlying chemical and physical processes are well understood. During backing, there is the combination of gas production and retention which cause changes in bread dough rheological properties due to the flour proteins reactions[30,32]. The study of wheat bread rheology can provide numerous information about bread dough formulation, structure, texture, processing and then final bread quality confirmed by Nakai *et al.*[33]. According to Peter *et al.*[24], knowledge of the rheological and mechanical properties of various food systems is important in the design of flow processes for quality control, in predicting storage and stability measurements, and in understanding and designing texture.

The rheological characterization of foods provides important information for engineers and food scientists to improve and optimize their products and manufacturing processes. Rheological instrumentation and measurements have become essential tools in the analytical laboratories of food companies for characterizing ingredients and final products, as well as for predicting product performance and consumer acceptance showing that the main importance of the raw material rheological properties determination during the bread making process.

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CONCLUSION

Mixing, kneading, fermentation and baking are the main steps of breadmaking process able to provide adequate rheological variables of the raw material in order to ensure the quality of the future use-end product. In many cases of bread making process, the relationship between product and process is so strong that it may be wrong to consider them as separate issues.

In practice many of the variation in such bread making processes are very small and usually consist of minor variations about a central “standard” process, so that we are able to group many of the variation into a number of more generic processes in order to consider the changes which occur within them and their contribution to final product quality.

All of the process which have evolved for the manufacture of bread have a single, common aim, namely to convert wheat flour into an aerated and palatable food. In achieving this conversion, these key steps of bread making process are a number of largely common processes which are used. Because of this concept the rheology of food product remain complex and difficult subjects for scientific researches.

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