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# Technology Involved in Quality of Biscuits: Influence of Factors and Impact on Processing – A Critical Review

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## ABSTRACT

*Biscuits are convenient food products, becoming very popular among both rural and urban populations of worldwide. Some of the reasons for such wide popularity are low cost among other processed foods, varied taste, easy availability and longer shelf life. This paper presents a review regarding several aspects of the quality and impact of biscuits making until biscuits packaging, mainly from food technologist point of view. During biscuit production, the rheological characteristics of dough, textural properties of biscuits and baking (heat and mass transfer) process may cause the quality. Besides the major influence of this phenomenon on selection of ingredients, equipment usage and monitoring complete processing; it is the responsible for other relevant changes occurring in during biscuit baking. Experimental and mathematical studies on dough mixing, aeration of dough, moisture content, cooling the products, baking oven during baking are also reviewed.*

***Key words:*** *Biscuits, Rheological characters, Textural properties, Baking, Shelf life.*

## INTRODUCTION

Bakery products are one of the most profitable segments in supermarket retailing. The use of frozen dough by retail bakers has advantages and is more convenient. Control over biscuit weight, biscuit dimensions (thickness and to a lesser extent diameter) and biscuit moisture content is vital for the manufacturer. Large variability in biscuit weight and thickness will cause production breakdown problems at the closely tolerance packaging stations and can also result in excessive underweight and overweight packets that violate packaging legislation[21]. Cookies have been suggested as a good way to use composite flours as they are ready-to-eat, provide a good source of energy, and are consumed widely throughout the world[1,7]. The term cookies, or biscuits as they are called in many parts of the world, refers to a baked product generally containing the three major ingredients flour, sugar and fat. These are mixed together with other minor ingredients to form dough[8,25,30]. In the USA, the cookie and cracker manufacturing industry includes about 300 companies with combined annual revenue of about $11 billion[19]. Zucco *et al*[35]., repoted that fine and coarse flour fractions obtained opposite activities for cookie width and thickness.

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**Baking technology**

Bakery industry has seen a revolution over the past 150 years. The small artisan bakeries, which were present in every village, made way for high technological bakery industry. Industrial mono-production took over from the high variety bakeries as bread could be produced in a more efficient way. Productivity became the key of success. Different baking technologies were developed to respond better to new market demands[13]. Continuous improvement in baking technology is worth investigating primarily for better quality product, development of nutritionally superior product and economic consideration. Bakery products differ from other products in that they are leavened or raised to yield baked goods of low density. It is a yeast-raised product. Leavening is done by CO2 produced from yeast fermentation. Leavening is produced only if the gas trapped in a system that will hold it and expand along with it. Therefore, much of baking technology is the engineering of food structures through formation of correct dough and batter to trap leavening gases and the fixing of these structures by the application of heat[2].

**Major ingredients of biscuit dough**

The main sequential operations in the production of plain, round biscuits are ingredient metering, dough mixing, dough sheeting, dough sheet relaxation, biscuit shape forming, biscuit baking, cooling and packaging. Every process step will influence the final biscuit character. Ingredient metering and dough mixing must be carefully controlled. The vital influence on the final product quality includes the rate and amount of heat application, the humidity level in the baking chamber and baking time. During baking, the most apparent interactions are volume expansion, crust formation, enzymatic activities, protein coagulation and partial gelatinization of starch in batter[28]. Biochemical and physico-chemical reactions in biscuit batter during baking are very complex, involving protein denaturation, loss of starch granular structure, fat melting, Maillard and browning reactions, and batter expansion resulted from water evaporation as well as production and thermal expansion of gases. Expansion, a relevant event in texture formation, is determined by the rheological properties of batter, which depend on the behaviour and interactions of its components and the solubility of gas in the continuous phase[9].

Addition of sugar decreased viscosity and relaxation time. It promotes increase in length, and reduced the thickness and weight of the biscuit. Also, sugar-rich biscuits were considered by a highly cohesive structure and crunchiness. Addition of fat softened the dough, and caused a reduction in viscosity and relaxation time, which were characterized by a friable structure easy to break. Water content increase the intake of total specific energy (TSE), to a sharp decrease in dough viscosity and to a slight reduction of relaxation time. The biscuits became longer, with slightly smaller thicknesses. Proteins in the range between 14 and 20% promotes to an increase in the water absorption by the flour, and in the viscosity and relaxation time of the dough. Laguna *et al*[20]., done experiment to replaced 20% part of wheat flour with a resistant starch of functional fiber with potential health benefits; up to this proportion did not affect the dough rheology, while higher quantity gave stiff doughs. Dogan[15], reported sustainable of functional properties, physical properties and shelf life of refrigerated and frozen dough for biscuits. Biscuit dough can be store at 4 °C for 6 weeks and at –18 °C for 6 months. Unique quality differences exist between the two ovens (gas oven & electric oven). Electric oven without air circulation was superior for baking sugar snap cookies and hazelnut biscuits, and the gas oven with air circulation was better for chocolate chip cookies.

In different mixing methods express the CM and the SSM are suitable for the preparation of short dough rotary moulded biscuits, in this method reduces the development of gluten network. BM are less suitable but better than the AOM and the CWFM. The development of dough by the elastic retrieval values following order: CWFM> AOM> BM> SSM or CM. Although, the doughs made from 10.8% flour, the elastic values were higher which reflects the quality of the biscuits and CM produced good quality biscuits with good crispness[26].

Fustier *et al*[18]., were used to study the substitution of commercial soft wheat flour with gluten, water extractable, prime starch and starch tailing fractions isolated from patent and clear flour streams on dough rheology and semisweet biscuits characteristics. In prime starch and the water soluble had minor effects on these properties and undoubtedly, soft wheat dough properties changed largely, that vital relationship between composition and functional behavior. Increasing of starch tailing gave largest influence on consistency and hardness of the dough, whereas lowered crunchiness, apparently higher pentosan. Addition of amount of fraction can be controlled the dough rheological properties and biscuit characteristics; that is also gluten, and pentosans and the complete composition of the flour blend cab largely affect the quality of the semi- sweet biscuits.

**Studies on mixing dough**

Mixing is the key stage in semi-sweet biscuit making. in the case of the French Biscuits Petit- Beurre, energy input during dough mixing were found to control biscuit quality. Specific mechanical energy (SME) onset of 60 kJ/kg beyond which, biscuit length suddenly reduced. During mixing, the SME imparted to the dough is partially converted into heat by frictional forces. The viscous dissipation of SME imparted to the dough. Semisweet biscuit length and thickness are influenced by different mixing variables, respectively identified as dough temperature at the end of mixing ($T_f$) and specific mechanical energy (SME) imparted to dough. The $T_f$ contributed to an increase in the storage modulus (G´) and hence the elastic behavior of dough, whereby dough stickiness and biscuit length decreased. A rise in dough temperature is likely to induce melting of fat crystals. Consequently, interactions between protein chains and fat crystals would be suppressed and dough elasticity increased. Dough density also rose, suggesting that fat crystals stabilized air bubble interfaces in semisweet biscuit doughs, probably according to a mechanism like that demonstrated by Brooker[5] for cake batters. SME imparted to the dough did not affect rheological properties but contributed to greater biscuit thickness, maybe by some physicochemical change in the dough yet to be identified. When SME and $T_f$ are not correlated, biscuit length and thickness appear to be independent quality parameters, so mixing conditions can be selected to control them separately. Conversely, in standard mixing conditions (i.e., for a given temperature of regulation), mixing speed, SME and $T_f$ are strongly correlated. the positive influence of mixing speed on biscuit length was hidden by the rise in dough temperature and not detected in our previous study[10]. The control of $T_f$ (by regulation of the mixing bowl, liquid nitrogen spraying, or preliminary cooling of the ingredients) would successfully shift the relationship between $T_f$ and SME input so the targeted combination of biscuit length and density could be obtained[10].

A sort of dough mixing gives different physical properties also depend upon ingredients which obtained in this study. In preparation of wire- cut cookie doughs, sucrose was fine granulation; for deposit and rotary- molded doughs, powdered sucrose was used. Dough were mixed at 61 rpm for 2,6, or 12 min, representing “under mixed,” “optimal mixed,” and “over mixed” condition, respectively to study the mixing time. Through different mixing and manipulate of fat, sugar, and water in a dough, density, and shortness of cookies. Physical properties can change by machining and handling method; it depends on distribution of fat and water in the system; if increased fat in formulation, decreased the consistency and band width of the dough.If sugar crystals are not coat with fat while mixing, slack, non-cohesive dough is formed. Water content does not impact deposit dough much, because of dominating effect of fat. In in wire- cut dough, water content increased gluten formation. Rotary- molded doughs give curves with reduced consistency as increased water level. Addition of 10 %( by weight) excess water to doughs affected a slackening, due to the formation of syrups[29]

**Aeration of dough**

Edoura-Gaena *et al*[16]., gave The distinctive texture is due to the high whole egg content, the removal of fat and the combination of three means of aeration at different stages of the process: use of chemical raising agents at the formulation stage, whipping or gas injection during the mixing stage and thermal expansion during baking. The final aerated structure and volume of the biscuits depend on both the aerated structure of the batter and the expansion of bubbles during baking. Before heat-setting, each bubble is stabilised by a protein-lipoprotein interface with sufficient surface elasticity to accommodate expansion[14].

If the temperature exceeds 60 ° C, egg proteins start networking and make the mixture much stiffer[22,23]. Incorporation of air causes a declining in batter density and changes in batter viscosity, thus influencing texture and appearance of lady fingers. Thus aeration is considered as a crucial step in lady finger preparation. In the field of aerated products, most studies have required to characterise the effect of ingredients and processing conditions on properties of batters, mainly density, bubble size and textural properties.

The results obtainedin this study could be interpreted on the basis of Foegeding's model[17] has reviewed by Edoura-Gaena *et al*[16].

• For high batter density values the small amount of air in the batter enlarges a lot leading to low values of crumb density, batter at 1 min at all the speed.

• For low batter density values, batter collapses during baking, leading to intermediate crumb density values; batters attained at 250 or 350 rpm.

• For intermediate batter density values, the virtual importance of expanding and collapsing can lead to a broad range of crumb density values; may be related to matrix properties, which are influenced by aeration conditions. The physicochemical processes during baking that can affect gas retention and thus crumb density would require assessing changes in protein structure and interactions between polymers and proteins[16].

The main inclinations for batter properties was OR(over-run) and bubble number increased with duration As concerns the relations between the properties of the batter and the biscuits, indicated significant associations between batter and biscuit texture, between the set of sensory indicators and batter properties. However, no significant link between batter and biscuit aeration was identified

Finally, aeration duration proved to be a critical variable for controlling biscuit and batter properties:

(i) Most of the properties change in the first minutes

(ii) Short durations (<5 min) beneficial biscuit properties are obtained: higher crumb aeration, biscuit development and lower crumb density, and resistance to rupture

**Factor affects physical properties**

Baltsavias *et al*[3], analyzed mechanical properties of short-dough biscuits of several compositions was determined in three-point bending tests. Commonly, decreased fat content increased the absolute value and the fracture stress of biscuits. The relative magnitude of this effect depended on the fat type. Sucrose syrup slightly enhanced the brittle character of biscuits, compared with crystalline sucrose were not the fracture-inducing defects. Replacing starch for part of the flour had relatively little effect on the mechanical properties. Sugar-free biscuits had a significantly lower modulus and fracture stress. It is concluded that biscuits comprise a glassy matrix; their mechanical properties are mainly determined by air and fat volume fraction as well as the size of in-homogeneities in an account for fracture.

Pareyt *et al*[31]., investigated the impact of the oxidant and reducing agents on sugar snap cookies. Low level of redox agents obstructed neither dough nor cookie properties but high levels of reducing agents (10,000 ppm on a flour base) significantly decreased set time, and, hence, cookie diameter. The cookie dough is undeveloped; a protein network is formed over covalent bonding of SH (organosulfur) groups. They also reduced the degree of collapse, which then, obviously, alsoincreased cookie height. Internal cookie structure and intrinsic material properties depend on the occurrence of a (continuous) protein network which, influence cookie breaks strength.

Brosnan & Sun[6] review that evaluated the bakery products by computer vision, it influence of quality attribute, correlating with product flavor and visual perceptions of consumers. Contribution of overall impression of the products quality is through the internal and external appearance. Recently, an experiment represents digital images of chocolate chip cookies were used to evaluate physical properties such as size, shape, baked dough color and fraction of top surface area.

Piston and roller extruders play a dominant role in the baking of cookies and other baked snack goods. Many bakeries use piston type dough depositors that either directly deposits dough into a pan or use a wire to cut a layer of dough to be baked on a cookie sheet. Generally, short dough is used for these types of products to ensure a clean cut. Roller extruders can be smooth and used to make thin sheets that are required to make cracker type products. Here the rollers move back and forth perpendicular to the cookie sheet to layer the cracker dough. The layers are held together with docking pins during baking and are responsible for the holes found in saltines. The thin sheets of dough can also be used to make figure cookies, such as animal crackers, by cutting the dough layers into various shapes and sizes. They can also be perforated to various shapes and sizes to make formed products such as Oreo type cookies. Sugar and shortening are used at lower levels than those for conventional cookies to ensure the dough does not spread while baking and yet the design of the perforated roller is not lost. This leads to a crumbly dough that is just wet enough to work with.

Peck *et al*[32]., gave a description of complex rheological behavior of biscuit doughs like dense solid–liquid pastes investigated using an instrumented counter-rotating roll mill, which allowed the roll torque, separating force and surface pressure to be monitored and two dough quantified by analyzing data from ram extrusion experiments in terms of a quasi-plastic model and a power law fluid model. The doughs were not preferable to the quasi-plastic analysis. The power law parameters differed remarkably between the doughs but both were strongly shear-thinning (power law shear indices of 0.25 and 0.5), with large extensional viscosities. The power law fluid approach based on the lubrication assumption tended to under predict the work requirement due to the significant contribution from extensional deformation. Interestingly, the system could be modeled in terms of an apparent power law rheology by fitting data to Levine’s model. Superioragreement was obtained for some parameters but not reliable so, indicating that the power law approach is not adequate for these soft-solid materials.

Cronin & Preis[12], study the biscuit physical properties affected during baking, based on they conducted comparing dispersion in dough pieces’ weight and thickness of biscuits; disperse in biscuit weight is mainly due to variability in dough piece weight is linked to longitudinal variation in the thickness of the dough sheet from pieces were cut.

**Post cooling the biscuit for secondary processing**

The majority of freshly baked biscuits are cooled before packaging or secondary processing. The normal method of industrial cooling is that at the oven exit, the biscuits are transferred from the oven band to an open conveyor and carried through the factory to cool naturally in ambient air until they are hand-hot or less. In some cases, forced air cooling in cooling tunnels is employed to achieve greater control over biscuit temperature at the end of the cooling process. Typical secondary processing involves the deposition of cream, jam or marshmallow on the biscuit or the enrobing of the biscuit with a chocolate or icing coating. Generally speaking, the biscuit should be as cool as possible prior to such processing. The most important category of these post-cooling operations is the addition of chocolate as a coat. Franke states that the biscuits to be coated should be at a temperature of between 18 and 26℃; biscuits that are too warm will affect the temper of the chocolate and biscuits that are too cool will cause viscosity problems which affect the evenness of coating and perhaps the pickup weight. The thickness of the coating deposited on the biscuit is also sensitive to biscuit temperature and this in turn will influence the optimum subsequent cooling time of the coated biscuit. Franke has also shown that even a relatively small change in initial biscuit temperature (from 22 to 19˚C) produces a higher rate of chocolate crystallisation on the biscuit and ideally should involve an adjustment of the cooling regime. Discussions with the industry suggest that the typical random variability in biscuit surface temperature prior to enrobing should be ± 3˚C at a maximum. The range in biscuit center temperature will be less than this, generally within a band of ±2˚C. Any variations greater than this would have their origin in systematic spatial or temporal effects. As an example of the former, a systematic gradient in biscuit temperature across the conveyor width could be present due to the particular layout or geometry of the cooling system. More important may be temporal variations where deliberate changes in up-stream set-point parameters (such as oven temperature) will produce definite changes in downstream biscuit temperature. Systematic spatial and temporal variations that will occur in biscuit temperature are not the focus of the paper. Deviations from the target value of biscuit temperature at the commencement of the enrobing stage are unwanted, causing problems with respect to product quality and processing costs. However, it is impossible to completely prevent dispersion in this parameter. Given a distribution in the biscuit initial temperature (i.e. biscuit temperature at the exit of the baking oven), variability in biscuit thermal properties (including thermal conductivity, specific heat, density and physical dimensions) and random fluctuations in surface heat transfer coefficients and surrounding cooling medium temperature, there inevitably will be dispersion in the temperature at the end of the cooling process.

Coefficients of variation for the properties lay in a range from 3% to 10%. This dispersion in biscuit thermal properties produces randomness in the biscuit cooling process meaning that biscuit temperature at the end of cooling is subject to a random variability. This in turn has implications for the quality of post-cooling operations on the biscuits. The behavior of biscuits in a laboratory cooler has been experimentally quantified and analyzed with the Monte Carlo method and a theoretical approach. Standard deviation in final biscuit temperature for a variety of cooling schedules was found to be in the region of ± 3.7˚C equivalent to a range in temperature of about ± 8̊ C. The Monte Carlo method gave good predictions for the mean and standard deviation in biscuit temperature for all three schedules. It also captured the actual distribution in biscuit temperature at the termination of cooling quantifying the proportion of biscuits that lay within a given temperature range. Parameter studies with the Monte Carlo model demonstrated that for the system analyzed here dispersion in the specific heat capacity between biscuits was the single greatest cause of dispersion in final biscuit temperature. Variability in biscuit thickness and in the surface heat transfer coefficient was also relatively significant while dispersion in biscuit thermal conductivity, density and initial temperature made little contribution to the random variability in final product temperature. The mathematical approach, based on the theory of functions of random variables, gave very good results in terms of predicting standard deviation in temperature for a previous study using an inert non-food system. However, it does not appear to be as successful for this situation of a food undergoing a thermal process because the underlying physical phenomena are more complex and the actual variability is less easy to precisely define. The methodology outlined here is capable of being applied to industrial use. The industrial biscuit cooling process, particularly forced-air tunnel cooling, will be more uniform (in terms of the variability that occurs in biscuit temperature) than the process studied here though the underlying relationships will be the same. Thus the random component of the distribution in biscuit temperature at the end of the cooling process can be quantified and separated from systematic effect of line variability. Knowing the distribution in temperature and in particular the range in temperature that can be expected (i.e. the hottest and coldest biscuits) will permit downstream processes such as coating and enrobing to be optimized. The influence of different cooling schedules on final temperature variability can be analyzed as an aid in selecting the optimum cooling schedule. The biscuit thermal parameters that make the largest contribution to temperature dispersion can be identified which will allow the most efficient strategy to diminish product temperature variability to be decided upon[11].

**Mathematical modeling of dough and biscuit baking**

Biscuit baking involves temperature, moisture content and moisture diffusion, hygroscope, aeration, and fracture that are strongly integrated. Researchers proposed comprehensive mathematical model with the aim of predicting and therefore controlling the problematic process in dough preparation and baking. However, modeling this process in bakery products is a major challenge, since mixing dough, sheeting, wire-cut or dropping, baking involves complex mechanisms that are still not elucidated, moreover occur in non-ideal system where simultaneous changes in ingredient, temperature and water activity.

Mirade *et al*[27]., studied the prediction of air temperature and velocity profile inside the baking chamber with application of a computational fluid dynamics (CFD) are numerical technique that solve fluid flow problems coupled with heat transfer and turbulence phenomenon. This technique useful for evaluate process of an industrial biscuit baking tunnel oven. They revealed that CFD comparison of numerical results with experimental measurements expressions an equally related agreement in the qualitative prediction and less inaccuracies predicted of the air temperature profiles within the baking chamber.

Thermal conducting model of bakery product has been used as an Artificial neural network(ANN) to determine function product moisture content, temperature and apparent density were used from Sablani *et al*[33]., compare the performance of various ANN configuration were:

$$MAE = \frac{1}{n}\sum_{i=1}^{n}[K_D - K_P\ ]$$

$$MRE = \frac{1}{n}\sum_{i=1}^{n}\frac{K_D - K_P}{K_D}$$

$$SE = \frac{\sqrt{\sum_{i=1}^{n}(K_D - K_p)^2}}{n-1}$$

Where $n$is the number of data points, and $K_D$ and $K_P$ are desired and predicted values of thermal conductivity, respectively. This ANN model comprised of two hidden layers, with six neurons in each hidden layer and values with an MRE of approximately 10% and SE of 0.003 W/m K. One hidden layer and two neurons had a good prediction with an MRE of less than 15%. This model is recommended and used to estimate thermal conductivity of various bakery products. It can easily be incorporated in numerical analysis of heat and moisture transfer while baking described by Sablani *et al*[33].

Certainly, the best approach to model the dough mixing to till baking would be to consider the actual mechanisms of the reaction and transport of heat occurring in products during baking. For instance, the model proposed by Saleem *et al*[34]. studied the material properties for biscuit cracking have been determined for semi-sweet biscuits; relativity moisture contents the diffusion coefficient. Hygroscopic expansion coefficient was determined from the slope of strain vs. moisture content. Mechanical and fracture properties can have done with computer software according to the following expressions[4].

$$\sigma = \frac{3FL}{2bh^2}$$

$$\varphi = \frac{6tY}{L^2}$$

$$E = \frac{L^3 m}{4bh^3}$$

Maache Rezzoug *et al*[24]., determined rheological behavior of the dough by uniaxial compression at crosshead speed of 0.7m/s; physical properties also defined. Maxwell model were used to determine the rheological characteristic of biscuit dough, this law measured stress but this quantity is not directly accessible.it assumed sample volume and perfectly cylindrical shape during deformal surface area is therefore expressed at time *t*by the relation:

$$S(t) = \frac{h_0}{h(t)} S_0$$

The stress- time curves were described Maxwell's convected model:

$$\lambda^2 \dot{T} + 2\lambda \dot{T} + \left[1 - 2\lambda^2 \frac{V_0^2}{h^2}\right] T = 3\eta \frac{V_0}{h}$$

Baltsavias *et al*[3]., discussed several models for ultimate determine the fracture properties and mechanical properties of short-dough biscuits of various composition were in three- point bending tests.

They revealed a material has been proposed by Gibson and Ashby, another model was proposed by Kerner, isotropic and homogeneous composite consisting of homogeneous and isotropic filler particles.

Peck *et al*[32]., expressed the rheological properties of two doughs were quantified by analyzing data from ram extrusion experiments in terms of a quasi-plastic model (following the Benbow- Bridgwater approach) and power law fluid model representing range of shear- thinning or shear- thickening fluids.

The shear stress τ is related to shear strain rate. Biscuit food dough are examples of 'soft-solid', viz. materials that retain a yield stress but are sufficiently soft to be shaped readily. Traditional technique by Benbow & Bridgwater to encounter the problems, method of material characterization via capillary extrusion given by

$$P = 2(\sigma_0 + \alpha V^m) \ln\left(\frac{D_0}{D}\right) + 4(\tau_0 + \beta V^n)\left(\frac{L}{D}\right)$$

Robinowitsch- Mooneyequation for capillary flow of a fluidcan be obtained the shear rate at the wall

$$\dot{\gamma}_w = \frac{3}{4}\dot{\gamma}_{app} + \frac{\tau_w}{4}\frac{d\dot{\gamma}_{app}}{d\tau_w}$$

The apparent shear strain rate given in terms of the volumetric flow rate *Q* and capillary die diameter *D*

$$\dot{\gamma}_{app} = \frac{32Q}{\pi D^3}$$

The shear viscosity component, $P_c$, can be calculated using the following expression,
The first Gibson equations:

$$P_s = \frac{2K(\sin^{3\lambda}\theta)}{3\lambda\theta^{1+3\lambda}}\left(\frac{1+3\lambda}{4\lambda}\right)^{\lambda}\dot{\gamma}_{app}^{\lambda}\left(1 - \left(\frac{D}{D_0}\right)^{3\lambda}\right)$$

The second Gibson equation evaluates this extensional term $P_c$, as

$$P_e = (K_e \dot{\gamma}_{app}^{\Lambda}) \times \frac{2}{3\Lambda}\left(\frac{\sin\theta(1+\cos\theta)}{4}\right)^{\Lambda}\left(1 - \left(\frac{D}{D_0}\right)^{3\Lambda} + \frac{\Phi}{4^{\Lambda}}\right)$$

Where

$$\Phi = \int_0^{\theta} (\sin^{\Lambda+1}\theta)(1+\cos\theta)^{\Lambda-1}\, d\theta$$

The average extensional strain rate for flow into the die land is given by:

$$\bar{\dot{\varepsilon}} = \frac{\dot{\gamma}_{app}\sin\theta(1+\cos\theta)}{4}$$ and $$\bar{\eta}_e = K_e \bar{\dot{\varepsilon}}^{\Lambda-1}$$

The trouto number, $N_{Tr}$, as measure of the ratio between extensional viscosity and shear viscosity and thus a function of strain rate. For uniaxial flow it is conventional to assess the apparent shear viscosity at a strain rate √3 times the extensional strain rate, as follows:

$$N_{\mathrm{Tr}} = \frac{\bar{\eta}_e(\bar{\dot{\varepsilon}})}{\eta(\sqrt{3}\bar{\dot{\varepsilon}})}$$

Another modeling, behavior of dough using - plasticity- based model: Orawan's hot metal rolling model. The mean strain rate given by:

$$\bar{\dot{\varepsilon}} = \frac{1}{L}\frac{4Q}{\pi}\left(\frac{1}{D^2} - \frac{1}{D_0^2}\right)$$

Evaluated for the extrusion geometry, used for characteristics and estimate of deformation zone length of dough is expressed as:

$$P_0 = 2\left(\sigma_0 + \alpha'\left[\frac{V}{D}\right]^n\right)\ln\left(\frac{D_0}{D}\right)$$

Rolled sheet of dough decreased in thickness, reported that the strain rate during rolling expressed as :

$$\dot{\varepsilon} = \frac{2H_0\omega R\sin\phi}{H^2\cos\phi}$$

The mean strain rate for rolling is obtained from:

$$\bar{\dot{\varepsilon}} = \frac{1}{\phi_e - \phi_f}\int_{\phi_f}^{\phi_e} \dot{\varepsilon}\,\mathrm{d}\phi$$

Modified to include strain rate dependency but dough's behaviorcould be effectively described by this model. The power law approach is not adequate for soft- solid materials.

Broyart and Trystram who pointed out that steady- state mathematical to calculate heat and mass transfers during the baking in a continuous, indirect, gas- fired oven. The equation of the model discussed, temperature and composition of the baking atmosphere and biscuit on a transversal oven section are may be uniform. It described heat transfer by radiation, convection and conduction as well as product- water- phase change and, probable condensation of steam from baking atmosphere to surface of biscuit and biscuit drying. It shows an authorized the model and good agreement was found between predicted and measured values were shown**.**

## CONCLUSION

This review studies represents on how ingredients, dough mixing, baking and cooling during biscuit process. It is ultimate for industrialist and food technologist to identify and control the requirements extent in biscuit baking. However, notwithstanding the wealth of knowledge and understanding gained from research into this phenomenon, the exact reason for the baking biscuits between ingredients and mixing methods. Experimental studies were mainly focused on measurements of incorporation of air, heat, moisture, density and cooling at various phases in biscuit baking.

## REFERENCES


1. Arshad, M.U., Anjum, F.M. and Zahoor, T., Nutritional assessment of cookies supplemented with defatted wheat germ. *Food Chemistry*, **102:** 123-128 (2007).
2. Balaji, N., Modelling of transient temperature distribution during bread baking by finite difference analysis. B.Tech Thesis, IIT, Kharagpur, India. (1991).
3. Baltsavias, A., Jurgens, A. and Van Vliet. T. Fracture properties of short-dough biscuits: Effect of composition. *Journal of cereal Science*, **29:** 235- 244 (1999).
4. Benham, P.P. and Crawford, R.J., Mechanics of engineering materials. Essex, England: Longman Scientific & Technical (1987).
5. Brooker, B.E., The stabilisation of air in cake batters. The role of fat. *Food Struct.*, **12:** 285-296 (1993).
6. Brosnan, T. and Sun, D.W., Improving quality inspection of food products by computer vision- a review. *Journal of Food Engineering*, **61:** 3- 16 (2004).

7. Chavan, J.K. and Kadam, S.S., Nutritional enrichment of bakery products by supplementation with nonwheat flours. Critical Reviews in Food Science and Nutrition, **33(3):** 189-226 (1993).
8. Chevallier, S., Colonna, P.A., Della Valle, G. and Lourdin, D., Contribution of major ingredients during baking of biscuit dough systems. *Journal of Cereal Science*, **3:** 241-252 (2000).
9. Chevallier, S., Della Valle, G., Colona, P., Broyart, B., and Trystram, G. Structural and chemical modifications of short batter during baking. *Journal of Cereal Science*, **35:** 1- 10 (2002).
10. Contamine, A.S., Abecassis, J., Morel, M.H., Vergnes, B. and Verel, A., The effect of mixing conditions on the quality of dough and biscuits. *Cereal Chem*., **72:** 516-522 (1995).
11. Corrales, J.C., Cronin, K., Abodayeh, K., Lopez, G.G. and Falomir, C.O., Analysis of random variability in biscuit cooling. *Journal of Food Engineering*, **54:** 147-156 (2002).
12. Cronin, K. and Preis, C., A statistical analysis of biscuit physical properties as affected by baking. *Journal of Food Engineering*, **46:** 217-225 (2000).
13. Decock, P. and Cappelle, S., Bread technology and sourdough technology. Trends in Food Science and Technology, **16(1–3):** 113– 120 (2005).
14. Dickinson, E. and Stainsby, G., Colloids in food. London: Applied Science Publishers.
15. Dogan, I.S., Effect of oven types on the characteristics of biscuits made from refrigerated and frozen doughs. *Food Technol. Biotechnol*., **44(1):** 117–122 (2006).
16. Edoura-Gaena, R.B., Allais, I., Trystram, G. and Gros, J.B., Influence of aeration conditions on physical and sensory properties of aerated cake batter and biscuits. *Journal of Food Engineering*, **79:** 1020–1032 (2007).
17. Foegeding Luck & Davis. Factors determining the physical properties of proteins foams. *Food Hydrocolloids*, **20:** 284–292 (2006).
18. Fustier, P., Castaigne, F., Turgeon, S.L. and Biliaderis, C.G., Impact of endogenous constituents from different flour milling streams on dough rheology and semi-sweet biscuit making potential by partial substitution of a commercial soft wheat flour. LWT - *Food Science and Technology*, 363–371 (2009).
19. Hodgen, D.A., Cookie and cracker manufacturing. United States Department of Commerce/International Trade Administration (2004).
20. Laguna, L., Salvador, A., Sanz, T. and Fiszman, S. M., Performance of a resistant starch rich ingredient in the baking and eating quality of short-dough biscuits. LWT - *Food Science and Technology*, **44:** 737- 746 (2011).
21. Lawson, R., Oven control system to reduce packet weight tolerance in biscuit manufacture. *Baking Industries Journal*, **8:** 7-14 (1975).
22. Lostie, M., Peczalski, R., Andrieu, J. and Laurent, M., Study of sponge cake batter baking process. Part I: Experimental data. *Journal of Food Engineering*, **51(2):** 131–137 (1982).
23. Lostie, M., Peczalski, R., Andrieu, J. and Laurent, M., Study of sponge cake batter baking process. Part II: Modeling and parameter estimation. *Journal of Food Engineering*, **55(4):** 349–357 (2002b).
24. Maache Rezzoug, Z., Bouvier, J.M., Allaf, K., Tayeb, J. and Patras, C., Study of mixing in connection with the rheological properties of biscuits dough and dimentional characteristics of biscuits, *Journal of Food Engineering*, **35:** 43–56 (1998).
25. Mamat, H., Abu-Hardan, M.O. and Hill, S.E., Physicochemical properties of commercial semi-sweet biscuit. *Food Chemistry*, **121(4):** 1029-1038 (2010).
26. Manohar, R.S. and Rao, P.H., Effect of sugars on the rheological characteristics of biscuit dough and quality of biscuits. *J Sci Food Agric*., **75:** 383–390 (1997).
27. Mirade, P.S., Daudin, J.D., Ducept, F., Trystram, G. and Cle´ment., J.

Characterization and CFD modelling of air temperature and velocity profiles in an industrial biscuit baking tunnel oven. *Food Research International*, **37:** 1031–1039 (2004).

28. Mondal, A. and Datta, A.K., Bread baking - A review. *Journal of Food Engineering*, **86(4):** 465-474 (2008).
29. Olewnik, M.C. and Kulp, K., The effect of mixing time and ingredient variation on farinograms of cookie dough. *Cereal chemistry*, **61(6):** 532- 537 (1984).
30. Pareyt, B. and Delcour, J.A., The role of wheat flour constituents, sugar and fat in low moisture cereal based products: a review on sugar-snap cookies. *Critical Reviews in Food Science and Nutrition*, **48:** 1-16 (2008).
31. Pareyt, B., Steertegem, B.V., Brijs, K. Lagrain, B. and Delcour, J.A., The impact of redox agents on sugar- snap cookie making. *Journal of Cereal Science*, **52:** 192- 199 (2010).
32. Peck, M.C., Rough, S.L., Barnes, J., Wilson, D.I., Roller extrusion of biscuit doughs. *Journal of Food Engineering*, **74:** 431–450 (2006).
33. Sablani, S.S., Baik, O.D. and Marcotte, M., Neural networks for predicting thermal conductivity of bakery products. *Journal of Food Engineering*, **52:** 299-304 (2002).
34. Saleem, Q., Wildman, R.D., Huntley, J.M. and Whitworth, M.B., Material properties of semi-sweet biscuits for finite element modelling of biscuit cracking. *Journal of Food Engineering*, **68:** 19–32 (2005).
35. Zucco, F., Borsuk, Y. and Arntfield, S.D., Physical and nutritional evaluation of wheat cookies supplemented with pulse flours of different particle sizes. *Food Science and Technology*, **44:** 2070- 2076 (2011).