

Study on the influence of heat transmission way while baking on the bread quality and crumb structure

Constantinescu (Pop) Cristina Gabriela*

¹Ștefan cel Mare University of Suceava, Food Engineering Faculty, 13th University Street, 720229,
Suceava - Romania

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Abstract

For thousands of years the baking process has remained almost unchanged. But, along with the industrial revolution of the 20th century and appearance of big bakeries, the baking process began to change. Thus, if initially it was based on heating by thermal conductivity new baking methods were investigated and implemented in order to reduce the baking time and increase production capacity in view of profit maximization. In the present context, the main goal of this paper was to investigate the impact of different baking methods and processes on the white bread quality. Two types of traditional wood-heated ovens, one of bake stone type and the other of roll type, were used. As modern ovens, a forced induction oven and bread-making machine where heating is done by means of an electrical resistance were used. The influence of different types of baking on more determining parameters was studied: moisture content, crumb structure and crust. Another aim of this paper is to investigate whether modern baking techniques succeed in providing bakery products with sensorial characteristics close to those of the traditional ones and whether the traditional baking methods are still surviving in the modern times. The analysis results have shown that there are significant differences of moisture, crumb structure, crust structure but from the organoleptical point of view as well. Thus, the bread baked in electrical forced induction oven has the shortest baking time and also an extremely pleasant exterior aspect, by making this type of baking is very suitable for commercial users. Instead, it registered the greatest losses during baking. Regarding the bread baked in traditional ovens, this registered average baking times, weight and losses. Also, it is found out that the use of these ovens is much more difficult, involves more effort and requires good knowledge of the oven. Instead, the bread baked in such ovens makes the difference in terms of flavored taste, having high potential in drawing consumers' attention.

Keywords: oven, thermal behavior, bakery product

1. Introduction

Baking is the last but most important stage in the bread making process. During this stage a series of physical, chemical and biological changes take place such as: water evaporation, porosity formation, volume expansion, protein denaturation, and starch gelification, crust formation **Error! Reference source not found.** The fine structure of bakery products is a very important factor which determines sensorial

characteristics like texture as well as storing and staling properties. Besides porosity which can be determined by density measurements, the size of pores plays a very important role. Together with the geometric distribution of pores, it also determines the ratio surface volume as well as connectivity of pores, both influencing significantly the rate of changes (undesired) during storage. The size distribution of pores can be assessed by 2D imagistic analysis, by magnetic resonance and Monte Carlo simulations

Error! Reference source not found. The use of these methods facilitates the analysis of the effect of different combinations of temperatures, times and levels of moisture on bread. Temperature is the dominant factor which causes various physico-chemical changes during baking. Optimization of oven functioning is necessary to reduce the energy consumption and improve the quality of products. A common industrial practice is to bake bread in oven at constant temperature to obtain optimum baking. But, the prediction of optimum baking conditions is a difficult task, as the baking mechanism is not completely understood yet. The literature reports and emphasizes the fact that there is a close dependence between the quality and lifetime of baked products and time and temperature of the baking process. Some studies **Error! Reference source not found.**, have shown that small breads baked in hybrid oven registered the highest heating rate ($25.1^{\circ}\text{C}/\text{min}$), whereas big breads baked in conventional oven had the lowest heating rate ($6.0^{\circ}\text{C}/\text{min}$). From the data analysis depending on heating rate, it is found out that the recrystallizing enthalpy of amilopectin, firmness rate of bread and the quantity of soluble amylose are lower when the heating rate is slower. The differences noticed regarding the product's firmness while stored may be explained by the high degree of hydration of starch granules, better swelling and dispersion, all these being affected by the heating rate during baking.

Protein denaturation and starch gelatinization influence water distribution by releasing and absorbing water. These two phenomena occur in the same range of temperature of $60\text{-}85^{\circ}\text{C}$ and contribute to the change of bread dough. Higher temperature at the dough surface and heat transport lead to an increase in water content in the middle of bread, fact caused by evaporation and condensation. **2**

For long time there has not been any method to study the changes in local content of water during processing without interrupting the process. Some authors developed a method which allows continuous studies on water and heat transport in bread while baking, using instruments with optical fiber, NIR and thermocouples **3**. It was demonstrate that that water seemed to move

towards the coldest area and not the geometric centre. Phenomena of heat and mass transfer take place simultaneously during bread baking, fact which causes physical, chemical and structural changes **4**. To understand the baking process in detail it is necessary for all these processes together to be known. The goal of this study is to compare the characteristics of bakery products using different heating methods during baking.

2. Materials and method

In order to determinate the differences resulting from the application of different heat treatments the dough was repeatedly prepared according to the same recipe: Flour 500 g, Water 375 ml, Yeast 7 g, Salt 10 g, Oil 50 ml, Sugar 31, 5 g l by strait method, mention being made about the fact that the baking process took place using the four types of oven described. Ovens used were: traditional bake stone oven uses woody fuel, the wood supplying is done through the door the dough is introduced in the oven - SAMPLE 1; traditional oven with roll has as main advantage the reduced consumption of wood and the distribution of heat inside. As heating principle, baking is done in these ovens on the basis of conductive method in the inferior side and convective one in the superior side and lateral sides respectively - SAMPLE 2; electrical forced convection oven, meant to industrial bakeries, made by Helpan Forni Convection ovens are specially made for pre-baked or frozen bread as well as for products meant directly to bake - SAMPLE 3 and Bread making machine made by Heinner (model BM 950) and has a power of 700 W, the heating is done by means of an electrical resistance placed downside the oven, below the tray As heating method, bread making machine uses convection - SAMPLE 4.

For the relevance of this study, the samples obtained were evaluated by technological characteristics and parameters like moisture content, crumb structure and crust.

3. Results and Discussion

3.1 Crumb moisture

The results regarding moisture are shown in figure1.

It is found out that the bread baked in bread making machine has the highest moisture 46%, whereas the

bread baked in the electrical oven has the smallest moisture of 42%.

These results confirm the fact that the big weight of bread baked in the bread making machine, reduced weight of bread baked in the electrical oven respectively is due to high moisture, low moisture respectively.

3.2 Structure of crumb

The differences of crumb structure of the four breads can be noticed by section analysis of bread (Figure 2).

For a detailed analysis of crumb structure of the four breads, a trinocular Stereomicroscope made by Optika was used. The results obtained for all the four breads are shown in Figure 3 and confirm the above mentioned. Also, a difference of crumb color may be observed between the breads baked

in traditional ovens (bake stone and roll) and those baked in electrical ovens. In the case of the latter ones, color is brighter whereas in the case of former ones the color is more yellowish.

3.3 Crust Structure

As regards crust structure this time, too, the differences are major and visible. As for crust thickness, it was observed that the bread baked by traditional techniques has a thicker crust and harder texture.

The bread baked on bake stone has the thickest inferior and side crust due to direct heat transfer. The thickest superior crust is registered in the bread baked in roll, this due to big height of the tray and the small distance from heat source implicitly. Also, in the case of traditional baking methods, crust is more fresh-colored (Figure 4)

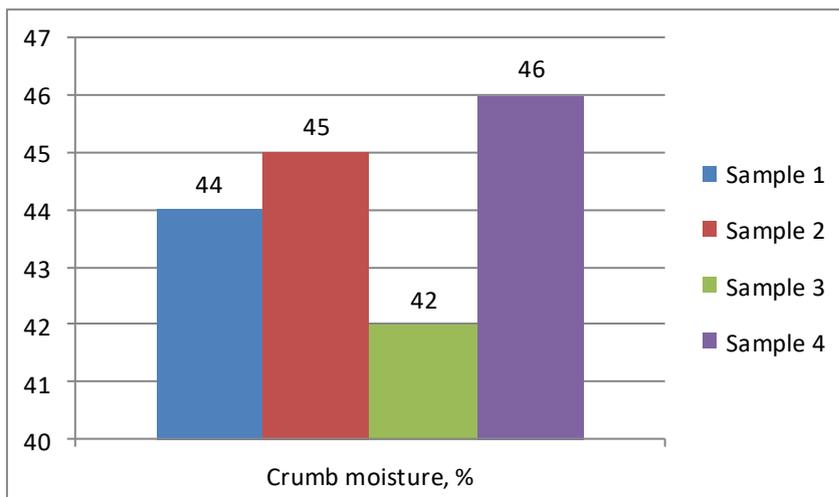


Figure 1. The content of moisture of the samples crumb

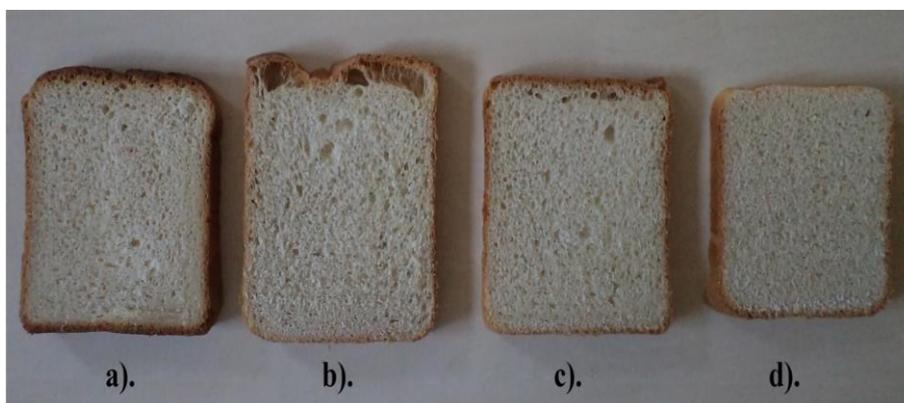


Figure 2. Section of bread: a).Bread baked in bake stone oven type; b). Bread baked in roll; c). Bread baked in electrical convection oven; d). Bread baked in bread making machine.

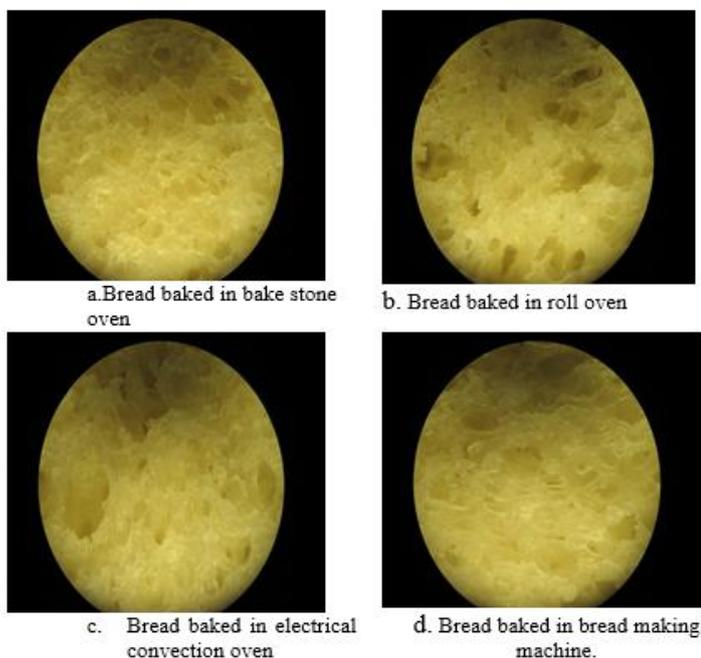


Figure 3. Crumb structures of the four samples

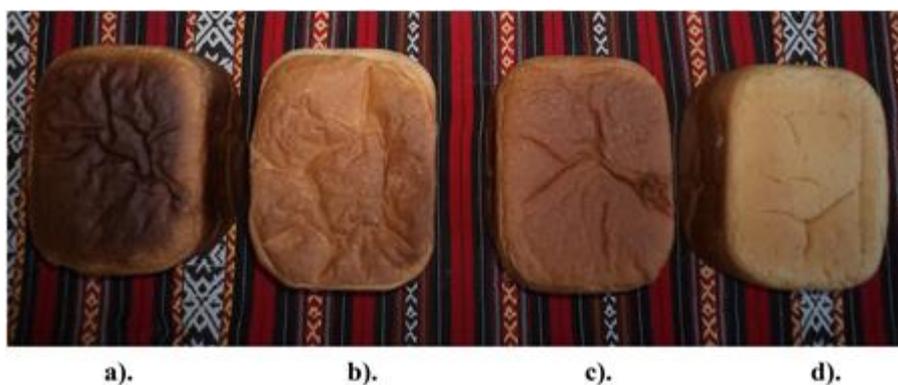


Figure 4. View of superior crust of four breads: a). Bread baked in bakestone oven; b). Bread baked in roll oven; c). Bread baked in electrical convection oven; d). Bread baked in bread making machine.

Table 1. Variation of crust thickness depending on the type of oven used

Oven Type	Crust thickness [mm]			Observation
	Upward	Downward	Lateral	
Bakestone	6-7	4-5	4-5	Crust color is dark.
Roll	6-14	2-3	2-3	Superior crust contains blanks reaching 10 mm.
Electrical oven	3-4	2	2	Crust is uniform, pleasant color.
Bread making machine	1	3-4	4	Superior crust is very thin, the colour is extremely bright and texture is close to that of crumb.

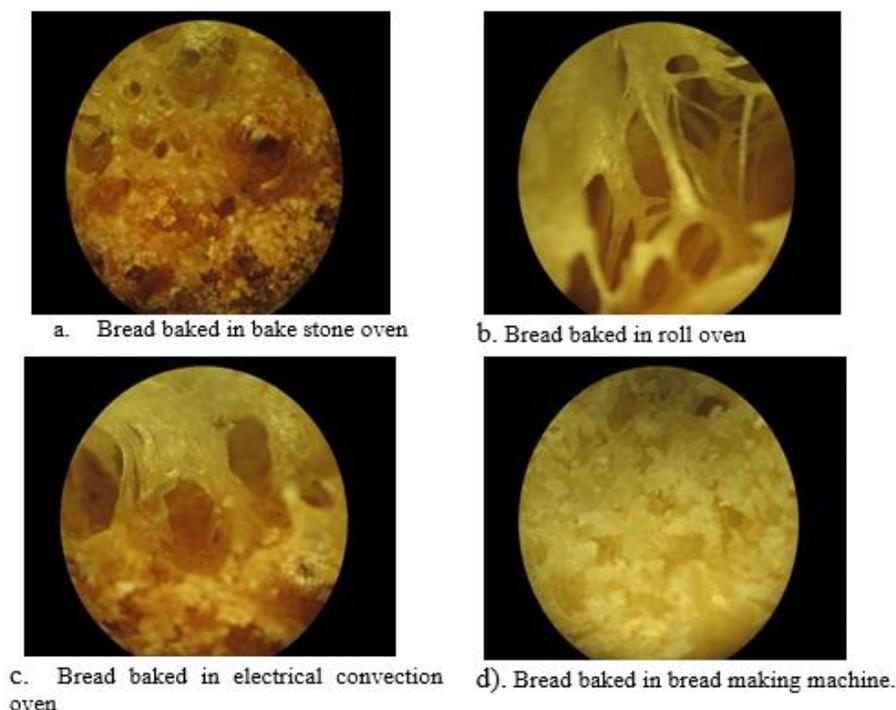


Figure 5. Microscope view of superior crust structure of four breads

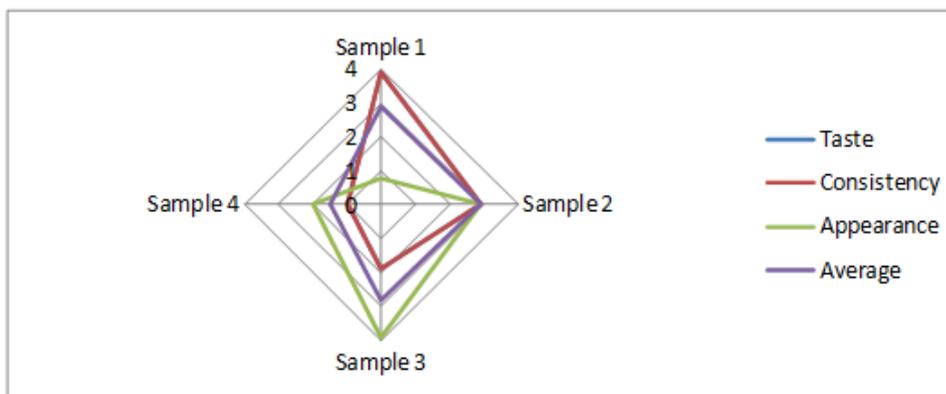


Figure 6. Subjective assessments of organoleptical properties

This is explained by the difficulty in controlling exactly and accurately the temperature from inside. In the case of bread baked in bread making machine, it is found out almost total lack of superior crust, this one being very thin and having a structure similar to that of crumb. This phenomenon is explainable as the heat source is placed inside and therefore the superior side

temperature is not high enough to provide bread with toasting. Instead, inferior crust is well baked, thick and well defined.

As regards the crust of the bread baked in electrical oven, this one has an average thickness, is uniform and has pleasant overall aspect. This information is summarized in Table 1 and shown in Figure 5.

These results emphasize very clearly the differences brought about by the baking method used. Thus, for the bread baked in a stone oven one can observe much darker colour as compared with that baked in a roll high porosity as compared with other breads, and the bread baked in a bread making machine one can notice the very bright colour and structure similar to that of crumb.

3.4 Organoleptical properties

From the point of view of the overall exterior aspect, the bread baked by traditional techniques (stone oven and roll oven) is less attractive as compared with that baked in electrical ovens. This is due to the difficulty of controlling temperature exactly in the case of traditional ovens, leading to excessive toasting. As regards consistency and taste the bread baked by traditional methods is more consistent and its taste is more pleasant and flavored with a sweet tint. In order to show also graphically the assessment of organoleptical properties, the aspects regarding taste, consistency and overall aspect were subjectively evaluated, each one being given a grade (satisfaction index) from 1 to 4. This assessment is shown in Figure 6.

4. Conclusions

The aim of these studies was to understand as better as possible the changes occurring during the process of turning dough into a finished product, but also to investigate the effect of different stimuli and that of baking conditions on the product. In this scope, the dough was baked in two types of traditional ovens, stone oven and roll one, both being heated by wood. Also, two types of electrical ovens were used as well: an electrical oven with warm air jet and a bread making machine. The analysis results have shown that there are significant differences of moisture, crumb structure, crust structure but from the organoleptical point of view as well. Thus, the bread baked in electrical forced induction oven has the shortest baking time and also an extremely pleasant exterior aspect, by making this type of baking be very suitable for commercial users.

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Compliance with Ethics Requirements. Authors declare that they respect the journal's ethics requirements. Authors declare that they have no conflict of interest and all procedures involving human / or animal subjects (if exist) respect the specific regulation and standards.

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